200 8a T

SYSTEMATICS AND BIONOMICS OF THE SCORPIONS OF SOUTH WEST AFRICA (Arachnida, Scorpionida)

(SUBMITTED IN TWO VOLUMES

VOLUME 1

Text, Text Figures 3.1,
3.8, 3.9, 4.9 and 4.28,
References and Appendices)

by

N 2v.

200 8f

A
BRUNO H. LAMORAL

N Thesis (Ph.D.; Zoology) - University of Natal, Pietermaritzburg, 1978

Submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the Department of Zoology, University of Natal

December 1978

210 Thesis, Ph.D. (Zoology), Natal, 1978.

This thesis, unless specifically indicated to the contrary in the text, is my own original work. It has not been submitted for a degree to any other University.

CONTENTS

ABSTRACT

All the taxa of scorpions previously described from South West Africa are revised and a monographic account presented with phylogenetic and biogeographic discussions and conclusions derived in terms of current concepts in systematic zoology which include cladistics and historical biogeography. South West Africa is treated as a subregion of the Afrotropical region and the limits of this subregion coincide broadly with the political borders. All the characters used are defined and illustrated. Many characters previously unstudied for the fauna are investigated. These include comparative studies of trichobothria distributions and detailed structures of the hemispermatophore. Disc electrophoresis of the haemolymph of a few species was carried out and the results discussed. Ecological factors are extensively described and discussed. The nature of the substratum, taken in its broadest possible definition, was found to be the most important single factor determining species distribution. 70 subgeneric taxa were revised, 45 of which are retained as valid, while 11 new species are described bringing the number of known species to 56. These are distributed among seven genera as follows : *Buthotus*, two species; *Karasbergia*, one species; *Parabuthus*, 14 species; *Uroplectes*, 10 species; *Hadogenes*, three species; *Lisposoma*, two species; *Opisthophthalmus*, 24 species. Determination keys are provided for all levels of taxa occurring in South West Africa.

ACKNOWLEDGEMENTS

I wish to express my gratitude to the following for their assistance in the course of this investigation.

For their mentorial support: Professors J. Heeg and J.A. Meester.

For financial support of field work: The Council for Scientific and Industrial Research, The Council of the Natal Museum and Total Petroleums S.A. (Pty) Ltd.

For permission to work in areas under their jurisdiction : The Department of Nature Conservation and Tourism of South West Africa, the Department of Plural Administration of South West Africa, The Namib Desert Research Unit at Gobabeb, The Consolidated Diamond Mines of South West Africa Ltd , Imcor Zinc (Pty) Ltd at Rosh Pinah and Ochta Diamonds (Pty) Ltd.

For extensive help with many general aspects related to the planning and accomplishment of field work and for collecting numerous specimens: Mr C.G. Coetzee, the Director of the State Museum in Windhoek and staff members Dr M.-L. Penrith and Mr M. Penrith, Dr P. Olivier and S. Louw.

For the hospitable permission to camp and work on their properties: all the owners of farms or land listed under material examined in this thesis.

For their congenial participation in field work during the following expeditions: 1969, Dr R. Day; 1972, Mr A. Bannister; 1973, Messrs L. Raw and K. Porter; 1976, Ms L. Ferguson and Mr & Mrs J. Alfers.

For the loan of material and various facilities provided: The Director and staff members of all the Research Institutes listed in Chapter 1.

For the hospitality provided while working in their Research Institutes: Dr C.K. Brain (Director), Messrs G. Newlands and W. Haacke and staff members, Transvaal Museum, Pretoria; Dr T. Barry (Director) and staff members, South African Museum, Cape Town; Professor M. Vachon (Director) and colleagues, Laboratoire des Arthropodes, Museum national d'Histoire naturelle, Paris; Professor P.L.G. Benoit (Director) and staff members, Section des Invertébrés (non Insectes), Musée royal de l'Afrique

centrale, Tervuren; Mr F. Wanless and Dr B. Parry , Department of Arachnology, British Museum (Natural History), London.

For discussions on and laboratory facilities for haemolymph electrophoresis and related aspects: Dr M. Goyffon, Museum national d'Histoire naturelle, L.E.R.A.I., Paris; Professor G. Quicke and Dr I. Dreosti, Department of Biochemistry, University of Natal, Pietermaritzburg, and Dr Barry Bredenkamp, Institute of Parasitology, Durban.

For the conscientious typing of the manuscript of this thesis: Mrs P. Jerling.

For their help with a few of the drawings: Ms L. Ferguson and Ms S. Britz.

For her help with the printing and sticking of the plates in this thesis: Mrs A. Seymour.

For discussions and reading certain sections of this thesis: Drs Miller, Stuckenberg and Londt.

For permission to reproduce some of his maps: Dr W.G. Coaton.

CHAPTER 1

INTRODUCTION

> "What sort of insects do you rejoice in, where *you* come from?" the Gnat inquired.
>
> "I don't *rejoice* in insects at all," Alice explained, "because I'm rather afraid of them—at least the large kinds. But I can tell you the names of some of them."
>
> "Of course they answer to their names?" the Gnat remarked carelessly.
>
> "I never knew them do it."
>
> "What's the use of their having names," the Gnat said, "if they won't answer to them?"
>
> "No use to *them*," said Alice; "but it's useful to the people that name them, I suppose. If not, why do things have names at all?"
>
> (Lewis Carroll. Through the Looking Glass)

HISTORICAL BACKGROUND

The South West African scorpion fauna is known mainly through assorted publications by the following workers: Karsch (1879); Simon (1887); Thorell (1876-1877); Peters (1861); Kraepelin (1897, 1899 & 1908); Purcell (1898-1901); Hewitt (1913-1935) and Lawrence (1927-1969). Hewitt (1918) published the first comprehensive monograph and key on the fauna of South Africa including species described from South West Africa. Lawrence (1955) produced a comprehensive checklist of the southern African fauna (including South West Africa) and updated Hewitt's 1918 key. Lamoral and Reynders' 1975 catalogue includes all the species described from South West Africa up to December 1973.

Of the 175 infrageneric taxa listed from southern Africa (south of the 17^{0} latitude) in my 1975 catalogue, 70 are reported from South West Africa (see table 1.1). Thus 40% of the southern African fauna was found to occur in South West Africa. On the assumption that the proportion of invalid taxa will be found to be approximately the same for the whole of southern Africa, it is suggested that the above percentage will remain more or less the same when the fauna of this region has been completely revised.

South West Africa covers approximately one quarter of the surface area herein referred to as southern Africa. Hence South West Africa harbours 40% of the scorpion species in 25% of the surface area of southern Africa.

MOTIVATIONS

The decision to revise the scorpion fauna of South West Africa was based on several considerations, the more important of which were:

- The taxonomy of the group was in dire need of revision with many suspected synonymies causing problems in phylogenetic appraisals. See table 1.1.
- Virtually all of previous publications were of a purely taxonomic nature, contained little or no biological information, were mostly based on a few specimens and consequently lacked information on possible intraspecific variation.
- No comprehensive treatise or illustrated key to species existed for the fauna of such a vast subregion.
- Preliminary findings indicated that a very large proportion of the fauna was endemic and that consequently South West Africa represents a major subregion of the Afrotropical region (sensu Crosskey & White, 1977).
- The region was poorly collected although supporting a large number of species.

AIMS AND LIMITATIONS

The present study was initiated as an attempt to overcome the deficiencies outlined above, to present as complete a monographic account as possible and to derive phylogenetic and biogeographic conclusions in terms of current concepts in systematic Zoology.

Only taxa recorded within the political borders of South West Africa are revised as these borders were found to coincide broadly with the biogeographic limits of this subregion.

Limitations affecting phylogenetic and biogeographical considerations are discussed in Chapter 5.

MATERIAL

The material studied was obtained as follows:

- about 3100 specimens collected during five field expeditions to South West Africa in 1969, 1970, 1972, 1973 and 1976;
- about 1800 specimens collected by staff members of the State Museum in Windhoek in support of this project;
- about 300 specimens sent for study by the institutions listed under material examined in Chapter 4;
- approximately 300 specimens examined in the collections of the Musée national d'Histoire naturelle in Paris and the British Museum (Natural History) in London.

Thus approximately 5500 specimens were examined altogether.

Published records for the species revised are available from my 1975 catalogue and these are not duplicated in this thesis.

ABBREVIATIONS FOR RESEARCH INSTITUTES

A.M.	Albany Museum, Grahamstown, South Africa.
ANG.	Museu do Dundo, Luanda, Angola.
B.M.	British Museum (Natural History), London, England.
G.N.M.	Göteborgs Naturhistoriska Museet, Göteborg, Sweden.
L.U.Z.M.	Lund University Zoology Museum, Lund, Sweden.
M.C.Z.	Museum of Comparative Zoology, Cambridge, Massachusetts, United States of America.
M.N.H.P. R.S.	Museum national d'Histoire naturelle, Paris.
N.M.	Natal Museum, Pietermaritzburg, South Africa.
N.M.S.	Naturhistorische Museum, Senckenberg, Germany.
N.M.W.	Naturhistorischen Museum, Wiesbaden, Germany.
N.R.S.	Naturhistoriska Riksmuseet Stockholm, Sweden.
S.A.I.M.R.	South African Institute for Medical Research, Department of Entomology Collection, Johannesburg, South Africa.

S.A.M.	South African Museum, Cape Town, South Africa.
S.M.N.	State Museum, Windhoek, South West Africa.
T.M.	Transvaal Museum, Pretoria, South Africa.
W.U.S.	Wiener Universität Sammlung, Vienna, Austria.
Z.M.B.	Zoologisches Museum Berlin, DDR Berlin, Germany.
Z.M.H.	Zoologische Staatsinstitut Zoolosiche Museum Hamburg, Germany.

METHODS

Procedural approach.

The material studied was treated as follows:

- undetermined material was sorted out into species lots without referring to existing keys;
- each species lot was allocated an existing species name after comparison with type material and original descriptions; lots containing undescribed species were given new species names; previously determined material was reallocated within this framework.
- new keys were then constructed on the basis of character states listed in tables such as those in chapters 4 and 5.

This procedure was devised in an attempt to ensure that the revision would be unaffected by previous taxonomic deductions and keys.

In accordance with current trends in systematics, no formal subspecific names are used in this thesis. Previously described subspecies were found to be either conspecific with their typical form or to exhibit diagnostic differences warranting species status.

Field work was planned to include visits to as many type localities as possible in an attempt to collect topotypes.

Methods of presentation.

This thesis is submitted in two volumes. Volume 1 contains the list of contents, the text divided into five chapters, five text figures (3.1, 3.8, 3.9, 4.9 & 4.28), the list of references and two appendices (a gazetteer of locality names and an offprint of my 1978 paper). Volume 2 contains the tables, all the remaining figures and the plates.

Tables, figures and plates are referred to with a double number separated by a fullstop (period). The first number refers to the chapter number and the second to the actual number of the item in the relevant chapter.

Chapter headings and contents are reflected in the list of contents.

Chapter 4, on the systematics of the group, is structured to provide the following:

- keys to families, subfamilies, genera and species;
- generic diagnoses;
- treatment of each species in alphabetical order within each genus.

The treatment of each species comprises the following:

- reference to the original description;
- synonyms if applicable;
- a diagnosis;
- a description of the habitus and associated aspects such as variation and type material;
- a list of material examined;
- the broad distribution;
- bionomics.

Character states described in the diagnosis as well as those adequately and comprehensively described in the literature are in most cases not repeated in the detailed description of each species which as a result only contains new or corrected information.

The descriptions of new species in this thesis are in press in the *Annals of the Natal Museum*. To ensure that no confusion will arise regarding the date and medium of the original descriptions of the new species, these are temporarily identified as *new species A*, *new species B* etc. ... within each genus treated.

A fairly large proportion of the type material examined is deposited in overseas institutions and consequently not readily available. Whenever possible, I have designated a HOMOTYPE for such types. Mayr *et al* (1953: 239) gives the following definition for homotype: A specimen compared by another than the author of a species with the type and determined by him to be conspecific with it." Homotypes are not recognised as types by the Code of Zoological Nomenclature but designation of such typical specimens are certainly useful.

Colour descriptions for all the species treated are given using the ISCC-NBS Colour Designation (Kelly & Deane, 1965) which consists of the standard colour name followed by its number. Although Munsell Renotations are supplied by Kelly & Deane, these are not quoted in colour descriptions of the species, as they are too lengthy and can in any case be looked up in the tables provided by these authors.

A gazetteer of all the localities listed for the material examined during the present survey is supplied in appendix 1. In this list, each locality is followed by the magisterial district in which it falls at the time of writing. The names and boundaries of these districts are shown in fig. 1.2.

All the magisterial districts of South West Africa, with the exceptions of Homelands, derive their names from the town that is the magisterial seat. The names and boundaries of several of the magisterial districts changed in 1972. The former names and boundaries of these appear in fig. 1.1. These changes must be borne in mind when consulting the species distribution maps in Chapter 4 which bear the names of towns that were magisterial seats prior to the 1972 changes.

Field and laboratory methods

These include methods not described elsewhere in this thesis.

Field methods

The use at night of two portable ultra-violet light units during the last three expeditions to South West Africa greatly improved collecting yields. It has been known for some time that scorpions fluoresce when subjected to U-V light but this technique had never been used before in southern Africa.

The use of a rake on sandy substrata under shrubs and other small plants often yielded good results during daytime collecting.

Pitfall traps set in the ground yielded comparatively poor results. Other collecting methods included digging out burrows, looking under stones, rocks, bark of trees and, generally, inspecting any potential shelter.

Laboratory methods.

Measurements were taken using either a sliding micrometer or a microscope measuring eyepiece.

Most of the drawings were prepared with the use of a camera lucida.

All final drawings were done in black ink on sheets of Bristol Board measuring 37 x 24 cm. Most of the hemispermatophore drawings were done on textured paper. All final drawings were reduced to fit the page size of this presentation. Reduced drawings were then photocopied for presentation in this thesis. As a result of these two processes, some of the figures, especially those of the hemispermatophores have lost a certain amount of their original details and quality.

Printed determination labels have been placed with all examined specimens sent on loan to the Natal Museum.

CHAPTER 2

BIONOMICS AND THE ENVIRONMENT

GENERAL BIONOMICS

HABITAT

Desert and semi-desert biomes, such as found in well over half of the South West African region, are the least complex of all terrestrial biomes and offer a smaller selection of potential habitats than any other biome.

The scorpions of this region have successfully adapted to virtually the full range of potentially compatible terrestrial habitats and the degree of their success in colonising these is reflected in the ubiquitous nature of these animals.

A broad analysis of the South West African scorpion fauna according t habitat preference appears in table 2.1. More detailed information on the habitats of individual species is available in chapter 4 for each species.

Table 2.1 shows that 89% of the fauna is hemiedaphic, 9% epigeic and 2% euedaphic. Some of the species which have a preference for a particular habitat in one region, are often found in a different habitat in another region if their preferred habitat is not available. *Buthotus conspersus*, for instance, can be found either under rocks or under the bark of trees, but the former is the preferred habitat where both are available. No species are unselective in their choice of habitats, but a few species will be found wandering from one habitat to another when searching for prey. Also, *Uroplectes carinatus* has often been found moving about at night on shrubs, occasionally on trees and in rock crevices in the same locality, although it normally rests under rocks on the ground during its diurnal inactive period and its normal habitat during the nocturnal active period i on the ground. *Uroplectes otjimbinguensis*, by contrast, is always epigeic on vegetation ranging from trees to large shrubs and it is very seldom foun on the ground.

As seen from table 2.1, 43% of the scorpions of South West Africa are fossorial and the surface and underground configuration of their burrows is of interest.

There is very little variation in the external configuration of burrows in all species and the occasional discrepancies observed are due entirely to local topographical adaptations and not to definite intraspecific patterns. The surface configuration of burrows of *Opisthophthalmu wahlbergi* and *O. holmi* is shown in plates 2.1 and 2.3. The burrow entrances of scorpions are oval in cross-section and enable one to distinguish them from those of other fossorial arthropods, which in the majority of cases are round in cross section. In addition, a fan-shaped mound radiating away from the entrance and consisting of the soil that has been excavated and pushed out is always found at the mouth of freshly dug or deepened burrows.

Data on the underground configuration of burrows were collected for most of the fossorial species dug out and records of these were studied to find out whether there was any constant intraspecific pattern which differed significantly on an interspecific level. It was found that there were no significant interspecific differences and that no single configuration represented an intraspecific characteristic.

The average configuration of a burrow is as follows. At a point about 10-20 cm from the entrance, the burrow spirals vertically down for one to three turns and thereafter follows a random downward path to the bottom of the burrow that is enlarged into a chamber enabling the scorpion to turn around. The piece of white string in plate 2.5 shows the path followed by a typical burrow of *Opisthophthalmus adustus*. The entrance to this burrow was situated at the beginning of the string near the matchbox. The other end of the string is at the bottom of the burrow, 50 cm below ground surface.

Plates 2.1 to 2.28 illustrate some of the habitats of South West African scorpions and associated terrain and vegetation and the section on soils, below, discusses these habitats at greater length.

MORPHOLOGICAL ADAPTATIONS

The scorpions of South West Africa display an interesting range of morphological adaptations to their habitats. These are described, whenever relevant, in chapter 4, for individual species treated. The following is a generalised list of the different adaptations to the habitats listed in table 2.1.

All South West African fossorial species use their chelicerae to loosen soil particles and their anterior two pairs of legs to scrape and rake soil out of the burrow. Fossorial species burrowing in hard soils have powerful chelicerae and short robust legs laterally and distally provided with rows of stout, spine-like setae distributed so as to improve functional efficiency in burrowing in this type of medium.

Ultrapsammophilous and to a lesser extent psammophilous species have long legs with long ungues, a pad of numerous fine setae on the ventral surface of the tarsi, and sweep-like rows of long setae on the anterior and posterior edges of tibia, protarsi and tarsi of legs I and II (see plates 3.5 and 3.6). The latter adaptation is particularly well developed in burrowing ultrapsammophilous species such as Opisthophthalmus holmi.

Infrasaxicolous, lithoclasicolous and infracorticicolous species have greatly dorso-ventrally compressed bodies and appendages, long and slender tails, and short, stout spine-like setae on the ventral surface of tarsi I-IV which operate in conjunction with the greatly curved ungues to provide the legs with a vice-like grip on rough surfaces such as rocks and trees. This adaptation efficiently enables such scorpions to move rapidly in any spatial plane of their habitats.

ECOLOGICAL FACTORS

The selection of habitats and distribution of species in scorpions, as in other animals, is governed by an interaction of various ecological factors. The following sections on soils, vegetation, climate, topography and geology serve as a summary of available information on these broad ecological factors in South West Africa.

In chapters 4 and 5 the importance of these factors and their possible effects on distribution and range of species are dealt with in terms of their availability for single species or groups of species.

The section on soils is the result of extensive investigations carried out during this survey and represents an aspect hitherto unstudied.

SOILS

All scorpions of the genus Opisthophthalmus find shelter by digging burrows in the ground, and the following objectives formed an integral part of this thesis:

(1) To determine whether habitat selection, distribution and range of species are correlated to a soil type;

(2) to determine the more important factors affecting soil type selection;

(3) to establish widely applicable parameters for (2).

(4) to investigate the effect of (1) on apparently sympatric species.

The results obtained for these objectives have recently been publishe (Lamoral, 1978, see offprint in appendix 2).

The tables and figures of this publication relevant to references and discussions elsewhere in this thesis, have been incorporated into this chapter bearing numbers altered to conform with the present system. Thus :

- Table 2.2 in this thesis corresponds to Table I in the offprint
- Table 2.3 in this thesis corresponds to Table II in the offprint
- Fig. 2.2. in this thesis corresponds to Fig 1 in the offprint
- Fig. 2.3.a. in this thesis corresponds to Fig. 2 in the offprint
- Fig. 2.3.b in this thesis corresponds to Fig. 3 in the offprint

Examples of the relevant soil categories for species of Opisthophthalmus can be found in the section on bionomics for individual species in chapter 4 and in figs 2.2 and 2.3 a & b.

THE ENVIRONMENT

VEGETATION

The definitions and characteristics of the vegetation types used in this study follow those described and delimited by Coaton and Sheasby (1972) with the assistance of Mr W. Giess of the South West African Herbarium in Windhoek.

The 14 vegetation types of south West Africa are delimited in fig. 2.4 and classified in table 2.4. Some of these are illustrated in plates 2.4, 2.6, and 2.8 to 2.28.

Correlations between vegetation and the distribution of species appear under the section of bionomics for each species treated in chapter 4

CLIMATE

Taking into account such aspects as temperature, rainfall, wind and amount of solar radiation, South West Africa is divided into climatic regions delimited in fig. 2.5 and described in table 2.5. The data appearing in fig. 2.5 and table 2.5 were obtained from Barnard (1965) and Köppen (1931). The symbols such as BW kln, used as codes for the different climatic regions, are those used by Köppen and are internationally accepted by geographers. More accurate information on the mean annual rainfall appears in fig. 2.6 while a comparison of figs. 2.5 with 2.7 shows an interesting correlation between climate and altitude.

TOPOGRAPHY AND GEOLOGY

A broad impression of the topography of South West Africa is given in fig. 2.7. South West Africa is roughly divisible into three major topographical zones, namely: (1) the coastal zone which extends up to the 900 metre line; (2) the interior plateau with contour lines ranging from 900-1200 metres; (3) the interior highlands composed of the highland plateaux (1200-1500 metres) and mountains (1500 metres plus).

The highland plateaux and mountains have been shaded in fig. 2.7. The large central highland block stretching from north-east of Tsumeb to west of Behtanie forms an important geographical barrier to the distribution of several species and this will be discussed at greater length in subsequent chapters. Other interior highlands of interest are the Aus and Karasberge plateaux in the south, the Brandberg and Erongo mountains in the west and the highlands of the Kaokoveld in the north-west.

Two geological systems have a determining influence on the distribution of South West African scorpions. These are the Namib sand system and the Kalahari sand system. The distribution of these two systems is shown in fig. 2.8. The two systems are well separated by a very wide corridor of non-sandy regions with varying geological, topographical and vegetational systems which effectively operate as a barrier to the migratior of psammophilous and semi-psammophilous species. This is a particularly significant factor in the case of fossorial species, as seen earlier in the section on soils.

CHAPTER 3

DESCRIPTION AND EVALUATION OF THE TAXONOMIC CHARACTERS STUDIED

MORPHOLOGICAL TERMINOLOGY

The morphological terminology used in this work is largely that currently recommended by Vachon (1952-1975) and Stahnke (1970) as tabulated by the latter (table 1: 309-312). In some cases, I have selected a terminology differing from that in Stahnke's table, pointing out the changes where relevant. The decisions for any of the changes were based solely on the necessity to retain a terminology that is well established and currently employed by the majority of contemporary workers. An example of a choice that had to be made is my decision to use Vachon's trichobothrial nomenclature instead of Stahnke's. The latter is incomplete, lacks universality and compares unfavourably on the practical level with the well documented terminology pioneered by Vachon in 1948, followed by several amendments which have led to a well-tried and universal system covering all the scorpion families (see Vachon, 1973). This is currently used by the majority of contemporary scorpiologists.

The following is a list of terms used in this work to describe principal morphological entities.

BODY
Prosoma (bearing all appendages)
- Dorsal:
  - Carapace
    - Lateral eyes
    - Ocular tubercle bearing median eyes
- Ventral:
    - Maxillary lobes I
    - Maxillary lobes II
    - Sternum

- Opisthosoma
  - (1) Mesosoma
    - Dorsal:
      - Tergites (I-VII)
    - Ventral:
      - Genital operculum (I)
        - Genital aperture
        - Genital papillae (♂ only)
      - Basal piece (II)
        - Pectines (sing. pecten)
          - Marginal lamellae
          - Middle lamellae
          - Fulcra
          - Teeth
      - Sternites (III-VII)
        - Stigmata
    - Lateral:
      - Pleural membranes
  - (2) Metasoma
    - Cauda (I-V)
      - Cauda I-IV
        - Dorsal furrow
        - Intercarinal areas
        - Keels (carina)
          - Dorsals
          - Dorso-laterals
          - Median laterals (intermediary laterals)
          - Ventro-laterals
          - Ventrals
      - Cauda V
        - Keels (carina)
          - Dorsal accessory (crest)
          - Dorso-laterals
          - Median laterals (intermediary laterals)
          - Ventro-laterals
          - Ventro median (axial)

- Anal arch (anal frame)
  - Anterior crest
  - Posterior crest
- Telson
  - Peduncle
  - Pedicular plate
  - Vesicle (Bulbus)
  - Aculeus (sting)
  - Subaculear tubercle or tooth

APPENDAGES

- Chelicerae
  - Basal segment
  - Chela
    - Manus (hand)
    - Fingers
      - Fixed
      - Movable
- Pedipalps
  - Coxa
  - Trochanter
  - Femur
    - Surfaces: dorsal, external, ventral, internal
  - Tibia
    - Surfaces: dorsal, external, ventral, internal
  - Chela
    - Fingers
      - Fixed
      - Movable
      - Cutting edges with median, external, internal
      - Rows of teeth
    - Manus (hand)
      - Surfaces
        - Dorsal
          - Keels
            - Finger (digital) keel

        - External
        - Ventral
        - Internal
    - Keels
        - Marginal
            - Dorso-internal (dorsal crest)
            - Dorso-external
            - Ventro-external
            - Ventro-internal

- Legs (I-IV)
    - Coxa
    - Trochanter
    - Prefemur
    - Femur
    - Tibia
        - Tibial spur
    - Protarsus (basitarsus)
        - Pedal spurs
            - Internal
            - External
    - Tarsus
        - Median lobe (dorsal)
        - Lateral lobes
    - Post-tarsus
        - Lateral claws (ungues)
        - Median claw (unguicular spine)

MORPHOLOGICAL AND MORPHOMETRIC CHARACTERS

The aim of this section is to clarify and illustrate the interpretation of the characters used in the taxonomic sections of chapter 4. Not all of these characters are described; only those that have previously been inadequately described or ambiguously interpreted, those that represent new and original contributions and those hitherto treated in languages other than English. Examples of the latter are Vachon's (1973) treatment of thrichobothriotaxy and San Martin's (1969) work on hemispermatophores. The use of trichobothriotaxy and comparative studies of hemispermatophores is of topical significance because this is the first instance of application to taxa in the Afrotropical faunal region.

COLOUR

Owing to intraspecific, maturation stage and clinal variations, colour is often of limited diagnostic significance. This is particularly relevant in the case of colour shades but less in that of colour patterns. Consequently the importance of colour should be viewed critically and colour should be used as a diagnostic character only in cases where a large number of representative samples is available.

Of greater and more reliable significance is the consistent presence or absence of certain colour patterns such as, for instance, "blackening" of caudal segments or other morphological entities, as in the case of *Uroplectes teretipes*.

To ensure uniformity and to avoid subjective interpretation in the colour descriptions of species treated, all colour designations are based on the ISCC-NBS Colour Designation used by Kelly and Deane (1965). In each case, the colour designations allocated to individual species has been directly compared with the colour charts provided by these authors and the colour designations kept as simple as possible.

TRICHOBOTHRIA (δ)

The symbol "δ" will be used extensively in this work to refer to trichobothria.

Trichobothria are found only on the femur, tibia and chelae (not on movable fingers) of pedipalps. Newlands (1972) states (p.42) that "The pedipalps and caudal segments of *Hadogenes* are richly endowed with trichobothria ....." and (p.44) that "*Cheloctonus* has relatively few palpal and caudal trichobothria compared to *Hadogenes* and *Opisthacanthus*". Careful examination of the cauda of various species of the genera listed by Newlands has failed to confirm the presence of any δ on the cauda and one can but surmise that he misidentified microsetae as trichobothria.

Trichobothria are highly sensitive mechanoreceptors which are readily distinguished from normal setae, from which they very likely evolved. Plates 3.1. to 3.4. show the characteristic and distinguishing features of δ and setae. Vachon (1973) gives a full account of the current use of δ in systematics and stresses their great diagnostic importance at various levels, defining trichobothriotaxy as the study of the number and relative distribution of δ; Vachon proposes the terms *orthobothriotaxy* to describe the basic or fundamental number of δ for any given group of taxa studied, for example at the family level, and *neobothriotaxy* as any departure from this basic number. Increases and decreases in the basic numbers are called increasing (+) and decreasing (-) neobothriotaxies respectively. The absence of δ d_2 on the tibia of *Karasbergia methueni* and the presence of 28 δ instead of 13 on the external surface of the tibia in *Protophthalmus holmi* are examples of (-) and (+) neobothriotaxies respectively.

Vachon (1973) has designated three fundamental types of orthobothriotaxies, namely type A for all the taxa of the family Buthidae, type B for Chaerilidae and type C for Scorpionidae and the remaining four families. The fundamental δ of types A and C appear in table 3.1. and many examples of their distribution are illustrated in the figures provided for each species in chapter four. Table 3.3. provides a key to the δ codes used in table 3.1, chapter 4 and elsewhere.

Vachon (1973) points out that although the position of single δ or groups of δ can often vary intraspecifically, this variation occurs within definite limits which he calls territories. The frequency of such variations is higher in cases of marked (+) neobothriotaxies reaching levels where the trichobothriotaxies of certain segmental surfaces cease to be of interspecific diagnostic significance. This is the case for instance with the external δ of the tibia in *Protophthalmus holmi* and the ventral δ of the tibia in species of *Hadogenes*.

Intraspecific variation in the position of single δ or groups of δ are usually indicated by a broken line demarcating the limits of territories (see text fig. 3.1.).

Fig. 3.1.

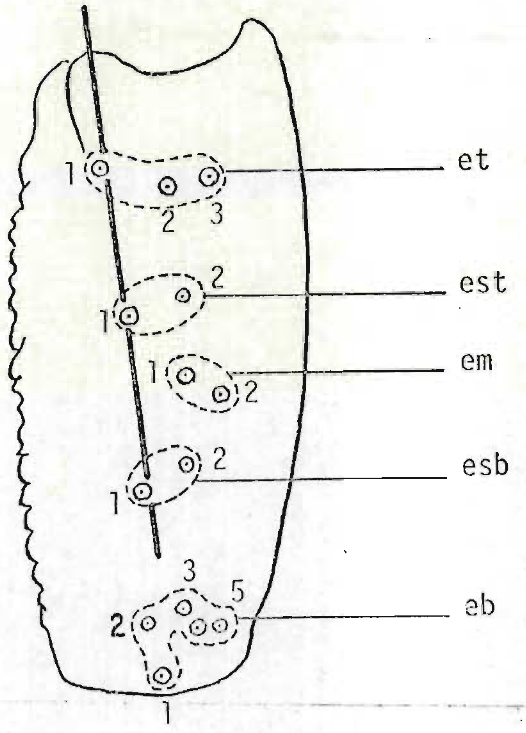


Fig. 3.1. δ on external surface of tibia in Opisthophthalmus

Certain δ occupy very stable positions with minimal intraspecific variation and these are known as "pilot trichobothria". δ esb_1 and et_1 on the external surface of the tibia are pilot δ (see fig. 3.1). The spatial stability of pilot δ provides a starting point from which the variable positions of adjacent δ can be deduced and facilitates the delimitation of territories. In addition, a line drawn to join pilot δ of different territories provides one with an additional stable reference parameter to determine the positions of different territories. This is diagramatically illustrated by a thick line in fig. 3.1 showing the δ distribution on the external surface of the tibia in Opisthopthalmus. The thick line drawn in fig. 3.1. acts as a reference parameter not only for territories esb, em, est and et but also for eb and the position of individual δ within all these territories. In all the species studied in this work, territory em is always positioned on the righthand side of the reference parameter line drawn in fig. 3.1 and em_1 never straddles this line.

While δ have proved to be of diagnostic significance in many taxa it must be borne in mind that trichobothriotaxy must be used with caution. The levels of significance vary from group to group of taxa and both intra and interspecific variation must be studied. In many cases the level of significance enables interspecific diagnoses but in others it does not, as reported in chapter 4 for the species of the genus Buthotus.

SETAE

The only other movable projections occurring on cuticular surfaces of scorpions are setae. These are classed into macrosetae, (setae forming the bulk of the vestiture), and microsetae. This classification is an arbitrary one and the main criterion is size. Macrosetae are robust, stiff, coloured and vary considerably in length and medial width ranging from long to short, squat, spine-like setae. Microsetae have small, fine whitish bristles attached to a poorly developed areolar cup. In all three kinds of setae, the shaft of the bristle is much thicker at the base than near the apex and the base almost completely fills the inner space of the areola; the shaft is stiff, brittle and readily breaks off.

The short, robuts, macrosetae occurring on the distal leg segments of some scorpions have in the past as well as in a few contemporary publications been described as spines. A similar situation prevails in taxonomic papers on Solifuges. In a paper on the taxonomy of this group (Lamoral, 1973: 85-86), I have pointed out that this practice should not be encouraged and preferably dropped altogether as there are very few true spines on scorpions. Most contemporary arachnologists use entomological terminology and never use the word spine when referring to strong setae. It is, however, quite acceptable to use the term "spine-like setae" when referring to the strong setae found on the appendages and body of scorpions. The difference between a spine and a seta is that a spine is an immovable cuticular process whereas a seta contains an extension of its underlying trichogen cell and is located in a basal socket formed by the termogen cells. All setae are linked to the cuticula by a membranous joint which allows movement to a greater or lesser extent, depending on their function.

The distribution and number of setae is of diagnostic importance in certain species of scorpions, but in most cases chaetotaxy is unreliable in taxonomy.

The presence of pads made up of numerous fine setae on the ventral surface of the tarsi of all legs and sweep-like rows of long stiff setae on the anterior and posterior edges of tibia, protarsi and tarsi of legs I and II, is a good indicator of a psammophile habit. Plates 3.5 and 3.6 picture such setae.

The number and distribution of the setae on the pedal spurs and the dorsal side of the pectines are usually fairly stable and do not exhibit much interspecific variation. In the few instances where they do they become significant diagnostic characters.

PARAXIAL ORGAN AND HEMISPERMATOPHORE

The male genital system has been described in various publications including Vachon (1952), Alexander (1957, 1959) and San Martin (1969). The terminology used to describe the various parts of the paraxial organ (Vachon & San Martin) or half spermatophore sac (Alexander) is basically that of Alexander (1957, 1959). Alexander's terminology for the hemispermatophore of Parabuthus and Opisthopthalmus was altered and added to by San Martin (mainly 1969) and is now applicable to other families. The terminology here used for the hemispermatophore is therefore basically that of San Martin, with admendments brought about by language differences, and with many additions necessitated by taxonomic differences. The terms used are illustrated in figs 3.3 to 3.6 and plate 3.7, and listed in table 3.3.

The paraxial organ exhibits a few characters which are diagnostic at family and sometimes generic level . The hemispermatophores, produced by and enclosed in the paraxial organs of sexually mature males prior to extrusion and mating, provide a far greater number of stable characters and parameters of diagnostic importance down to species level in many genera of scorpions of the Afrotropical faunal region. The relative importance and stability of intergeneric and interspecific characters used is discussed in context in chapter 4.

Two dissections are necessary to obtain a hemispermatophore.

These are not difficult but should be performed with great care in order to avoid mutilation, particularly when dealing with valuable material. Unless otherwise stated, all the paraxial organs and hemispermatophores illustrated come from the right hand side.

The first dissection consists of the removal of one of the two paraxial organs from the mesosomal cavity. First the lateral pleural membrane is cut open by a longitudinal incision starting at the level of tergite VI and ending approximately at the level of tergite I (see fig. 3.2). Lifting the dorsal integument then reveals the distal portion of the paraxial organ imbedded in, and on occasions partially obscured by, digestive glands (see fig. 3.2). Fig. 3.3. shows the position of the two paraxial organs in relation to body segmentation. Bearing in mind this configuration, the next step consists of freeing the paraxial organ from surrounding tissue, moving from the distal to the proximal end until the common chamber can be seen. The paraxial organ should then be cut off at its base, as close as possible to the common chamber and transferred immediately to a small dissecting dish containing a preserving fluid, preferably 70% ethanol, for subsequent dissection.

During the second dissection the tissues of the paraxial organ which enclose the sclerotised hemispermatophore are removed. This is best done by working with the two pairs of fine forceps and gently teasing and tearing the paraxial organ tissues apart, taking care not to damage delicate components. Once the hemispermatophore has been completely freed, it should at all times be kept in preserving fluid as dehydration leads to irreversible distortion. The dissected hemispermatophore should be stored in a micro-vial, preferably containing the specimen's accession number, and at all times kept in the same container as the specimen.

The hemispermatophores of Buthidae and Scorpionidae consists of three regions, basal, median and distal (see figs 3.4 to 3.6). The basal region comprises of the foot, its stalk and the basal portion (BP) which is long and slender in Buthidae but broad, thin and ventrally concave in Scorpionidae. The median region is composed of four lobes, basal (bl), Median (ml), outer (ol) and inner (il) (figs. 3.4 to 3.6). A survey of available literature shows that there is a difference in lobe terminology for some of the families. The differences appear to have originated from allocation of lobe terminology on a positional basis rather than from functional and histological homologies. This has given rise to a situation where the lobe bearing the hook (h) has been termed distal lobe in Bothriuridae by San Martin (1969, fig. 1) and Maury & San Martin (1973); internal and median lobe, in two different figures, in Scorpionidae by Vachon (1952, figs 484 and 485); median lobe by Vachon (1952, fig. 86) and by Maury (1969, fig. 7) in Buthidae. As pointed out by Alexander (1959), the anatomical details and functional aspects of scorpionid and buthid spermatophores differ greatly, but there is a basic similarity. While it might be implied that the similarities are a result of convergence, these similarities are, however, too great to substantiate such a hypothesis and it is more probable that the great dissimilarities are a result of extensive divergence from a plesiomorphic state, in which there was no rotation of the hemispermatophores during extrusion.

These considerations are undoubtedly the reasons for the difficulty experienced in homologising the lobes of the hemispermatophores of the scorpionids with those of the buthids. From the data so far obtained in another research project on spermatophore homologies in scorpion families, I have come to the following preliminary conclusions: (1) it is possible to homologise the various anatomical components of the spermatophores of buthids and scorpionids on the basis of functional, tissue and histological constituents; (2) the spermatophore of these two families are not the result of evolutionary convergence but rather of marked anatomical modifications of components caused by extensive divergence.

Examples of the application of these criteria to a few spermatophore characters are: the distal portions of the hemispermatophore, termed distal lamina (DL) in scorpionids and flagellum in buthids, are not homologous structures because the former is an extensive axial outgrowth of the hook-bearing median lobe (ml) while the latter is an outgrowth of the inner lobe (il) as illustrated in figs 3.4, 3.5.c and 3.6.a; the inner lobe (il) of buthids encapsulates the sperm mass and the lobe, performing the same function in scorpionids, is its homologue and should accordingly be termed inner lobe (see il, fig. 3.4) and not basal lobe as by Vachon (1952, fig. 485) for Scorpionidae and by Maury & San Martin (1973, fig. 3) for Bothriuridae.

The lobe terminology proposed and illustrated in this work is the result of deductions similar to those explained above and is derived from that used for the family Buthidae in the majority of existing publications.

The distal region of the hemispermatophore in Buthids is an extension of the inner lobe; it is long, whip-like and called flagellum; it is divided into three parts, pars recta (pr), pars reflecta (prf) and pars bireflecta (pbrf) (figs 3.5.c. and 3.5.d). The distal region in scorpionids is an extension of the median lobe and consists of a long, flattened and ventrally concave structure called the distal lamina (DL) which bears a proximal, lateral process known as the hook (h) (fig. 3.4).

The terms used in this text to describe positional aspects of the hemispermatophore refer to the normal position of the various surfaces inside the body cavity, prior to any dissection and removal. Thus, dorsal and ventral are the surfaces facing those respective regions of the body. Ectal refers to the surface or side normally facing the outer lateral region of the body, and ental, that facing the inner region.

The following are useful and stable parameters which in many cases serve as primary indicators of interspecific diagnostic differences in scorpionid hemispermatophores:

(1) ha - bsh distance as a percentage of ha - w distance, namely the distance between the hook apex (ha) and the basal scallop (bsh) as a percentage of the distance between the hook apex (ha) and the waist (w). This is calculated by the following formula:

$$\% \text{ ha} - \text{bsh} = \frac{\text{ha} - \text{bsh} \times 100}{\text{ha} - \text{w}}$$

(2) ha - w distance as a percentage of dcr - w distance, namely the distance between the hook apex (ha) and the waist (w) as a percentage of the distance between the distal crest (dcr) and the waist (w). This is calculated by the following formula:

$$\% \text{ ha} - \text{w} = \frac{\text{ha} - \text{w} \times 100}{\text{dcr} - \text{w}}$$

The symbols used in these two formulae are illustrated in fig. 3.4. Other similar formulae have occasionally proved to be useful diagnostic indicators within small groups of species and these are explained in their relevant context in chapter 4.

Several attempts were made to prepare hemispermatophores for study under a scanning electron microscope. Although this proved useful in the interpretation of anatomical homologies, it was found that, because of their very fragile nature, hemispermatophores require a great deal of care in their preparation, which is too time-consuming for diagnostic purposes. Plate 3.7 shows the result obtained from scanning an hemispermatophore.

MORPHOMETRIC CHARACTERS

Several of the diagnostic characters used consist of measurements, ratios, or percentages of measurements, or other mathematical combinations. Such measurements or mathematical combinations are supplied as the arithmetic mean of each set followed by the range in brackets; for example in *Uroplectes carinatus*, length/width ratio for cauda I 1,05 (1,0-1,10) in ♀. Frequency is determined by the number of specimens available for study of each species and is obtainable from the lists of material examined, in chapter 4.

In addition measurements of typical adult specimens are given for each species treated in chapter 4.

Fig. 3.7. a to d, illustrates the manner in which some of the key measurements were taken. The following is an expounded list of some of the main ratios used:

- Carapace ratios. Several of the ratios used are functions of carapace length. This is based on the positively tested assumption that carapace length is not subject to allometric growth discrepancies. It therefore seves as a stable character diagnostic of age. The absence of a regression in graphs plotting carapace length *versus* another measurement indicates that the other measurement is also not subject to allometric growth, thus confirming its diagnostic reliability.

  The following are often used (see fig. 3.7. b-c):

  $\frac{\text{lc}}{\text{x}}$ or $\frac{\text{lc}}{\text{y}}$; $\frac{\text{lc}}{\text{pwc}}$; $\frac{\text{pwc}}{\text{aw}}$; $\frac{\text{hcs}}{\text{lcs}}$ $\frac{\text{or width caudal segment}}{\text{lcs}}$ plotted against carapace length. $\frac{\text{width sternite V}}{\text{carapace length}}$ is a good indicator of comparative overall slenderness, often characterising intraspecific sexual dimorphism.

- Chela ratios (fig. 3.7.a). Ratio $\frac{lmf}{lhb}$ is an important diagnostic character as it is not affected by allometric growth. $\frac{lhb}{lch}$ and $\frac{whb}{lhb}$ are other useful ratios.
- Telson ratios (see fig. 3.7.d). The following are often used: $\frac{la}{lt}$ or $\frac{lv}{lt}$; $\frac{hv}{lv}$; and $\frac{\text{width vesicle}}{\text{height vesicle}}$
- Pecten ratio. $\frac{\text{pecten length}}{\text{dentate margin length}}$ is often a good indicator of intraspecific sexual dimorphism as well as interspecific diagnostic differences.

PHYSIOLOGICAL CHARACTERS

Electrophoresis of haemolymph

In working out the status of certain closely related taxa, the diagnostic importance of a large proportion of the key morphological characters studied tended to be only marginally significant. This inferred the possible occurrence of clinal variation, subspeciation, or sibling speciation. Series of electrophoretic analyses of the haemolymph proteins of such groups of species were therefore run in order to obtain additional diagnostically significant characters.

Methods

A combination of the methods described by Davis (1964) and Goyffon *et al.*(1970) for disc electrophoresis was employed with minor modifications in the composition of the stock and working solutions. Davis' (1964 : 410) polyacrylamide stock solutions (C) and (D) were prepared using 28,73 g and 10.0 g respectively of "Cyanogum 41" to 100 cc distilled water each. The working solutions were prepared as following:

Small pore pH 8,9	Large pore pH 6,7
1 part A	1 part B
1,75 parts C	2 parts D
1,25 parts dist. water	1 part E
4 parts ammonium persulfate (160 mg to 100 cc dist. water)	4 parts F

The small pore solution was used for the running or migration gel and the large pore for the sample and spacer gels.

The sample gels were prepared as following:

- 5 µl of haemolymph was added to 400 µl of large pore gel in a small sample vial and mixed thoroughly.
- 200 µl of this solution was introduced into an electrophoresis tube thus giving a sample gel containing 2.5 µl of haemolymph.
- 200 µl of large pore was then added to the remaining portion in the small sample vial and the solution was again mixed thoroughly.
- 200 µl of this solution was introduced into an electrophoresis tube thus giving a sample gel containing 1,25 µl of haemolymph.

The sample gels were then polymerised under U.V. light for 30 minutes prior to adding the spacer gel.

This procedure ensured that each haemolymph sample yielded two sample gels of different concentrations. 12 tubes of gels with haemolymph and two blanks as controls were electrophoresed for about one hour per run. Altogether seven runs were made yielding a total of 84 electrophoresed gels. Details regarding the technique, apparatus, staining of electrophoresed gels and other aspects involved in the final production of phoregrams (or gels with stained protein bands) are given by Davis (1970).

The significant parameters derived from these phoregrams are: (1) the number of protein bands that have migrated away from the end of the spacer gel; (2) the rates of migration or Relative Mobility, generally abbreviated to R_M. R_M values are calculated as illustrated in text fig. 3.8. Thus the R_M for band 3 shown in this figure = $\frac{b}{a}$ = 0,64. The stained protein bands are numbered starting with the one showing greatest mobility, namely the one nearest to the migration or bromophenol blue front, as illustrated.

As pointed out by Goyffon et al. (1970) only the more mobile or fast protein fractions with a R_M greater than 0,35 are of diagnostic importance in scorpions.

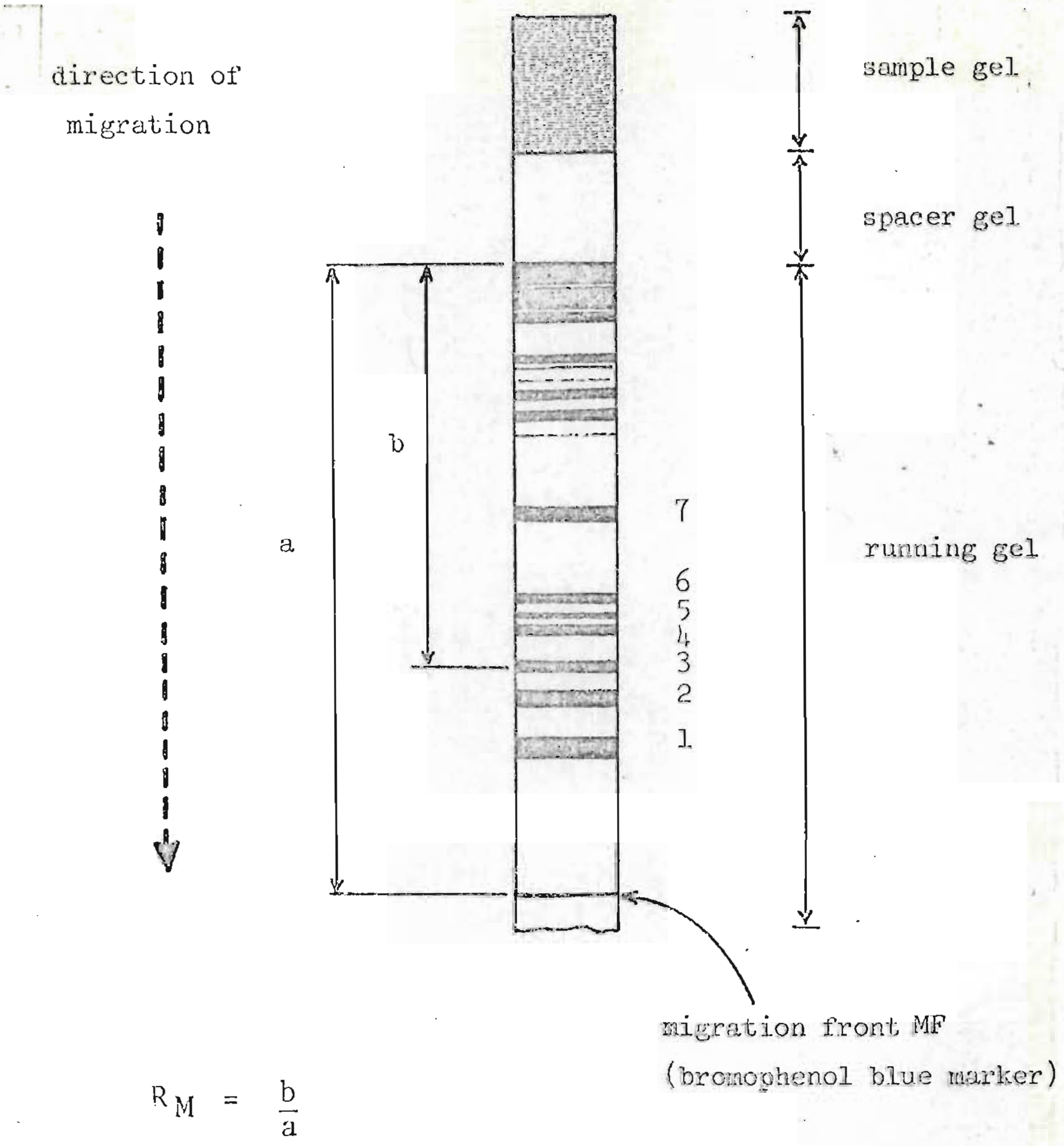


Fig. 3.8. Diagrammatic representation of a phoregram of Buthotus conspersus.

Each phoregram was densitometrically scanned using a "Variant Techtron UV-VIS" scanning spectrophotometer connected to a recorder. This yielded permanent graphic records of the number of bands, their photometric density and their migration rates. Such records also enable one to calcualte the R_M values more accurately. The graphic record obtained on scanning the phoregram of Buthotus conspersus illustrated in fig. 3.8, is shown in text fig. 3.9.

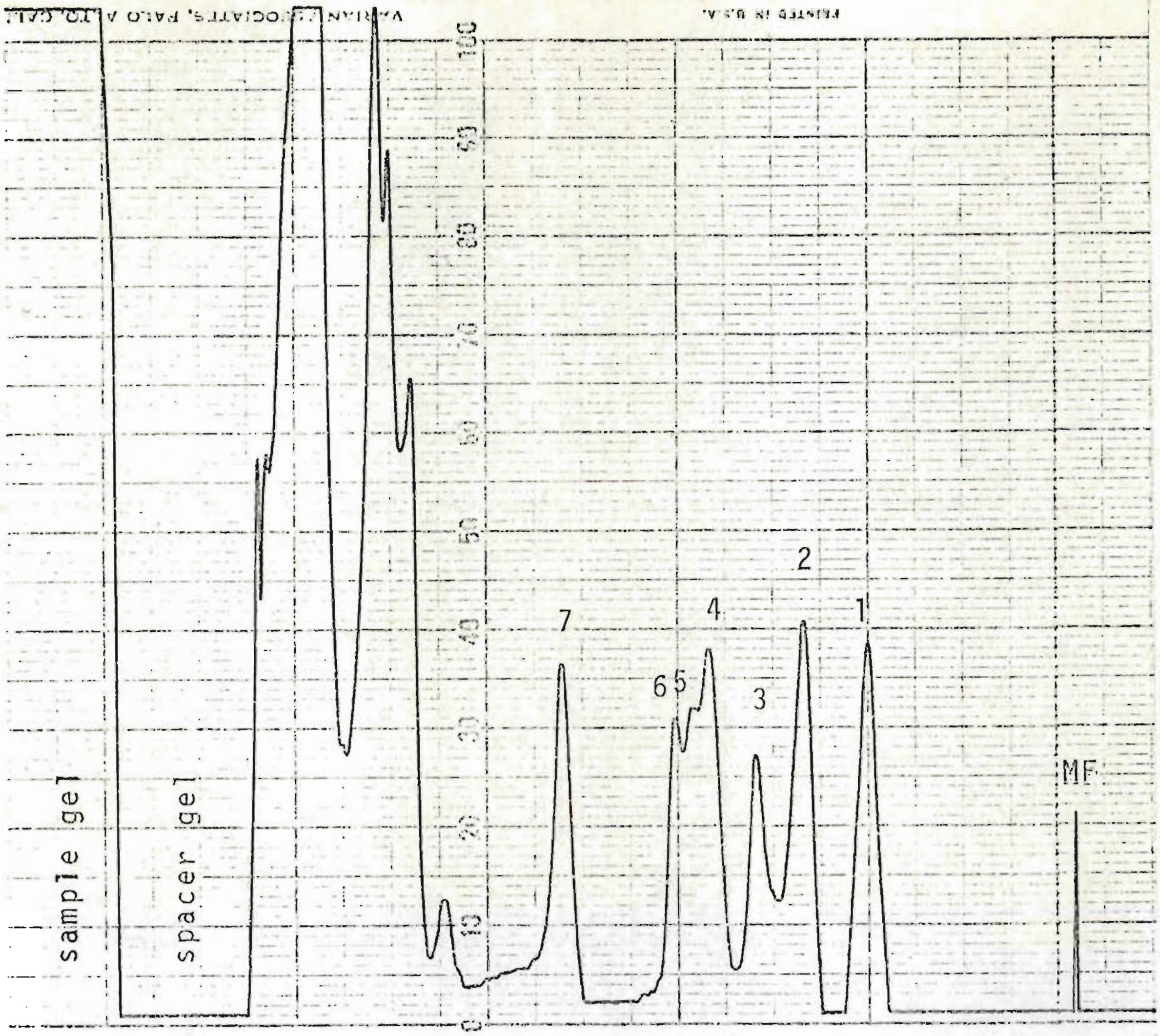


Fig. 3.9. Graphic record obtained on scanning the phoregram of *Buthotus conspersus* with a spectrophotometer.

Material

During the last field survey of South West Africa in 1976, 80% of the material required for the planned electrophoretic analyses of haemolymph was captured. However, three quarters of the specimens brought back were found dead or dying on the day after they had been settled in their vivaria in the laboratory, owing to the fact that the soil and sand supplied as substratum for the vivaria was contaminated with insecticide. The few specimens left available for electrophoreses left big gaps in the intended program.

CHAPTER 4

SYSTEMATICS

Key to families

1. Pedipalp tibia never with any ventral trichobothria (fig. 4.2.f); legs III and IV ventrally with a tibial spur (plate 3.6) between tibia and protarsus; arising from the ventral region of the intersegmental membrane between the protarsus and tarsus of each leg a pair of pale but dark-tipped spurs, the anterior of which is usually bifurcate (plate 3.6); hand round to ovoid in cross-section, usually very slender, very seldom with keels, its upper surface never separated by a distinct keel into inner and outer portion (except faintly so in Buthotus conspersus) ... ... Family BUTHIDAE

\- Pedipalp tibia always with from three to numerous ventral trichobothria (fig.3.7.e); legs III and IV without a tibial spur; only one spur (the anterior one) between protarsus and tarsus of each leg; hand large and flattened, higher than broad, with upper region usually divided longitudinally by a keel (finger keel) into distinct inner and outer portions ... ... Family SCORPIONIDAE

Family BUTHIDAE E. Simon, 1879

Subfamily BUTHINAE Kraepelin, 1899

Key to the South West African genera of Buthinae

1. Two teeth on ventral proximal margin of fixed finger of chelicerae (fig. 4.7.b); species usually large (adults 4-13 cm long) 2

- No such teeth; species usually small (adults up to 6 cm long) 3

2. Dorsal surface of caudal segments I, and to a lesser extent II, with a stridulatory area composed of fine to coarse granules, sometimes forming transverse ridges; abdominal tergites with one weakly developed median keel; carapace without keels ... ... Parabuthus

- Dorsal surface of caudal segments I and II without a stridulatory area; abdominal tergites with three well-marked longitudinal granular keels; carapace with conspicuously symmetrical granular keels ... ... Buthotus

3. Trichobothria Eb_3 of hand much smaller than Eb_2 or missing (fig. 4.10.a), d_2 of tibia (fig. 4.10.e) and femur (fig. 4.10.f) missing; granular rows of movable finger of pedipalp with an inner but no outer flanking series; size very small (adults not exceeding 2,3 cm in total body length) Karasbergia

- Trichobothria Eb_3 of hand only slightly reduced in size and always present; d_2 of tibia and femur always present; granular rows of movable finger of pedipalp with an inner and an outer flanking series; size small (adults up to 6 cm) Uroplectes

1. Genus Buthotus Vachon, 1949

Type species: Buthus judaicus E. Simon, 1872

Diagnosis

Vachon (1949: 143-145; 1952: 229-231; 1968: 891) diagnoses this genus in detail.

Distribution

See fig. 4.1

Key to the South West African species of *Buthotus*

1. Width/length of cauda I ratio 1,01 (0,95-1,05) for ♂; 1,08 (1,03-1,14) for ♀. (see fig. 4.5); ratio of $\frac{x}{y}$ (see fig. 4.3.a) 0,85 (0,80-0,90) in cauda V; area bounded by dorso-lateral and ventro-lateral keels of cauda V elongate subrectangular (see fig. 4.3.a); carapace length of adult ♂ 3,8 mm (3-4 mm), of ♀ 4,4 mm (3,4-5,2 mm) ...... *arenaceus* (Purcell)

\- Width/length of cauda I ratio 1,31 (1,22-1,42) for ♂, 1,37 (1,28-1,47) for ♀ (see fig. 4.5); ratio of $\frac{x}{y}$ (see fig. 4.3.b) 1,15 (1,10-1,20) in cauda V; area bounded by dorso-lateral and ventro-lateral keels of cauda V elongate sub-oval (see fig. 4.3.b); carapace length of adult ♂ 5,3 mm (4-6,4 mm), of ♀ 6,1 mm (4,4-8,0) .... *conspersus* (Thorell)

Buthotus arenaceus (Purcell, 1901)

Figs 4.2, 4.3a, 4.4, 4.5, 4.6, 4.7 a-d; Plate 4.1.

Buthus arenaceus Purcell, 1901: 137-139

Diagnosis

Greatest body length of adult ♂ 3,2 cm (carapace 4 mm), of ♀ 4,3 cm (carapace 5,2 mm). Lateral keels of tergites always blackened, median keels only faintly blackened in specimens just south and north of the Orange River, but with pronounced blackening in populations further to the north. Specimens from latter with overall darker colouration and blackening of all keels on body and appendages, except for a distinct pale yellow halo around the base of each trichobothrium on the pedipalps. Most closely related to B. conspersus but is distinguished from it by the following characters: dorso- and ventro-lateral keels of cauda V almost parallel to each other along their entire lenght; median cross-section of cauda V subtrapezoidal in shape with the long base on the ventral side (fig. 4.3.a); ratio of width over length of cauda I almost equal to 1.

Description

The following supplements Purcell's (1901: 137-139) original description which was based on a single ♀.

Sexual dimorphism:

Males differing very little from females except in: average total body length 25% shorter; more slender than females, mean ratio of width of sternite V over carapace length 1,17 in males and 1,32 in females; males 21 - 24 teeth per pecten , females 16 - 19.

Males and females:

Granulation: Overall granulation of body and appendages composed of very small and fine granules, giving a matt appearance; chelicerae agranular, smooth and shiny (fig. 4.7.a & b). Sternites III to VII ranging from densely and finely granular over the whole surface to sparsely granular and almost smmoth to shiny in some specimens, the latter conditions being more predominant in males. Prefemur to protarsus of legs I-IV with well-defined keels.

Colour: Overall fairly uniform moderate yellow No. 87 to dark orange yellow No. 72. Tergites as in fig. 4.7.c & d, with blackening of keels in specimens from localities further north, tergites with three keels distinctly blackened and a median transverse black marking on each side stretching from lateral keel to two thirds of distance to outer margin (fig. 4.7.d): postero-lateral margins of tergites and their submarginal granules also blackened. In specimens from northern areas, body and appendages slightly infuscated except for well defined clear halos around each trichobothrium. In B. conspersus haloed areas found in arenaceus are darkened, forming distinct dark spots around each trichobothrium.

Pedipalps: Keels weakly developed and distributed as in fig. 4.2.a-g. Cauda: Caudal keels moderately developed, slightly blackened in specimens from type locality, more strongly in populations further north. Cauda V and telson as in fig. 4.3.a. Ventral and lateral sides of telson vesicle with fewer granules than in conspersus. Telson vesicle proportionately smaller than conspersus (fig. 4.3). Cauda V with dorso- and ventro-lateral keels sub-parallel and median cross-section sub-trapezoidal with long base on ventral side, i.e. mean ratio of transverse median distances of dorso-lateral over ventro-lateral keels ($\frac{x}{y}$ in fig. 4.3.a) equal to 0,85 (range 0,8 - 0,9). These two form very good diagnostic characters. Cauda I with mean width/length ratio equal to 1,01 for ♂ (range 0,95 - 1,05, S D = 0,014), 1,08 for ♀ (range 1,03 - 1,14, S D = 0,02, see fig. 4.5). Fig. 4.4 reflects the actual measurements obtained from two samples of populations from different localities. 10 specimens of comparable size from Louwshoop and Schwarskuppen farms compared with topotypical material, for mean cauda I width/length ratio do not differ significantly at either the 0,1 or 0,5 levels (using Student's t-tests) and the slight differences in ratio are consistent with normal intraspecific variations. The absence of a regression in the values plotted in fig. 4.4 indicates that width/length ratios are not subject to allometric growth and that they represent a good diagnostic character. Figs 4.4 and 4.5 also show that there is a slight amount of sexual dimorphism in the values obtained for these ratios.

Lawrence (1927: 71) states that in *B. arenaceus* caudal segment V is not quite twice as long as I. Vachon and Stockman (1968: 136) used this information in their key to distinguish *arenaceus* and *conspersus* from *aeratus*. The ratio length cauda V/length cauda I in 30 specimens of *arenaceus* gave $\bar{x}$ = 2,18 range 2,05 - 2,33; in specimens collected near the Kunene River (the type locality of *aeratus*) $\bar{x}$ = 2,25 with range 2,17 - 2,40, while 10 specimens from mid-western S.W.A. (where the type of *conspersus* was collected $\bar{x}$ = 2,26 with range 2,17 - 2,37. The overlap indicates that the ratio lengths of cauda V/I is not diagnostic for any of the species of *Buthotus* from S.W.A.

Pectines: ♂21 - 24, ♀16 - 19 teeth per pecten

Trichobothria : As in figs 4.2 a-g. My observations on the distribution of ȯ in the two species occurring in S.W.A. confirm those of Vachon (1968: 83-84) for other species of the genus, namely that the number of ȯ is fixed and their distribution relatively constant and that there is virtually no interspecific difference of diagnostic importance.

In *B. arenaceus* ȯ db of the fixed finger can be distal, level with or exceptionally basal to est. Other ȯ of the hand also have a variable distribution but it is interesting to note that this variation occurs within a definite trichobothrial field and that it is always related and not random.

Paraxial organ: The structure of the paraxial organ and hemispermatophore in the genus *Buthotus* has very little diagnostic importance, the amount of variability being such as to bridge that existing between related species. I compared 20 hemispermatophores of the three southern African species *arenaceus*, *conspersus* and *trilineatus* (Peters, 1861) (the latter is a non-S.W. African species) and could find no single stable morphological feature of diagnostic importance. These studies revealed that the following are particularly variable: the size of the paraxial organ; the shape of the distal tip of the internal lobe, the relative position of the basal lobe and the length of the *pars reflexa* relative to the *pars recta* of the hemispermatophore. The *pars bireflexa* can be virtually absent, is of variable length and can be either straight or spiralled. Figs 4.7. f & e show a fairly typical paraxial organ, and a hemispermatophore of *B. conspersus* which is virtually the same as that of a *B. arenaceus*.

Variation

The number and distribution of the very fine granules on the sternites vary within single populations, while some males have almost smooth sternites. Males have 21-24 teeth and females 16-19 teeth on each pecten. Populations in the northern regions of the species range are darker than those in the south.

Measurements of larger topotypes (in mm)

♂. Carapace length 4,0, posterior width 4,2; length of handback: 2,5; of movable finger: 4,9; handback width: 1,4; length of caudal segments: I 2,0, II 2,5, III 2,7, IV 3,0, V 4, 3: of telson 4,6; widths of these segments 2,2, 1,9, 1,8, 1,8, 1,8, 1,8; total body length 34,6.

♀ Carapace length 5,2, posterior width 5,5; length of handback 2,9; of movable finger 5,9; handback width 1,7; lengths of caudal segments I 2,4, II 2,8, III 3,2, IV 3,6, V 5,2, of telson 5,5; width of these segments 2,7, 2,4, 2,2, 2,2, 2,2 2,2; total body length 42,0.

Location of type material

Purcell's ♀ holotype is deposited in the South African Museum (No. 2206) but it is in bad condition as it was allowed to dry and was badly damaged by mould which has destroyed all tissues, dismembered it and rendered the cuticle soft and translucent. As a result of this the type looks very much like a discarded exuvium. I was able to collect a small but good series of specimens from the type locality (29° 04' S, 18° 06' E, 21 km S.W. of Goodhouse, N. Cape, S. Africa) and a pair each of these topotypes has been deposited in the South African Museum, Transvaal Museum and Museum National d'Histoire naturelle Paris. The balance of the topotypes are in the Natal Museum collection (NM 10377).

Material examined

♀ holotype, 29° 04' S, 18° 06' E between Henkries and Wolftoon, Koa Valley northern Cape, S. Africa, February 1901, M. Schlechter (S.A.M., No. 2206). 8 ♂, 12♀ , 1 juv. ♀ , topotypes, 29-31 January 1973, B. Lamoral (N.M. 10377 5♂, 10♀) (S.A.M. 1♂ 1♀) (T.M. 1♂, 1♀) (M.H.N.P. 1♂ 1♀); 1♀, 29° 00' S 18° 13' E, ± 13 km South of Goodhouse, N.W. Cape, S. Africa, B. Lamoral (N.M. 10378); 1♀, Ai-Ais, no date, N. Hoon (S.M. 102); 3♂, 2♀, 3 km West of Rosh Pinah, 17 February 1973, B. Lamoral (N.M. 10369); 6♂, 14♀. Louwshoop farm, 3 February 1973, B. Lamoral (N.M. 10373); 7♂, 7♀, Schwarzkuppen farm, 8 February 1973, B. Lamoral (N.M. 10372); 1♀, 1♂ Belda farm, 28 January 1973, B. Lamoral (N.M. 10371 & 10370).

Distribution

As in fig. 4.6.

Bionomics

B. arenaceus is nocturnal. Most specimens were collected at night resting on raised sand surfaces at the base of small succulent shrubs such as *Euphorbia* and *Ruschia* spp., or slightly larger shrubs such as *Catophractes* and *Rhigozum* spp. in areas of vegetation types 3A and 9. Being such small scorpions it is virtually impossible to spot them at night with ordinary field light and all specimens caught were spotted by using ultra-violet light. No specimens were ever found under rocks on sandy surfaces. Specimens caught, marked and replaced where they had been found at night were dug out the following day from shallow burrows (6-10 cm deep) around the base of the shrubs referred to above. The entrances to these burrows were in each case impossible to detect as they were closed up with sand. Further tracking of marked specimens indicated that females are fairly sedentary, having been recaptured under the same shrubs on three consecutive nights, whereas males move about more since no specimens were ever recaptured under the same shrub.

Remarks

In their revision of the genus *Buthotus*, Vachon & Stockmann, 1968: 97-99, described, figured (fig. 15) and accepted Lawrence's determination of a ♀ specimen from the Natal Museum collection (N.M. 9045) as *Buthotus arenaceus* collected from the Brandberg Mountains in S.W. Africa. Re-examination of the specimen in the course of the present study has revealed that it is a typical example of *B. conspersus* (Thorell) and in the ensuing treatment of this species I have selected it as a homotype of Thorell's type.

Buthotus conspersus (Thorell, 1877)

Figs. 4.3.b, 4.4, 4.5, 4.6, 4.7 e-f, 4.8, text fig. 4.9;
Plates 4.2, 4.3, 4.4;
Table 4.1

Buthus conspersus Thorell, 1877; 41-44.

Synonyms

Buthus angolensis Monard, 1930: 38; see Vachon & Stockmann, 1968: 94.

Buthus conspersus aeratus Lawrence, 1927: 69; NEW SYNONYM. Lawrence originally described aeratus as a subspecies but raised its status to species level (1955: 207). Vachon & Stockman (1968: 94) followed suit.

Remarks

Vachon & Stockmann (1968: 96) state that the taxonomic history of Buthotus conspersus is complex. This is largely due to the fact that Thorell's type had until now remained undetected through mislabelling and thus unavailable. The problems of synonymy have now been resolved and there is no doubt that the following species listed by Vachon & Stockman are valid: conspersus, polystictus (Pocock, 1896) and trilineatus (Peters, 1861). Vachon and Stockmann accept the validity of B. emini (Pocock, 1890). My own findings on material from Zaire (ex Belgian Congo) and Tanzania have led me to the preliminary conclusion that emini is conspecific with trilineatus.

Diagnosis

Greatest body length of adult ♂ 5,5 cm (carapace 6,4 mm) of ♀ 6,2 cm (carapace 8 mm). For size range of adults see fig. 4.5. Most diagnostic characters subject to some clinal variation. Tergites I to VI with five distinct longitudinal black markings confined to posterior half of tergites in specimens from southern regions of range but spread into distinct bands almost extending from anterior to posterior margins of each tergite in specimens from northern regions. Specimens from the latter larger, darker yellow to brown in overall colouration with cauda IV, V and telson darkening from brown to dark brown. Base of each trichobothrium on pedipalps always partly or completely encircled with a black spot instead of a clear halo as in arenaceus.

Most closely related to B. arenaceus but can be separated from it by the following combination of characters: dorso- and ventro-lateral keels of cauda V clearly diverging away from each other medially; median cross-section of cauda V sub-trapezoidal in outline with the long base on the dorsal side (fig. 4.3.b); mean ratio of width over length of cauda I equal to 1,34 for both sexes (range 1,22 - 1,47, see fig. 4.5).

Description

The following supplements Thorell's (1877: 41-44) original description which was based on a single ♀ .

Sexual dimorphism:

Males differing very little from females except in: total body length 15% shorter in adults; only slightly more slender than females, mean ratio sternite V width/carapace length 1,21 for ♂ and 1,25 for ♀: males 19-28 teeth per pecten and females 13-20.

Males and females:

Granulation: overall granulation of body and appendages composed of very small and fine granules, giving these surfaces a matt appearance. In most females from the northern region of the range sternites III - V tend to be smooth and shiny to only partially granular; chelicerae agranular, smooth and shiny, closely resembling those of arenaceus. Prefemur, tibia and metatarsus of leg I-IV with well defined keels.

Colour: Based on homotype but with variation in specimens from northern regions of range added between brackets. Overall colouration, fairly uniform dark orange yellow No. 72 (moderate yellowish brown No. 77 with cauda III-V turning gradually to moderate brown No. 58 and telson strong brown No. 55). All keels on body and appendages only faintly blackened, excepting carapace, median and lateral keels of tergites (these more pronounced in northern specimens). Tergites I to VI with five distinct longitudinal black markings confined to the posterior half of each tergite (spread into distinct bands almost extending from the anterior to the posterior margins of each tergite), legs I to IV lightly to moderately infuscated and motley. Base of each trichobothrium on pedipalps always partly or completely encircled with a black spot instead of a clear halo as in arenaceus.

Pedipalps: Keels of hand, tibia and femur well developed and composed of granules as large as the caudal keel ones. For distribution of pedipalp keels see figs. 4.8. a-e.

Cauda: Caudal keels well developed. Dorsal and dorso-lateral keels of cauda I-IV with an enlarged terminal tooth posteriorly. Ventral and ventro-lateral keels of cauda II-V sparsely blackened in southern and central regions, becoming continuously and boldly blackened in northern regions of the range. Keels of cauda I unblackened except for two dark small spots on ventrals. Cauda V and telson as in fig. 4.3.b and plate 4.4.b. Cauda V with dorso- and ventro-lateral keels clearly diverging away from each other medially (see fig. 4.3.b); median cross-section of cauda V sub-trapezoidal in outline with the long base on the dorsal side, i.e. mean ratio of transverse median distances of dorso-lateral over ventro-lateral keels ($\frac{x}{y}$ in fig. 4.3.b) 1,15 (range 1,10 - 1,20). Cauda I with mean width/length ratio 1,31 for ♂ (range 1,22 - 1,42, SD = 0,02), 1,37 for ♀ (range 1,28 - 1,47, SD = 0,014) fig. 4.5. Fig. 4.4 reflects the actual measurements obtained from three samples of populations from the southern, central and northern regions of the range. Eight specimens of comparable size from the Brandberg Mts region (the locality of the homotype and presumably not far from the type locality of <u>conspersus</u>) compared with eight specimens from Kaoko Otavi area (not far from the type locality of Lawrence's <u>aeratus</u>) for mean cauda I width/length ratio do not differ significantly at either the 0,1 or 0,5 levels (using Student's t-test). The slight differences in ratios (1,327 at Brandberg and 1,343 at Kaoko Otavi) are consistent with normal intra-population variations and do not support a specific or subspecific separation of northern specimens (<u>B</u>. <u>aeratus</u>) from the southern <u>B</u>. <u>conspersus</u>, but merely represent two opposites of a cline. The absence of a regression in the values plotted in fig. 4.4. indicates that width/length ratios are not subject to allometric growth and that they represent a good diagnostic character. Figs 4.4 and 4.5 also show that there is slight sexual dimorphism in the values obtained for these ratios.

Lawrence (1927: 71) stated that cauda V in <u>B</u>. <u>aeratus</u> "is more than twice the length of I, while in the other two forms it is not quite twice as long". I have shown in the section dealing with the cauda of

B. arenaceus that length of cauda V/cauda I is not diagnostic for any of the species of Buthotus from South West Africa.

Trichobothria: As in fig. 4.8.a-e. Also see ♂ section of B. arenaceus.

Paraxial organ: As in figs 4.7.e-f. Also see paraxial organ section of B. arenaceus.

Pectines: Males 19-28 teeth and females 13-20 teeth per pecten In the southern regions of the species range, the number of teeth per pecten is usually 19-21 for males and 13-15 for females while in the northern regions it is 24-26 for males and 18-20 for females. In all the areas between these two regions the number of pectinal teeth fluctuates gradually with no evidence of discontinuities that might suggest that we are dealing with different subspecies. To retain aeratus as a subspecies of conspersus on the basis of a difference in the number of pectinal teeth is therefore not warranted.

In the list of "material examined" given below localities listed under (i) are from the southern regions, (ii) and (iii) from intermediary regions and (iv) from the northern and north-eastern regions of the species range in S.W. Africa. In specimens listed under (ii) and (iii) the number of teeth per pecten fluctuates from 21-24 in males and 15-19 in females.

Electrophoresis of haemolymph

Four samples of haemolymph were drawn from specimens (2 ♂ and 2 ♀) collected at each of four different localities selected so as to represent a transect through the north-south distribution of B. conspersus. From these 16 phoregrams were obtained. The four localities are: (1) farm Narib 4, Maltahöhe district (one of the more southern localities recorded); (2) farm Vrede 719, Damaraland (just south of the central transition region of the species range); (3) Sesfontein, northern Damaraland, (in the middle of the central transition region of the species range); (4) Opuwa, central Kaokoland (north of the central transition region of the species range). Text fig. 4.9 shows a sample of each of the phoregrams obtained from specimens at each of these four different localities. The numbers below each phoregram refer to the above localities. There is no significant difference in the R_M of any of the protein bands in phoregrams from the four localities. Band 3 of locality (3) has a slightly lower R_m (0,63) than that for the other three localities (0,64). The absence of any significant difference again indicates that B. aeratus is conspecific with conspersus and that aeratus should not be allocated subspecific status.

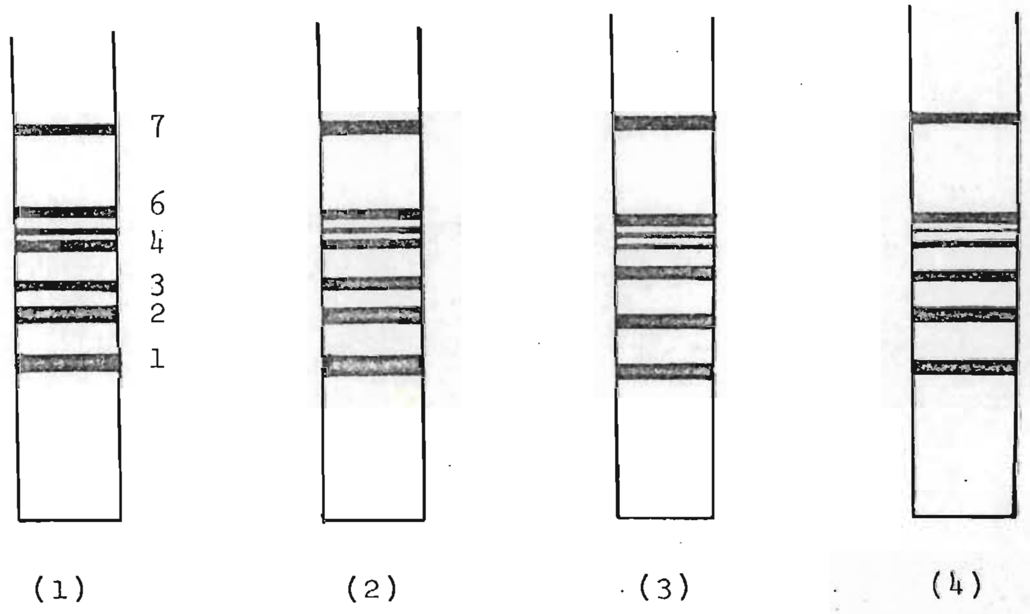


Fig. 4.9. Diagrammatic representation showing band distribution in phoregrams of B. conspersus from (1) farm Narib, (2) farm Vrede, (3) Sesfontein and (4) Opuwa. See text.

The significance of phoregrams as a diagnostic character in the genus Buthotus is discussed at length by Goyffon et al.(1973) who show that phoregrams from north African species and subspecies of Buthotus exhibit marked diagnostic differences in the R_M values of the bands of the different taxa.

In his work involving the use of phoregrams from taxa of the family Buthidae, Goyffon (1973) found that the phoregrams of all the species studied consistently contain a band with an R_M smaller than 0,45 which is absent in species of all other families. Goyffon accordingly labelled this band the "buthid band". Band 7 in phoregrams of B. conspersus is the buthid band and its R_M consistently worked out to a value of 0,39 for all the specimens tested.

Variation

Males have 19-29 teeth per pecten and females 13-20. The number and distribution of the very fine granules on the sternites are subject to variation within single populations while there is a tendency among many of the females in the northern regions of the range to have almost smooth and shiny sternites. Also see clinal variation in the diagnosis above. Populations in the northern regions of the species range are darker and larger than those in the south, this tendency being accentuated even more in specimens from Angola.

Measurements

See table 4.1. for measurements of holotype and homotype.

Location of type material.

Thorell's ♀ holotype is deposited in the Naturhistoriska Riksmuseet in Copenhagen, but was mislabelled and lost for many years.

On receiving my request for this type material, the Curator of the collection discovered a specimen labelled Buthus polystictus Pocock (not in Thorell's handwriting) together with a label identifying the collecting locality as "Caffraria" and the collector as "Wahlberg 1840-1845" and two other small labels bearing the numbers 148 and 16.

Thorell's type was collected by Wahlberg in 1840-1845 in South West Africa (= "Caffraria" of Wahlberg). The measurements of the specimen referred to above correspond very closely with those given for the type of B. conspersus by Thorell (see table 4.1), and the morphological characters agree very well with his description. On these grounds there can be little doubt that the specimen is in fact Thorell's type. It agrees very well also with material I have studied from the Brandberg Mountains, and accordingly I have selected a ♀ from this locality (N M 9045) in the Natal Museum Collection as Homotype. It also seems reasonable on the basis of the above to assume that the type locality of conspersus is south of the Brandberg Mountains.

Material examined

♀ holotype, Caffraria, 1840-45, J.A. Wahlberg (Naturhistoriska Riksmuseets Copenhagen, Entomologiska Afdeling no. 148/16).

(i)

1 ♀ , Brandberg-Numas Vallei, 2 August 1970, C.G. Coetzee (S.M.N. 99); 1 ♀ , 2 juveniles ♂, Farm Sesriem, June 1973, G. Sander (N.M. 10379); 1♂ Brandberg Numaskloof, 16 August 1969, P. Buys (N.M. 10411); 1♀ , Torrabaai, November 1961, W. Steyn (S.M.N. 169); 1 juvenile ♀ , Northern valley, Brandberg Mts., 20 February 1969, B. Lamoral and R. Day (N.M. 10016); 1♂ Klein Spitzkoppe farm, F. Gaerdes (N.M. 10408); 1♀ subadult, 1 juvenile ♀ , Brandberg, Numaskloof, 16 August 1969, P. Buys (S.M.N. 96); 1 ♀ Brandberg, June 1963, F. Gaerdes (N.M. 9045); 2♂, 7♀, from Narib 4, 9 March 1976, B. Lamoral (N.M. 10844);

(ii)

1♀ Onguati, 24 February, 1962, E. von Koenen, (S.M.N. 110); 1♂, Hoas 273, 11 May 1973, M-L. Penrith & J. Tebje (S.M.N. 444); 1♂, 3♀ , 1♂ subadult, Annabis farm, 24-25 February 1969, B. Lamoral & R. Day (N.M. 10020); 2♂ 1♀ subadult, Khorixas (formerly Welwitchia), August 1960, F. Gaerdes (N.M. 7322);

(iii)

1♀, Ugab River Bridge, 21 February 1969, B. Lamoral & R. Day, (N.M. 10021); 1♂, Otjitundua, 28 November 1970, (S.M.N. 210); 1♀ subadult, Marienfluss, 2-3 km S. Otjinungwa, 22 November 1970, E. Motgoabone (S.M.N. 224); 1♂, Onverwag 412, 8 May 1973, M-L. Penrith, (S.M.N. 445); 1♀ , Otjinungwa, N. Kaokoveld, 22 Nov. 1970, P.G. Olivier (S.M.N. 234); 6♂, 11♀ , farm Vrede 719, 31 March 1976, B. Lamoral (N.M. 10843);

(iv)

1♀, farm Tsuwandes 107, April 1973, G. Sander (N.M. 10376); 7♂, 7♀, 1 juvenile ♀ , Kaoko Otavi, Rocky Hill, 27 November 1970, J. Batista, E. Motgoabone (S.M.N. 203); 1♀, 4♂ subadults, 3 juveniles ♀ , Ondarusu, 23-25 August 1973, J B E M. (S.M.N. 473); 1♀, Ondarusu Falls, Kaokoveld 18 October 1971, M.J. Penrith, (S.M.N. 447); 1♂, 2♀, Ondarusu Falls, Kaokoveld, 18 October 1971, M.J. Penrith, (S.M.N. 447); 1♂, 2♀ , Ondarusu Falls, Kaokoveld, 18 October 1971, M.J. Penrith, (S.M.N. 448); 1♂, 8 km NE Omatjenguna, 24 November 1970, P.G. Olivier (S.M.N. 228); 1♂, 1♀ subadult, Orupembe 17 August 1973, J. Batiste & E. Mokgoabone, (N.M. 10410); 1♀ , 25 m S.W. of Orupembe Kaokoveld, 2 October 1965, P.S. Swart (S.M.N. 119); 1 juvenile ♂ Orumpembe = Anabib, 25 November 1970, P.O. Olivier (S.M.N. 244); 1♀ , 1 juvenile ♀ , W of Hartmansberge, 18 August 1973, (S.M.N. 462); 2♂, 2 subadults ♀ , Orupembe 17 August 1973, J.B.E.M. (S.M.N. 459); 1♂ juvenile 45 miles W. Ondarusu Falls, Kaokoveld, 26 October, 1971, M.J. Penrith, (S.M.N. 450); 1♀ subadult, N. of Orupembe, 18 August 1973, M-L. Penrith (S.M.N. 460); 1♂ juvenile, Otjinungwa, 22 November 1970, P.G. Olivier, (S.M.N. 251); 1♂, 1♀, Ondarusu, near Kunene River, 23-26 August 1973, J. Batista & E. Mokgoabone, (N.M. 10409); 1♀, 1♂ subadult, Ondarusu, 23-26 August 1973, J.B.E.M. (S.M.N. 472); 1♀ , 1♀ subadult, Ruacana, 26-27 August 1973, M-L. Penrith (S.M.N. 474); 1♂ Swartboys Drift, Kunene River, Dec-Feb., 1972 J. Menge (T.M. 10440); 1♀ , N. of Orupembe, 19 August 1973, E.M. (S.M.N. 466); 1♂, W. of Hartmansberge, 18 August 1973, M-L Penrith (S.M.N. 461); 1 juvenile ♀ , Okonjombo = now Nowantes, Kaokoveld, 26 November 1970, P.G. Olivier & E. Motgoabone (S.M.N.

255); 1♂ Otjinungwa, 21 November 1970, P.G. Olivier (S.M.N. 245); 3♀ , Kunene River, November 1960, F. Gaerdes, (N.M. 7327); 1♂, 1♀ Kaoko Otavi, Rocky Hill, 27 November 1970, J. Batista & E. Mokgoabone, (N.M. 10412); 6♂, 11♀ , 10 km W. of Sesfontein, 4 April 1976, B. Lamoral & L. Ferguson (N.M. 10841); 32♀ , 22♂, 3 km N. of Sesfontein, 3 April 1976, B. Lamoral & L. Ferguson (N.M. 10842).

Distribution.

The northernmost limit of the species range is central Angola. Fig. 4.6 shows the distribution in S.W. Africa.

Bionomics

B. conspersus is nocturnal, but specimens were occasionally seen moving about during daytime in the shade of trees in S.W. Africa. Most specimens captured in the southern and central region of the species range in S.W. Africa were found under large stones and boulders on sandy to sandy-loam soils in areas of vegetation types 1, 2 and 4. Further north, wherever these types of habitats are absent and the vegetation changes to type 5, specimens were usually found under the coarse bark of dead trees or under dead trees lying on the ground. Even further north, on the fringe of the Moçamedes desert in Angola, where the vegetation is transitional between types 1 and 5, most specimens were found under rocks, even though other potential microhabitats are available. This strongly suggests that rocks and boulders on the ground are preferred habitat and that dead trees are used as an alternative.

Discussion and conclusion

The differences previously used to separate *aeratus* from *conspersus* are unreliable because those differences are clinal and represent two opposites of such clines. The variation within these clines is gradual and there is no evidence anywhere within the species range of cline steps that may indicate that we are dealing with to subspecies. This leads to the conclusion that *aeratus* is a synonym of *conspersus*.

2. Genus *Karasbergia* Hewitt, 1913

Type species: *Karasbergia methueni* Hewitt, 1913

Diagnosis

At present monotypic, *Karasbergia* can be separated from all other genera of the family Buthidae by the following combination of characters: sternum subpentagonal in outline (fig. 4.11.a); antero-lateral margins of carapace on either side predominantly with two lateral eyes in adults but a third smaller eye occasionally present (fig. 4.10.g); distal end of hemispermatophore of male with a pars recta to flagellum but no pars reflecta (fig. 4.11.e and f); $\phi\ d_2$ of femur and tibia missing (fig. 4.10.e and f); male genital aperture without genital papillae; granular rows of movable finger of pedipalp chela with an inner but no outer flanking series; size very small, adults not exceeding 2,3 cm in total body length.

In addition there are no teeth on the ventral proximal margin of the fixed finger of chelicera, this character being found only in species of the genus *Uroplectes* in subfamily Buthinae. Dorsal and lateral surfaces of leg I-IV, pedipalp tibia and hand without keels.

Distribution

To date recorded only from localities between 25° and 29° S latitude in South West Africa and North Western Cape Province of South Africa. The eastermost record is along 21°E longitude. *Karasbergia* is therefore predominantly endemic to the South central regions of South West Africa.

Karasbergia methueni Hewitt, 1913

Figs 4.10, 4.11
Plates 4.5 to 4.8

Karasbergia methueni Hewitt, 1913: 148-149

Diagnosis

See generic diagnosis above. In addition: ventral surface of cauda I-III with scattered granules bounded laterally and posteriorly by a

U-shaped row of larger crescent-like granules (fig. 4.11.c); dorsal and dorso-lateral keels of cauda I very poorly developed; keels of all other caudal segments absent; no subaculear tubercle ventrally on telson; sternum with subcordate basal pit and no median furrow.

Description

The following account supplements Hewitt's (1913) original description which was based on three females. No males have been described prior to the present revision.

Sexual dimorphism:

Male genital aperture without genital papillae. The total absence of genital papillae is a rare occurrence in scorpions and this represents the first such recorded case among species of the Afrotropical faunal region. Due to the absence of genital papillae, previous workers experienced great difficulties in sexing adult specimens. Specimens can be sexed through the use of the following key:

1. Pectinal teeth 14-16 per pecten; caudal segment length/carapace length ratios 0,60 for cauda I, 0,68 for II, 0,72 for III, 0,76 for IV, 0,80 for V; width sternite V/carapace length ratio 1,0 .... MALES

\- Pectinal teeth 11-13 per pecten; caudal segment length/carapace length ratios 0,48 for cauda I, 0,56 for II, 0,60 for III, 0,64 for IV, 0,68 for V; width sternite V/carapace length ratio 1,40 .... FEMALES

In addition, in adults, males differ from females in the following characters: ♂ cauda longer and more slender; ♂ total body length subequal; ♂ pedipalp hand more slender (see fig. 4.11.b) with mean ratios of hand width/carapace length 0,30 for ♂ and 0,40 for ♀, representing a difference of 25%; ♂ carapace and tergites more heavily granular than ♀; sternites III to VI with very fine and scattered granules near lateral border in ♂, completely smooth and shiny in ♀; sternite VII granular over whole surface in ♂, over posterior two thirds in ♀.

Males and females:

Cauda: Dorsal surface of cauda I and II without a stridulatory area; lateral surfaces of cauda II-V, ventral surfaces of cauda IV-V and telson vesicle, punctate (see fig. 4.11.c and plate 4.5) with a very short microseta, averaging about 50μ in length, arising out of each punctation. Anal arch of cauda V as in fig. 4.11.c.

Legs: Tarsus lateral claws long (about half of tarsus length) with angle of curvature not exceeding 90°; lateral lobes greatly reduced and truncated, median lobe very short (about one tenth of tarsus length) and squat. Legs III and IV long, as long as length of cauda I-V; legs I and II one third and half of caudal length respectively.

Pectines: 3 marginal lamellae; 5 middle lamellae, proximal two rectangular, distal three ovoid to round in shape; fulcra present; pectinal teeth 14-16 per pecten in ♂, 11-13 in ♀.

Sternum: As in fig. 4.11.a.

Setation: Whole of body and appendages almost apilose, except for sparse vestiture of fine setae on ventral surface of protarsi and tarsi of all legs and microsetae arising out of punctations of the cauda described above. Three specimens (1 ♀, 2 ♂, N.M. 10919) from Springbok Vlaktes in the Richtersveld in the north western Cape and 1 ♂ (N.M. 10920) from Ai Ais in the southwestern part of South West Africa have strikingly pilose cauda and telson (see plate 4.6). The numerous fine setae present on these segments are long (1 mm) and inserted in the shallow punctations described above, replacing the microsetae typical of all other specimens of *K. methueni*

Trichobothria: As in figs 4.10.a to f. (-) neobothriotaxic for group A with d_2 of femur and tibia missing. Vachon (1973: 910) reports the absence of ȯ Eb_3 on the pedipalp hand. Examination of all available material has revealed that Eb_3 is present (see plate 4.7) but that its areola is extreme small, smaller than that of Esb, and its trichium very short, making this ȯ difficult to find other than under high magnification. In a few specimens, Eb_3 is absent (see plate 4.8) on one chela, but usually present on the other. In all the scorpions of the family Buthidae I have examined, ȯ it of fixed finger occupies a relatively distal position, but in *K. methueni* it is almost median (see fig. 4.10.c) and this represents the most basal position observed in Buthidae.

Paraxial organ and hemispermatophore: See figs 4.11.d - f and diagnosis.

Variation

Hewitt's types came from the central parts of the known species range and the following variation should be taken into account when examining material from other parts of the range: U-shaped rows of crescent-like granules on lateral and posterior margins of ventral surfaces of cauda I-III very poorly developed, and occasionally almost totally absent on cauda I in some specimens, and scattered granules on ventral surfaces of these segments usually similarly reduced; number and distribution of punctations found on lateral surfaces of cauda II-V and ventral surfaces of IV-V and telson vesicle subject to local variations ranging from numerous to very few. The most important variation encountered is in the occurrence of a strikingly pilose cauda (plate 4.6) described under the section on setae above for four specimens (N.M. 10919 and 10920) from the Richtersveld and Ai Ais. Another specimen from Ai Ais (1 ♀ S.A.I.M.R.) does not have this striking pilosity and the caudal segments have the normal vestiture described for typical forms. Were it not for this, one could speculate that specimens from Ai Ais and the Richtersvelt are possibly samples of populations deserving separate species status. Only access to new material from intermediate and marginal localities along the Fish River and between Ai Ais and the Richtersvelt will elucidate this striking variation.

Measurements

See figs 4.10, 4.11, plates 4.5 and 4.6.

Type material

Hewitt described <u>K. methueni</u> from 3 ♀ (1038, 1039, 1041) deposited in the Transvaal Museum. 1039 is missing from the type collection of this institution. The remaining two specimens have been allocated the following new numbers since Hewitt's description. TM 1869 (ex 1038) and 1070 (ex 1041).

Hewitt's specimens were syntypes as he did not designate a holotype. Specimen TM 1870 (ex 1041) is hereby selected as the LECTOTYPE of <u>Karasbergia</u> <u>methueni</u> and TM 1869 (ex 1038) as the PARALECTOTYPE. These specimens have been labelled accordingly.

Material examined.

♀ lectotype, Narudas Süd, no date, no collector's name (T.M. 1870 ex 1041); ♀ paralectotype, Kuibis (Quibis) no date, no collector's name (T.M. 1869, ex 1038). 1♀, Arigap river, September 1925, K.H. Barnard (N.M. 9968); 1 ♂, Upington, January 1956, no collector's name, (S.A.I.M.R. 858); 18 ♂, Tses, 24 February 1973, B. Lamoral (N.M. 10566); 7 ♂, 1♀, Aar, 29 Feburary 1976, B. Lamoral (N.M. 10893); 3♀, 6 ♂, Narudas Süd, 23 February 1976, B. Lamoral (N.M. 10890); 3♀, 6 ♂, Narudas Süd, 22 February 1976, B. Lamoral (N.M. 10889); 5♀, 15 ♂, Vredenhof 301, 21 February 1976, B. Lamoral (N.M. 10888); 1 ♂, 1♀, Vredenhof 301, id. (N.M; 10887); 2 ♂, Kuibis North 168, 28 February 1976, B. Lamoral (N.M. 10892); 2♀, 4 ♂, 10 km South of Berseba, 27 February 1976, B. Lamoral (N.M. 10891); 1♀, Blinkoog 30, 14 October 1970, J. Batista (S.M. N 370); 1♀ Blinkoog 30, 14 October 1971, no collector's name, (S.M. N 311); 1♀, Naus 27, 6 October 1972, H.C. Straus (S.M. N 389); 1♀, Ortmansbaum, 26 January 1973, B. Lamoral (N.M. 10567); 1♀ Ai Ais, 25 June 1974, J. Lensing (S.A.I.M.R. 868); 1 ♂, Ai Ais, 4 February 1973, B. Lamoral (N.M. 10920); 1♀, 2 ♂, Springbok Vlaktes, Richtersveld, 21 February 1973, B. Lamoral (N.M. 10919).

Distribution.

See distribution of genus.

Bionomics.

K. methueni is nocturnal. It is hemiedaphic and its habitat is infralapidicolous in regions of hard and gritty soils in areas of vegetation type 9 and the eastern fringe of 3A. It has never been found on sandy substrata within these areas and has not been observed to dig burrows or shallow scrapes in open ground. Because of its small size this species is almost impossible to spot with ordinary field lights; 95% of the specimens caught were spotted by using ultra-violet light. This explains the very low capture yield by previous workers and the paucity of material in the collections of research institutions. The larger ratio of males to females captured suggests that females are more sedentary than males. Courtship behaviour was observed in the field on three occasions and mating on one occasion. During the latter, the spermatophore was fastened to a horizontal rock slab. The overall behaviour was the same as that described for the genus _Parabuthus_ by Alexander (1959).

3. Genus Parabuthus Pocock, 1890

Type species: Androctonus liosoma Hemprich &
Ehrenberg, 1829

Diagnosis

Parabuthus is separated from the other genera of the family Buthidae by the following combination of characters: two teeth on ventral proximal margin of fixed finger of chelicerae; dorsal surface of cauda I, and to a lesser extent II, with a stridulatory area composed of fine to coarse granules, sometimes forming transverse ridges; tergites with one weakly developed median keel; carapace granulated but without keels; no subaculear tubercle on telson vesicle; anterior margin of carapace very slightly procurved and always with a very small median projection; distal end of hemispermatophore of male with a pars recta and pars reflecta to flagellum.

Distribution

Southern central, eastern and north-eastern Africa.

Key to the South West African species of Parabuthus

1. Cauda IV, dorsal keels obsolete to absent, lateral and ventral surface finely to coarsely granular and without distinct granular keels (see fig. 4.13) 2

\- Cauda IV, with 8 or 10 distinct granular to costate keels 5

2. Caudal segments, fig. 4.13.a: cauda V, distal half of ventro-lateral keels composed of distinctly lobate processes; cauda IV, antero-ventral margin demarcated by a transverse row of 5-6 strongly elevated, crescent-shaped tubercles; cauda II-III, distal section of

ventro-lateral keels and postero-ventral margin composed of strongly elevated crescent-shaped tubercles, forming a broad U-shaped pattern; cauda III, lateral and ventral intercarinal surfaces smooth and shiny. Pedipalp femur, fig. 4.12.e: ♂ d_2 on proximo-dorsal side of dorso-internal keel .... *brevimanus* (Thorell)

- Caudal segments, fig. 4.13. b-c: cauda V, distal half of ventro-lateral keels composed of weakly to well developed subspinose processes; cauda IV, antero-ventral margin either smooth or demarcated by a transverse row of isolated round granules; cauda II-III, without any crescent shaped tubercles on postero-ventral margins; cauda III, with at least distal one third of lateral and ventral intercarinal surfaces granular; Pedipalp femur, fig. 4.15.f: ♂ d_2 on proximo-internal side of dorso-internal keel 3

3. Caudal segments, fig. 4.13.b: cauda III-V, proximal one third of lateral and ventral surfaces smooth and shiny, antero-ventral margins smooth; cauda II-III, postero-ventral margins not demarcated by a transverse row of isolated round granules; cauda II-III, ventral and ventro-lateral keels costate; cauda I-II, lateral intercarinal surfaces lightly granular and shiny, ventral intercarinal surfaces smooth and shiny. Pedipalp femur, fig. 4.20.f: ♂ e_1, transversely halfway between d_4 and d_5; ♂ d_2 distal to i_1 .... *kuanyamarum* Monard

- Caudal segments, fig. 4.13.c: cauda III-V, lateral and ventral surfaces granular and matt, antero-ventral margins demarcated by a transverse row of isolated round granules; cauda II-III, postero-ventral margins demarcated by a distinct transverse row of isolated round granules; cauda II-III, ventral and ventro-lateral keels composed of isolated round granules; cauda I-II, lateral and ventral intercarinal surfaces granular and matt. Pedipalp femur, fig. 4.15.f: ó e_1 transversely either level with or distal to ó d_5; ó d_2 proximal to i_1 4

4. Pedipalp hand, fig. 4.15.a & b: movable finger length/handback length ratio 1,25 (1,17-1,33) for ♂, 1,55 (1,46-1,61) for ♀ ; ó Esb dorsal to Eb_2 - Et alignment. Pedipalp tibia, fig. 4.15.d: ó d_2 absent. Cauda I: width percentage of length 76 (74-77) for adult ♂, 82 (range 80-84) for adult ♀ . Sternum : greatest width/greatest length ratio 0,58 (0,55-0,60) for adult ♂ and ♀ . Pecten, fig. 4.14.1: first proximal middle lamella of ♀ distinctly enlarged and lobate; distal marginal lamella of ♂ and ♀ distinctly out of alignment with middle lamellae axis. Carapace length of adult ♂ 4,8 mm (4,2-5,2 mm), of adult ♀ 5,8 mm (5,1-6,0 mm) .... <u>new species A</u>

\- Pedipalp hand, fig. 4.23.a-b: movable finger length/handback length ratio 2 (1,93-2,08) for ♂ and ♀ ; ó Esb ventral to Eb_2-Et alignment. Pedipalp tibia, fig. 4.23.e: ó d_2 present and small. Cauda I: width percentage of length 91 (90-93) for adult ♂; 95 (94,0-96,5) for adult ♀ . Sternum: greatest width/length ratio 1,0 (0,97-1,04) for adult ♂ and ♀ . Pecten, fig. 4.14.j: first proximal middle lamella of ♀ truncate; distal marginal lamella of ♂ and ♀ in alignment with middle lamellae axis. Carapace length of adult ♂ 3,4 mm (3,2-3,6 mm), of adult ♀ 3,5 mm (3,3-3,8 mm) .... <u>new species C</u>

5. Cauda II, dorsal stridulatory area not reaching posterior margin 6

\- Cauda II, dorsal stridulatory area reaching posterior margin 10

6. Caudal segments, plates 4.13, 4.14: cauda IV, median lateral keel obsolete to absent; adult ♂ and ♀ telson width 67% (61-72%) of cauda V width; cauda V distal half of ventro-lateral keels with distinctly enlarged sub-lobate processes accessory dorsal crest absent. Pedipalp femur, fig. 4.16.e: δ d_2 on proximo-dorsal side of dorso-internal keel 7

\- Caudal segments: cauda IV, median lateral keel present and well developed; adult ♂ & ♀ , telson width percentage of cauda V width, not less than 75% and up to 101%; cauda V, distal half of ventro-lateral keels with moderately enlarged, laterally compressed sub-spinose processes, accessory dorsal crest present, composed of blunt to spiniform tubercles. Pedipalp femur: δ d_2 either on dorso-internal keel axis or on proximo-internal side of dorso-internal keel 8

7. Pedipalp chela, fig.4.16.a & b: movable finger length/handback length ratio 2,0 (1,95-2,05) for ♀, 1,55 (1,50-1,60) for ♂; δ db much closer to est than esb in ♀ , almost medial in ♂; δ dt distal to et; δ it level with second subterminal transverse row of enlarged teeth of dentate margin of fixed finger. Pedipalp tibia: fig. 4.16.d: δ et almost level with est; δ em much closer to est than esb_2. Pectines: ♀ 22-30 and ♂ 28-36 teeth per pecten. Tergites I-VI, median keels present .... <u>granulatus</u> (H.& E.)

\- Pedipalp chela, fig. 4.18. a & b: movable finger length/handback length ratio 1,60 (1,55-1,65) for ♀ , 1,15 (1,10-1,20) for ♂ ; δ db almost level with esb in ♀ & ♂; δ dt either closer to est than et or medial, but never level with et; δ it level with fourth subterminal transverse row of enlarged teeth of dentate margin of fixed finger. Pedipalp tibia, fig. 4.18.e: δ et distinctly distal to est;

ó em medial between est and esb$_2$. Pectines: ♀ 18-20 and ♂ 22-27 teeth per pecten. Tergites I-VI, median keels absent .... kalaharicus Lamoral

8. Caudal segments in adults, plate 4.30: cauda I-IV progressively decreasing in width, cauda IV 9% (8-10%) narrower than I; cauda I longer than wide, width percentage of length 97% (95-98%); cauda II-IV, dorsal aspect of dorsolateral keels subparallel; cauda I-III, distal granule of dorsal keel enlarged in ♀ and ♂; cauda I-V and telson, densely pillose. Pedipalp chela, fig. 4.27.a and b: ó eb distal to basal dentate margin of fixed finger .... villosus (Peters)

\- Caudal segments, in adults: cauda I-IV either all almost the same width or progressively increasing in width; cauda I wider than long, width percentage of length 113% (104-123%); cauda II-IV, dorsal aspect of dorsolateral keels convex; cauda I-III, distal granule of dorsal keel enlarged in ♂, seldom so in ♀ ; cauda I-V and telson sparsely pillose. Pedipalp chela: ó eb proximal to basal dentate margin of fixed finger 9

9. Caudal segments plate 4.25: cauda IV width percentage of length 93% (87-98%); cauda V in adults, ventral aspect of ventro-lateral keels subtrapezoidal, tapering anteriorly, anterior width 9% (3-15%) narrower than posterior width; cauda I-IV progressively increasing in width, cauda IV 14% (8-20%) wider than I; cauda II and III wider than long, width percentage of length 105% (103-107%); cauda II-III, distal granule of ventral and ventrolateral keels, distinctly enlarged, obtuse and elevated; cauda II and III, lateral and ventral

intercarinal surfaces slightly concave, sparsely granulated to smooth; adult ♂ and ♀ , telson width 94% (90-98%) of cauda V width; cauda V, dorso-lateral keel well developed throughout.
.... schlecteri Purcell

\- Caudal segments, plate 4.24: cauda IV, width perentage of length 73% (67-78%); cauda V in adults, ventral aspect of ventro-lateral keels subtrapezoidal, tapering posteriorly, posterior width 6% (3-10%) narrower than anterior width; cauda I-IV all almost the same width, cauda IV as wide as I, seldom slightly wider; cauda II and III narrower than long, width percentage of length 93% (90-97%); cauda II-III, distal granule of ventral and ventro-lateral keels, not enlarged and elevated: cauda II and III, lateral and ventral intercarinal surfaces flat, fairly densely and evenly granulated, never smooth; adult ♂ and ♀ , telson width 80% (75-85%) of cauda V width; cauda V, dorso-lateral keels almost obsolete medially .... raudus (E. Simon)

10\. Caudal segments: cauda I-V and telson, densely pilose; cauda IV, accesory dorsal crest present, composed of distinct, pointed tubercles. Colour: body, cauda and to a lesser extent appendages, always dark brown to brown black; pleural membranes dark greyish brown .... brachystylus Lawrence

\- Caudal segments: cauda I-V and telson, at most sparsely pilose; cauda IV, accessory dorsal crest absent. Colour: body, cauda I-III and appendages ranging from strong yellow to deep yellow brown; pleural membranes light yellowish brown 11

11. Pedipalp chela: movable finger length/handback length ratio less than 1,65 for ♀ and 1,30 for ♂ . Pedipalp tibia, δ esb_2 proximal, level or slightly distal to esb_1. Caudal segments: lateral and ventral intercarinal surfaces of cauda I-III and lateral surfaces of IV-V, smooth and shiny, rarely with a few scattered granules; cauda IV, median lateral keel poorly developed; cauda V, accessory dorsal crest obsolete to absent 12

\- Pedipalp chela: movable finger length/handback length ratio greater than 2,0 for ♀ , and 1,40 for ♂. Pedipalp tibia, δ esb_2 distinctly distal to esb_1. Caudal segments lateral and ventral intercarinal surfaces of cauda I-III and lateral surfaces of IV-V, matt, lightly to moderately and evenly granular; cauda IV, median lateral keel well developed; cauda V, accessory dorsal crest present, composed of distinct blunt tubercles 13

12. Caudal segments, plate 4.26-4.29: telson vesicle very distinctly and deeply excavated along longitudinal half of dorso-proximal surface; cauda II, plate 4.29, stridulatory surface composed largely of transverse ridges some of which, particularly in the posterior half, extend across the surface. Pedipalp chela, fig. 4.26.a-c: δ dt distal to et; δ db medial between esb and est. <u>stridulus</u> Hewitt

\- caudal segments, plate 4.20: telson vesicle shallowly excavated and not more so than in other species; cauda II, stridulatory surface composed largely of granules, occasionally including short transverse ridges posteriorly, none of which extend more than halfway across the surface. Pedipalp chela, fig. 4.21.a-b: δ dt proximal to or rarely level with et; δ db much closer to esb than est. .... laevifrons (E.Simon)

13. Caudal segments, plate 4.21: cauda I, antero-median surface of stridulatory patch gently inclined to the anterior descending portion; cauda II-IV, dorsal aspect of dorso-lateral keels subparallel, width percentage of length 67% (64-70%) for II, 63% (61-65%) for III, 54% (52-56%) for IV, giving the cauda a slender appearance; cauda IV, V and telson strongly infuscated. Pedipalp chela, fig. 4.22.a-c; δ eb level with or slightly distal to base of dentate margin. Pedipalp femur, fig. 4.22.g: δ d_2 on proximo-dorsal side of dorso-internal keel. Legs IV long and slender, reaching posterior end of cauda III. Pectinal teeth, ♀ 40-41, ♂ 42-47 per pecten .... new species B

\- Caudal segments, plate 4.17: cauda I, antero-median surface of stridulatory patch sharply inclined to the anterior descending portion; cauda II-IV, dorsal aspect of dorso-lateral keels convex, width percentage of length 93% (90-96%) for II, 88% (84-92%) for III, 81% (78-84%) for IV, giving the cauda a robust appearance; cauda IV, V and telson same colour as I & II. Pedipalp chela, fig. 4.19.a-b: δ eb proximal to base of dentate margin. Pedipalp femur, fig. 4.19.e: δ d_2 on proximo-internal side of dorso-internal keel. Legs IV, not reaching further than posterior end of cauda I. Pectinal teeth, ♀ 29-32, ♂ 33-36 teeth per pecten kraepelini Werner

Parabuthus brachystylus Lawrence 1928

see after P. villosus

Parabuthus brevimanus (Thorell, 1877)

Figs 4.12. 4.13.a, 4.14. a-c
Plates 4.9, 4.10

Buthus brevimanus Thorell, 1877: 110-113

Synonym

Parabuthus cristatus Pocock, 1901: 284-285; holotype ♀ (BM) from Zaïre (Congo). Seen. NEW SYNONYM.

Diagnosis

P. brevimanus is most closely related to P. kuanyamarum but can be separated from it and other species of the genus by the following combination of characters: Cauda, fig. 4.13.a: cauda V, distal half of ventrolateral keels composed of distinctly lobate processes; cauda IV, dorsal keels weakly developed to obsolete, lateral and ventral surfaces coarsely granular without longitudinal keels, antero-ventral margin demarcated by a transverse row of 5-6 strongly elevated crescent-shaped tubercles; cauda II-III, distal section of ventro-lateral keels and postero-ventral margin composed of strongly elevated crescent-shaped tubercles, forming a broad U-shaped pattern.

Description

The following account supplements Thorell's original comprehensive description, Purcell's (1901: 149-151) supplement, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionately smaller and more slender with width sternite V/carapace length ratios 1,10 (1,04-1,17) for ♂ and 1,40 (1,36-1,45) for ♀; ♂ pedipalp hand fingers shorter, handback wider and longer with movable finger length/handback length ratios 1,15 (1,05-1,23) for ♂ and 1,55 (1,48-1,61) for ♀ while mean chela length is only 3% less in ♂; lateral and ventral intercarinal surfaces of cauda I-III occasionally with few scattered granules in ♂; first proximal middle lamella of each pecten sub-triangular and truncate in ♂, sub-circular and lobate in ♀.

Males and females:

Cauda: See fig 4.13.a, plates 4.9 and 4.10. Dorsal surface of cauda I and II with well developed stridulatory areas composed of granules reaching the posterior margins.

Pectines: ♂ 28-32 and ♀ 21-25 teeth per pecten.

Trichobothria: See diagnosis and figs 4.12. a-e. Orthobothriotaxic for group A. Pedipalp hand: ȯ Esb dorsal to Eb_2 - Et alignment. Pedipalp femur, fig. 4.12.e: ȯ d_2 on proximo-dorsal side of dorso-internal keel: ȯ d_4 much closer to d_5 than to d_1; e_1 proximal to d_5; ȯ d_2 distal to i_1; ȯ d_3 closer to d_1 than d_4.

Paraxial organ and hemispermatophore: See figs 4.14.a-c. Hemispermatophore: pars reflecta about one third of hemispermatophore length; pars recta parallel to hemispermatophore axis; outer lobe rounded and not obtuse as in *P. new sp. A*; basal lobe shorter than median lobe.

Variation

Overall colouration fairly uniform strong yellow No. 84 and quite stable in most populations. Specimens from Karasberg Mountains, Namaland, Maltahöhe district, central Namib, Western Damaraland and Kaokoveld uniforml darker with following surfaces infuscated (deep yellowish brown No. 75): triangular area between lateral and median eyes and posterior margin of carapace; tergites I-VII; stridulatory regions of cauda I and II, ventral and lateral surfaces of cauda IV and V; dorsal keels, distal dorsal and external regions of pedipalp femur; dorsal, internal and external surfaces of prefemur and dorso internal surfaces of legs II-IV. Specimens from northern Kaokoland and south western Angola have better developed dorsal keels with a distal enlarged pointed spine in cauda I-IV and traces of an accessory dorsal keel in cauda V.

Measurements

See figures and plates.

Carapace length of adult ♂ 4,6 mm (14,0-4,8 mm), of adult ♀ 5,55 mm (5,2-5,7 mm). One of the smaller species of *Parabuthus*.

Type material

The type series consists of a ♀ and ♂ syntypes, no holotype having been designated. The ♀ is hereby selected as the LECTOTYPE of Parabuthus brevimanus and the ♂ as the PARALECTOTYPE. This material has been labelled accordingly and is deposited in the institutions listed under material examined.

Homotype

I have selected a ♀ homotype which is deposited in the Natal Museum collection (N.M. 10010).

Material examined

♀ lectotype, Southern Africa, 28 November 1864, Ch. Anderson (G.N.M.); ♂ paralectotype, Caffraria, 1840-1845, J.A. Wahlberg (N.R.5., Col. Thorell 38/8); ♀ homotype, Sandamap farm 13 February 1969, B. Lamoral & R. Day (N.M. 10010); 1 ♀ Gobabeb, January 1970, R. Jones (T.M. 9579); 2 ♀ 1 juvenile ♀ , Espinheira, 29 September 1969, C. Coetzee (S.M.N. 166); 23♂ , 4 ♀ , 10 juveniles, Kranzberg 59, 23 March 1976, B. Lamoral & L. Ferguson (N.M. 10819); 1♂ , Tinkas Mountains February 1972, B. Lamoral (N.M. 10367); 1♂ , Ortmansbaum farm, January 1973, B. Lamoral (N.M. 10366); 1♂ , Curocua, 19-21 October 1969, C. Coetzee (S.M.N. 162); 1♂ , Oncocua, 6-7 October 1969, J. Batista (S.M.N. 342); 1♂ , Otjangasemo, 10 November 1970, B.F. Kensley (S.M.N. 226); 1 ♀ , Hoas 273, 11 May 1973, M-L. Penrith, J. Tebje (S.M.N. 444); 1 juvenile ♂ , Otjitundua, 28 November 1970 (S.M.N. 210); 2♂ , Noachabeb, 6 February 1973, B. Lamoral (N.M. 10365); 1♂ , 2 juvenile ♂ , Sandamap farm, 13 February 1969, B. Lamoral & R. Day (N.M. 10930); 3♂ , 1♀, 1 juvenile ♀ , Springbokvlakte, 20-21 February 1973, B. Lamoral (N.M. 10442); 1♂ , Iona, 3 October 1969, C.G. Coetzee (S.M.N. 161); 1♂ , Ombombo, 23 August 1973, M-L. P., J.T. (S.M.N. 471); 1 ♀, Barby 26, 2-8 October 1972 (S.M.N. 392); 2 ♀ Bloedkoppie, 1-10 July 1970, Natal University students (S.M.N. 220); 1 ♀ , Marienfluss, 22 November 1970, E. Mokgoabone (S.M.N. 254); 1 ♀ , Koreangab Dam, 12 February 1971 (S.M.N. 270); 1 ♀ , Ovamboland, border, October 1961, P.J. Buys (S.M.N. 146); 2♂, Paulinenhof 72, 20-22 November 1972 (S.M.N. 403); 1 juvenile ♀, Warmquelle, 7 October 1968, P. Olivier (S.M.N. 118); 1♂, Sesriemfarm, June 1973, G. Sander (N.M. 10380); 1 ♀, Klein Karasburg, 10 February 1974, L. Wingate (N.M. 10547); 1♂, Palmfontein farm, 25 February 1969, B. Lamoral (N.M. 10009); 2♂, Omatjenguma, 25 November 1970, E. Mokgoabone (S.M.N. 223); 1 ♀, Swartboys Drift, December-February 1972, J. Menge (T.M. 10438); 1♂, Swartboys Drift, December-February 1972, J. Menge (T.M. 10439); 1♂, Huab 261, 29-30 November 1972, C.G. Coetzee (S.M.N. 415); 1♂ Annabis farm, 24-25 February 1969, B. Lamoral & R. Day, (N.M. 10008); 1♂, Khumib River, 2 February 1969, C.G. C. (S.M.N. 221); 3♂, Pastoril do Sul, 8-9 May 1974, M.J.P., M-L. P. (S.M.N. 522); 1 juvenile ♀, Orumana, 10 February 1975 (S.M.N. 594); 2♂, 1 ♀, Pastoril do Sul, 20-22 November 1974, M-L. P., E. Mokgoabone (S.M.N. 538); 1♂, Pastoril do Sul, 20-22 November 1974, M-L. P., E.M. (S.M.N. 533); 1♀ Kamombonde Oos 86, 5 January 1975 (S.M.N. 590); 1♂, Pastoril do Sul, 20-22 November 1974, M-L. P., E.M. (S.M.N. 534); 1♂, Orupembe, 9 July 1975, R.E. Griffin (S.M.N. 564); 1♂, 1♀, Messum Crater, 26 March 1976. B. Lamoral (N.M. 10847); 2♂, Huns 106, 29 September-4 October 1974, Museum staff (S.M.N. 524); 1♀, Okahandja, August 1960, F. Gaerdes (N.M. 7319); 1 juvenile ♀, Otjitambi, September 1960, F. Gaerdes (N.M. 7324); 1♀, Kunene River, November 1960, F. Gaerdes (N.M. 7326); 1♂, South West Africa (N.M. 10928). 1♂, Twyfelfontein, August 1966, F. Gaerdes (N.M. 9124); 1♂, Goodhouse, 30 January 1973, B. Lamoral (N.M. 10364); 1♂, 1 subadult ♂, Augrabies Falls, 4 April 1970, B. Lamoral (N.M. 10368); 1♀, 2♂, Narib 4, 9 March 1976, B. Lamoral (N.M. 10777); 1♂, 1♀ Kuibis North 168, 28 February 1976, B, Lamoral (N.M. 10781) ; 2 ♀, 7 ♂, 1 juvenile, Narudas Sud 268, 23 February 1976, B. Lamoral (N.M. 10769); 1 subadult ♀ Berseba, 28 February 1976, B. Lamoral (N.M. 10782); 1♂, 1♀, 2 juvenile ♂, Berseba, 24 February 1976, B. Lamoral (N.M. 10771); 2♂, 1 ♀, 2 juveniles, Bergkranz 370, 22 March 1976, B. Lamora L. Ferguson (N.M. 10851); 1♂, Pastoril do Sul, 20-22 November 1974, M-L. P., E. Mokgoabone (S.M.N. 536); 1 juvenile ♀, Excelsior 286, 26 January-2 February 1975 (S.M.N. 554); 1♂, Noordoewer, E. Griffin (S.M.N. 587); 1 subadult ♂, Ko528, 20-27 February 1975 (S.M.N. 562); 1♀, Rostock 393, 20-27 February 1975 (S.M.N. 563); 1 juvenile ♂, Ruacana, 26-27 August 1973, M-L. P. (S.M.N. 476); 1♀, Windhoek, 14 August 1973,

A. du Toit (S.M.N. 479); 1 subadult ♀, Kaoko Otavi, 22 August 1973, M-L.P. (S.M.N. 470); 1 juvenile ♀, Ondarusu Falls, 26 October 1971, M.J. Penrith (S.M.N. 449): 1♂, Brandkaros (N.M. 10937).

Distribution

North Western Cape Province, throughout South West Africa, southern and south-eastern Angola.

Bionomics

P. brevimanus is nocturnal, hemiedaphic and digs shallow burrows at the base of shrubs in sandy to consolidated sandy soils. A few specimens have occasionally been found in shallow scrapes under rocks. P. brevimanus has seldom been found in regions of hard and gritty soils. Sweep-like rows of long setae on the posterior edges of tibia, protarsi, and tarsi of legs I, II and to a lesser extent III indicate a semi-psammophilous adaptation. P. brevimanus is often sympatric with kuanyamarum, new sp. A and new sp. C all of which are fairly closely related.

Parabuthus new species A

Figs 4.15, 4.13.c, 4.14.g-h and k-l
Plates 4.11, 4.12

Diagnosis

This new species can be separated from other species of the genus by the following combination of characters. Cauda, fig. 4.13.c: cauda V, distal half of ventro-lateral keels composed of well developed, subspinose, non-lobate processes, antero-ventral margin demarcated by a transverse row of isolated, round, non crescent-shaped granules; cauda II-III, postero-ventral margins demarcated by a distinct transverse row of isolated, round granules; cauda II-III and to a lesser extent cauda I, ventral and ventro-lateral keels composed of isolated round granules; cauda I-III, lateral and ventral intercarinal surfaces granular and matt, dorsal keels poorly developed to obsolete; cauda IV, ventral and lateral surfaces granular and matt, no traces of any longitudinal keels. Sternum: greatest width/greatest length 0,58 (0,55-0,60) for adult ♂ and ♀. One of the smaller species of Parabuthus, it is most closely related to new sp. C. These two are in turn most closely related to the brevimanus-kuanyamarum group.

Description

The type series consists of females and males. The following description is based on the holotype ♀ , unless otherwise indicated, and supplements the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

Holotype and paratypes. In adults, males differ from females in the following characters: carapace width greater than length in ♂, subequal in ♀ , width/length ratio 1,13 (1,10-1,15) for ♂ and 1,01 (0,98-1,04) for ♀ ; telson vesicle proportionately smaller and more slender in males, lengths vesicle/aculeus ratio 1,25 (1,22-1,27) in ♂ and 1,5 (1,46-1,53) in ♀ , width cauda V/telson ratio 1,47 (1,45-1,50) in ♂ and 1,20 (1,17-1,22) in ♀ , while aculeus length is the same in both sexes; ♂ pedipalp hand fingers shorter, movable finger length/handback length ratio 1,25 for ♂ (1,17-1,33), 1,55 for ♀ (1,46-1,61); ♂ pedipalp handback length and width greater while mean chela length is only 4% less; first proximal middle lamella of each pecten sub-triangular and truncate in ♂, sub-circular and lobate in ♀ ; ♂ 28-33, ♀ 20-25 teeth per pecten.

Granulation: Cauda as in fig. 4.13.c and diagnosis. Following surfaces microscopically shagreened with overall unburnished appearance and few, scattered small granules: pedipalp hand and fingers; dorsal, external and ventral intercarinal surfaces of pedipalp tibia and femur; outer surfaces of prefemur I-IV. Following surfaces smooth and shiny: inner surfaces of prefemur I-IV; femur, tibia, protarsus, tarsus of legs I-IV. Middle and marginal lamellae of pectines punctate and shiny. Sternites III-VI, shallowly wrinkled to punctate in posterior half, otherwise smooth and shiny; sternite III with two medio-longitudinal rows of punctations; sternite VII sparsely punctate and granular, no traces of longitudinal keels. Carapace: coarsely granular, without distinct keels. Tergites I-VI, posterior half coarsely granular, anterior half finely granular, median keel present and well developed, no lateral keels; tergite VII, median and first lateral keels obsolete, second lateral keel present.

Colour: Overall, variably moderate yellowish brown No. 77, with tergites, carapace, distal half prefemur I-IV and external distal half pedipalp femur infuscated and darkly patterned as shown in plate 4.11.a-b; surface between lateral eyes and median eyes more darkly infuscated than rest of carapace, forming a dark triangle. Legs I-IV and distal half of pectines light yellow No. 86.

Cauda: Ventrally as in fig. 4.13.c. Stridulatory patch: cauda I narrow, consisting of fine granules reaching posterior margin; cauda II almost obsolete, barely reaching posterior margin. Cauda I: width percentage of length 76% (74-77%) for adult ♂; 82% (80-84%) for adult ♀.

Pectines: 22 and 23 teeth. Also see fig. 4.14.1. In paratypes, ♀ and ♂21-25 teeth per pecten. First proximal middle lamella of ♀ distinctly enlarged and lobate; distal marginal lamella of ♂ and ♀ distinctly out of alignment with middle lamellae axis.

Setation: Overall, moderately pilose as in P. *kuanyamarum*, varying as following. Pedipalp: hand and fingers, tibia, internal and external surfaces femur, ventral and internal surfaces trochanter and coxa with numerous short setae. Genital operculi, marginal and middle lamellae and fulcra of pectines with numerous short setae. Lateral and posterior margins sternites III-VI and anterior margin carapace with a row of short setae. Posterior edges tibia, protarsi and tarsi of legs I-III with a row of sweep-like long setae. Ventral surface tarsi I-IV with a poorly developed pad of setae. Inner surface chelicera hand and proximal region of fixed finger with a brush of short setae. Carapace, tergites and sternites apilose.

Trichobothria: See fig. 4.15. (-) neobothriotaxic for group A with d_2 of tibia missing. Pedipalp hand: δ Esb dorsal to Eb_2-Et alignment. Pedipalp femur, fig. 4,15, f: δ d_2 on proximo-internal side of dorso-internal keel; δ d_4 much closer to d_1 than to d_5; δ e_1 slightly distal to d_5; d_2 proximal to i_1; d_3 closer to d_1 than to d_4.

Paraxial organ: As for *P. brevimanus*. Hemispermatophore, figs 4.14.g-h: pars reflecta one third of hemispermatophore length; pars recta S-shaped and not parallel to hemispermatophore axis as in *P. brevimanus* and *kuanyamarum*; outer lobe obtuse; basal lobe longer than median lobe.

Variation

Mainly in the degree of infuscation. Specimens from Messum Crater and inland of Torra Bay (N.M. 10860) with infuscations described for the holotype. Specimens north of Cape Cross distinctly paler than holotype in overall colouration and infuscations only present on interocular surface and legs. Specimens from near Möwebaai distinctly paler than holotype in overall colouration (moderate yellow No. 87), without any infuscations on body and appendages but with cauda IV-V and telson lightly to moderately infuscated.

Measurements

See diagnosis, figures and plates.

Carapace length of adult ♂ 4,8 mm (4,2-5,2 mm), of adult ♀ 5,8 mm (5,1-6 mm).

Type material

Holotype and paratypes in Natal Museum collection. Paratypes from Messum Crater area (ex N.M. 10848) have been deposited in the following institutions: State Museum, Windhoek, S.W. Africa; Museum National d'Histoire naturelle, Paris, France: Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, United States.

Material examined

♀ holotype, Messum crater, 26 March 1976, B. Lamoral, L. Ferguson (N.M. 10925). Paratypes: 1 ♂, Messum crater, 26 March 1976, B. Lamoral, L. Ferguson (N.M. 10926); 8 ♂, 2 ♀, 4 juveniles, Messum Crater, 26 March 1976, B. Lamoral (N.M. 10848); 1 juvenile ♀, 1 subadult ♀, Möwebaai, 28 March 1976, B. Lamoral, L. Ferguson (N.M. 10857); 2♂, Cape Cross, 25 March 1976, B. Lamoral, L. Ferguson (N.M. 10854); 1 ♂, 1 juvenile ♂, Torra Bay, 30 March 1976, B. Lamoral, L. Ferguson (N.M. 10860); 3 ♂, 1 ♀, 4 juveniles, Möwebaai, 29 March 1976, B. Lamoral, L. Ferguson (N.M. 10859).

Distribution

Skeleton Coast, between Möwebaai and Cape Cross.

Bionomics

P. new sp. A is nocturnal, hemiedaphic and digs shallow burrows at the base of small, shrub-bearing dunes and under rocks on sandy to gritty plains (soil categories IV-V of table 2.2) in areas of vegetation type 1 such as shown in plate 2.9. Sweep-like rows of long setae on the posterior edges of tibia protarsi and tarsi of legs I, II and to a lesser extent III indicate a semi-psammophilous adaptation. P. brevimanus, a fairly closely related species, is sympatric with new sp. A in the Messum Crater area, but kuanyamarum and new sp. C are allopatric. Excepting the Messum Crater area, Uroplectes teretipes is sympatric with P. new sp. A in all the latter's recorded localities.

Parabuthus granulatus (Hemprich & Ehrenberg, 1828)

Fig. 4.16, 4.17

Plates 4.13, 4.14

Androctonus granulatus Hemprich & Ehrenberg, 1828: plate X1X, figs 3 & 4.

Synonyms

Buthus fulvipes E. Simon, 1887: 378-379; type ♀ , Kalahari (M.N.H.P., RS 0311). Seen. NEW SYNONYM . Parabuthus fulvipes; Kraepelin, 1899: 30.
Parabuthus granulatus fulvipes; Werner, 1936: 177-178.

Parabuthus granulatus bergeri Werner, 1916: 83-84; types 3 ♂ 4 ♀ , Berseba (N.M.W. 1046) and 1 ♂ 3 juveniles, Gochas/Haruchas (N.M.W. 1047), S.W.A. All seen. NEW SYNONYM .
Parabuthus bergeri; Werner, 1936: 178.

Parabuthus granulatus fuscus Pocock, 1901: 285; type ♀ , Kalahari (B.M. 1894.5.3.4). Seen. NEW SYNONYM .

Diagnosis

The following combination of characters separates P. granulatus from other species of the genus. Caudal segments, plates 4.13, 4.14: cauda IV, with 8 distinct granular keels, median lateral keel obsolete to absent, ventrals posteriorly obsolescent; cauda I, dorsal stridulatory area, narrow, reaching posterior margin in some populations; cauda II, dorsal stridulatory area narrow, poorly developed, and not reaching posterior margin; adult ♂ & ♀ , telson small, width 69% (65-72%) of cauda V width; cauda V, accessory dorsal crest absent, distal half of ventro-lateral keels composed of distinctly enlarged, sub-lobate processes.

Pedipalp chela, fig. 4.16.a & b: δ db much closer to est than esb in ♀, medial in ♂. Pedipalp femur, fig. 4.16.e: δ d_2 on proximo-dorsal side of dorso-internal keel; δ d_3 distinctly distal to d_2. One of the larger species of Parabuthus, it is most closely related to P. kalaharicus.

Description

Hemprich and Ehrenberg's original description is based on plate X1X, figs 3 & 4 published in 1828 and text published in 1831. I have seen the plates but not the text and have been unable to find page references to the text in any available reference catalogue. Purcell (1901: 168-173) has given a very comprehensive redescription of the species. The following account supplements Purcell's (1901: 168-173) comprehensive redescription, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionately smaller and slightly more slender with width sternite V/carapace length ratios 1,25 (1,19-1,29) for ♂ and 1,35 (1,30-1,41) for ♀; ♂ pedipalp hand fingers shorter, handback wider and longer with movable finger length/handback length ratios 1,50 (1,43-1,55) for ♂ and 2,00 (1,94-2,07) for ♀ while chela length is only 6% less in ♂; proximal dentate margin of fixed and movable fingers slightly emarginated in ♂ (not as distinctly as in P. kalaharicus), linear in ♀; ♂, with 28-35 and ♀ 24-32 teeth per pecten; first proximal middle lamella of each pecten supports 2-3 teeth in ♂, none in ♀; first proximal middle lamella of each pecten in ♂, sub-rectangular with mesial margin angular, in ♀ sub-oval with mesial margin arcuate (not enlarged and lobate).

Males and females:

Colour: See variation below.

Cauda: Mean width percentage of length for cauda I-V, 100, 92, 92, 73, 60, respectively.

Trichobothria : See diagnosis and figs 4.16.a-e. Orthobothriotaxic for group A.

Paraxial organ and hemispermatophore: As for species in couplets 6-9 of key and not differing diagnostically from any of these.

Variation

Referring to the regions arbitrarily delimited in fig. 4.17, the variation observed is as follows: Regions i, ii & iii: overall colour of body and pedipalps strong yellowish brown No. 74, legs dark orange yellow No. 72; ♂ with 30-32 and ♀ 25-28 teeth per pecten; granular keels of cauda I-V less well-developed than specimens from regions iv, v & vi. Region iv: overall colour of body and appendages much darker, ranging from dark brown No. 59 to dark olive brown No. 96 for body and pedipalps, and deep yellow brown No. 75 to light olive brown No. 94 for legs; in specimens from southern parts of this region pedipalps and legs much lighter in colour, tending towards deep yellow No. 85. Regions v and vi: overall colour of body and appendages lighter than in specimens from northern and central parts of region iv, more like that of specimens from southern parts of region iv.

Measurements

See figures and plates. Carapace length of adult ♂ 10 mm (9-11 mm), of adult ♀ 12 mm (10-14 mm).

Type material

Hemprich and Ehrenberg's unsexed holotype was presumed lost. It was rediscovered in the collection of the Zoologisches Museum Berlin, in east Berlin and found to be a male. It had originally been mounted dry on a pin but was reclaimed and transferred to alcohol. Its accession number is Z.M.B. 132.

Homotype

I have selected a ♂ homotype which is deposited in the Natal Museum collection (N.M. 10900).

Material examined

Male Holotype, Promont b.sp.(= abbreviation for promontorium bona spes - Mountain of Good Hope), no date Lichtenstein (Z.M.B. 132);

♂ homotype, Frischgewaagd, 20 March 1976, B. Lamoral. The roman numerals used below refer to material from the different regions in fig. 4.17.

(i)

1♀ , 1♂, Swartboys drift, December-February 1972, J Menge; (T.M. 10435-T.M. 10436); 1♂, Sesfontein, 4 April 1976, B. Lamoral, L. Ferguson (N.M. 10910); 1 subadult ♂, Sarusas, 6 October 1968, P. Olivier (S.M.N. 120); 1♀ Hartmanberge, 18 August 1973 (S.M.N. 463); 1 juvenile ♂, Ondarusu Falls, 17 October 1973, M.J.P., E.M. (S.M.N. 492); 1 subadult ♂, Otjinungwa, 19-21 August 1973, State Museum (S.M.N. 467); 1♂, Vrede 719, 31 March 1976, B. Lamoral, L. Ferguson (N.M. 10909); 1♀ , Vrede 719, 31 March 1976, B. Lamoral, L. Ferguson (N.M. 10899); 1♀ , Ohopoho, 7 February 1975, S. Enrödy Younga (T.M. 11098); 1♀ , Fazenda Valle, 28-29 November 1974, J.B. E.M. (S.M.N. 542); 1♂, Vrede 719, 31 March 1976, B. Lamoral, L. Ferguson (N.M. 10908); 1♂, Ombazu, 22 February 1973, J. Malan (S.M.N. 434); 1♀ Swartboys Drift, December-February 1972, J. Menger (T.M. 10437); 1♂, Vrede 719, 31 March 1976, B. Lamoral, L. Ferguson (N.M. 10905); 4♂, 5♀ , 9 juveniles, Vrede 719, 31 March 1976, B. Lamoral, L. Ferguson (N.M. 10836); 3♂, 1♀ , Sesfontein, 4 April 1976, B. Lamoral, L. Ferguson (N.M. 10835); 2♂, Okonjombo, 21 May 1963, P.J. Buys (S.M.N. 246); 1♂, 1♀ , Oncocua, 6-7 October 1969, C.Coetzee (S.M.N. 165); 1♂, Espinheira, 29 September 1969, C. Coetzee (S.M.N. 166).

(ii)

1♂, 1 juvenile ♀ , Sukses Dam, 2 March 1969, B. Lamoral, R. Day (N.M. 10075)

(iii)

1 juvenile ♀ , Hoas, 1971, J. Labuschagne (T.M. 10144); 1 juvenile ♀, Hoas, 1971, J. Labuschagne (T.M. 10145); 1 juvenile ♀ , Hoas, 1971, J. Labuschagne (T.M. 10147); 1♀ Hoas, 1971, J. Labuschagne (T.M. 10139); 1♀ , Kamombonde Oos 86, 5-7 January 1975 (S.M.N. 589); 1♂, Brandberg, 15 August 1968, P. Buys (S.M.N. 121); 1♂, Uis, March 1969. J.J. Nel (N.M. 10448); 1 juvenile ♀ , between Onanis and Walvis Bay, 4 March 1960, P. Buys (S.M.N. 153); 1 juvenile, Hentiesbaai, 14 August 1961, E Rusch (S.M.N. 149); 1 juvenile ♀ , Emeritus 123, 9 June 1967, Kapt. J.A. Pietersen (S.M.N. 64); 1 juvenile ♂, 1 juvenile ♀ Gobabeb, 5 January 1963,

P.J. Buys (S.M.N. 171).

(iv)

1♂, Kam River, October-December 1937, J.W. Bell-Marley (T.M. 9743); 1♂, Twilight 113, April 1973, L. Rothkegel (T.M. 10741); 1 juvenile Saffier 148, 5 March 1976, B. Lamoral (N.M. 10783); 1 juvenile Ghobab 381, 12 March 1976, B. Lamoral (N.M. 10767); 1♀ , Noachabeb 97, 22-28 April 1972, M-L. P. B.H., J.B. (S.M.N. 364); 1♂, Naukluft, 11 November 1968, P.M. van der Westhuizen (S.M.N. 263); 1♂, Frischgewaagd 289, 20 March 1976, B. Lamoral (N.M. 10900); 1♂, Kangas 371, 14 March 1976, B. Lamoral (N.M. 10849); 1♂, Neisip 34, 20 October 1970, F.A. Burger (S.M.N. 180); 1♀ , Aandster 147, 6 March 1976, B Lamoral (N.M. 10799); 1♀ , Richthofen 126, 16 February-2 March 1975, M. Penrith, M-L. Penrith (S.M.N. 559); 1♀ , Springbokvlakte, 20-21 February 1973, Lamoral, Porter (N.M. 10943); 1♀ , Vrede 719, 31 March 1976, B. Lamoral, L. Ferguson (N.M. 10901); 1 juvenile ♂, Augrabies Falls, 9 April 1970, B. Lamoral (N.M. 10454); 1♂, 1♀ , Namuskluft 88, 12-15 September 1973 (S.M.N. 530); 9♂, 3♀ , 4 juveniles, Berseba, 27 February 1976, B. Lamoral (N.M. 10731); 2♂, 1♀ , Ghobab 381, 12 March 1976, B. Lamoral (N.M. 10811); 1♂, Warmbad, 3 September 1959 (S.M.N. 77); 1♂, Noachabeb 97, 22-28 April 1972, J. Batista (S.M.N. 363); 1♂, 1 juvenile ♂, Huams farm, 1 February 1969, B. Lamoral, R. Day (N.M. 10459); 1♂, Noachabeb, 7-12 January 1972 (S.M.N. 322); 2♂, Na Sukkel, 8 November 1965, G. Chatwind (S.M.N. 135); 1♂, 1♀ , 1 juvenile ♀, Twilight, 8 February 1966, L. Rothkegel (S.M.N. 79); 1♀ , Leonardville, 11 October 1963, P.J. Buys (S.M.N. 66); 1 juvenile, Goreangab Dam, 19 December 1973, C.G.C., M-L.P., J.B,, E.M., S. Oosthuizen (S.M.N. 501); 5♂, Schwarzkuppen farm, 8 February 1973, Lamoral, Porter (N.M. 10520); 1♀ , 1♂, 1 juvenile ♂, De Waal farm, 17 March 1969, B. Lamoral (N.M. 10043); 2♂, Plateau 38/Aar 16, 15-18 January 1972 (S.M.N. 321); 1♂, De Waal farm, 17-18 March 1969, B. Lamoral (N.M. 10076); 1♂, 1♀ , Barby 26, 2-8 October 1972 (S.M.N. 391); 1♀ , Twilight 113, 9 December 1971, Mrs Rothkegel (S.M.N. 349); 1♀ , Arnhem 222, 23 October 1972, H.C. Strauss (S.M.N. 411); 1♂, Isabis 19, December 1974, L.A. Lester (S.M.N. 597); 1♀ , Tses, 23-24 February 1973, B. Lamoral, K. Porter (N.M. 10513); 1♂, Plateau 38, 28 February 1976, B. Lamoral (N.M. 10920); 1♀ , 3♂, Skaap river, March 1973, C.J. Coetzee (N.M. 10511); 1♂, 1♀ , Ortmansbaum, 1971 (S.M.N. 315); 3♀ , 2♂, Saffier 148, 4 March, 1976,

B. Lamoral (N.M. 10728); 3♂, Blaaskranz farm, 2 February 1969, B. Lamoral, R Day (N.M. 10014); 2♂, Goodhouse, 30 January 1973, B. Lamoral (N.M. 10516); 4♂, 1♀ , Perdepan, 17 February 1969, P.J. Buys (S.M.N. 221); 1♀, 1♂, Sesriem 137, 5-8 April 1972, M-L. P., B.H. (S.M.N. 351); 1♂, 1♀ , 3 juveniles Sterkstroom farm, 19-20 March 1969, B. Lamoral (N.M. 10031).

(v)

1♂, Rosh Pinah, December 1971, A. Maritz (T.M. 10539); 1♀ , Rosh Pinah Mine, December 1971, A. Maritz (T.M. 10544); 1♀ , Rosh Pinah, 9 June 1971, D.S. van Garderen (T.M. 10118); 1♀ , Rosh Pinah, July 1972, A. Maritz (T.M. 10556); 1 juvenile, Tsirub 13, 3 March 1976, B. Lamoral (N.M. 10786); 1♀ , Rosh Pinah, 17 February 1973, B. Lamoral (N.M. 10922); 1♂ , Rosh Pinah, 17 February 1973, B. Lamoral (N.M. 10523); 1 juvenile ♀ , Gorrasis 99, 14 February 1973, C.G.C., M-L. P., J. Tebje (S.M.N. 430); 1♂, Obib dunes, 16-20 September 1973, E. Mokgoabone (S.M.N. 485); 1♀, Aus, 16 January 1972, E. Eastwood (N.M. 10458); 3♀ , Swartpoort, February 1974, R. Faber (N.M. 10502); 2♂, 2♀ , Plateau 38, 29 February 1976, B. Lamoral (N.M. 10804);

(vi)

1o , Upington, 25 January 1971, S. Englebrecht (N.M. 10456); 1♂, Mata Mata, 24 April 1970, B. Lamoral (N.M. 10447); 2♂, 1 juvenile, Kalahari Gembsbok Park, 10 January 1972, E. Eastwood (N.M. 10450); 4♀ , Twee Rivieren, 1960-1970, Leriche family and staff (N.M. 10457); (N.M. 10455).

Distribution

North-western Cape Province, the whole of South West Africa and southern Angola.

Bionomics

Same as for *P. villosus* with the exception that *granulatus* also digs shallow burrows at the base of shrubs in sandy to consolidated sandy soils. With *P. villosus*, *granulatus* is one of the more commonly found buthid scorpions of South West Africa and it is also often cosmopolitan.

Parabuthus kalaharicus Lamoral, 1977
Fig. 4.18
Plates 4.15, 4.16

Parabuthus kalaharicus Lamoral, 1977: 101-107.

Diagnosis

The following combination of characters separates *P. kalaharicus* from *P. granulatus*, its most closely related species and from other species of the genus. Caudal segments, plates 4.15-4.16: Cauda IV, with six distinct granular keels, median lateral keel obsolete to absent, posterior three quarters of ventral keels obsolete; cauda V, accessory dorsal crest absent, distal half of ventro-lateral keels composed of enlarged subspinose, and occasionally distally blunt, processes; adult ♂ & ♀, telson small, width 66% (61-71%) of cauda V width. Pedipalp chela, fig. 4.18.a-c: ό db almost level with esb in ♀ & ♂; ό dt either closer to est than et or medial, but never level with or distal to et as in most species of *Parabuthus* from southern Africa; ό it unusually proximal, level with fourth subterminal transverse row of enlarged teeth of dentate margin of fixed finger.

Description

The following account includes the more important character states available from Lamoral's (1977) description.

Sexual dimorphism:

Holotypes and paratypes. In adults, males differ very little from females except in the following characters: movable finger length/handback length ratio in ♂ 0,45 lower than in ♀; proximal dentate margin of fixed and movable fingers distinctly emarginated in ♂, linear in ♀; ♂ have 22-27 and ♀ 18-20 teeth per pecten; first proximal middle lamella of each pecten supports 2-3 teeth in ♂, none in ♀.

Males and females:

Colour: Body and appendages, excepting legs and pectines, deep brown No. 56 with tergites and carapace dark brown No. 59; distal portion of pedipalp chela handback and proximal half of fixed and movable fingers distinctly infuscated; legs and pectines deep orange-yellow No. 69.

Pectines: see plates 4.15.b & 4.16.b. ♂ 22-27 and ♀ 18-20 teeth per pecten. First proximal middle lamella of each pecten in ♀ not enlarged and lobate as in most species of *Parabuthus*.

Setation: As in *P. granulatus*, sparsely pilose, cauda virtually apilose.

Trichobothria: As in fig. 4.18.a-f for ♂ and ♀. one of the two ♀ paratype (N.M. 10946) has an additional small trichobothrium on the dorsal surface of the right tibia only, situated just proximally to d_3 (see fig. 4.18.d); this is unusual and has not been found in any of the other types. Pedipalp tibia, fig. 4.18.e: ȯ et distinctly distal to est; ȯ em medial between est and esb_2. Pedipalp femur, fig. 4.18.f: ȯ d_2 on proximo-dorsal side of dorso-internal keel; ȯ d_3 distinctly distal to d_2 and closer to d_4 than d_1.

Paraxial organ: Paraxial organ and hemispermatophore as in *P. granulatus*.

Variation

Mainly in overall colouration and degrees of infuscation. Overall colouration either darker of lighter than holotype. In some paratypes cauda IV, V and telson are lightly infuscated. In subadults, the telson varies from deep brown to deep orange-yellow. These colour variations occur within samples of populations from all available localities.

Measurements

See diagnosis, figures and plates.

Carapace length of adult ♂ 7,3 mm (6,7-7,9 mm), ♀ 7,9 mm (only 2 ♀ collected). *P. kalaharicus* is one of the medium-sized species of *Parabuthus* with total body length of adult ♀ & ♂ about one third shorter than those of *P. granulatus*.

Type material

Holotype and paratypes in Natal Museum collection. Series of four paratypes from N.M. 10439 & 10455 have been deposited in each of the following institutions: South African Museum, Cape Town; Transvaal Museum, Pretoria; Kalahari Gemsbok Park Museum; Museum National d'Histoire naturelle, Paris, France; British Museum (Natural History), London England; Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, U.S.A.; California Academy of Sciences, San Francisco U.S.A.

Material examined

Holotype ♂, Twee Rivieren, Kalahari Gemsbok National Park, March 1970, B. Lamoral (N.M. 10945, type no. 2104). Paratypes: 2♀ , Twee Rivieren, March 1970, B. Lamoral (N.M. 10946, type no. 2105); 80♂ , Twee Rivieren, March 1970, B. Lamoral (N.M. 10439, type no. 2106); 9♂, Sterkstroom farm, 19 March 1969, B. Lamoral (N.M. 10947, type no 2106); 29♂, Mata Mata, 24 April 1970, B. Lamoral (N.M. 10948, type no. 2106); 4♂, Twee Rivieren, March 1970, B. Lamoral (N.M. 10452, type no. 2106); 1 juvenile ♂, Mata Mata, 27 April 1970, B. Lamoral (N.M. 10453, type no. 2106); 70♂, Twee Rivieren, 1960-1970, le Riche family and staff (N.M. 10455, type no. 2106).

Distribution

Kalahari Gemsbok Park and south-eastern part of South West Africa.

Bionomics

P. kalaharicus is nocturnal, hemiedephic and digs shallow burrows at the base of shrubs and under rocks on sandy to gritty soils in the shallow interdune valleys of the Kalahari sand dune system. Sweep-like rows of setae on the posterior edges of tibia, protarsi and tarsi of legs I-II and to a much lesser extent III, indicate a semi-psammophilous adaptation . P. kalaharicus and its most closely related species P. granulatus, are sympatric in the Kalahari Gemsbok Park.

Parabuthus kraepelini Werner, 1902
Fig. 4.19
Plate 4.17

Parabuthus kraepelini Werner, 1902: 599

Diagnosis

The following combination of characters separates P. kraepelini from other species of the genus. Cauda, plate 4.17: cauda I, antero-median surface of stridulatory patch sharply inclined to the anterior descending portion; cauda II, dorsal stridulatory patch reaching posterior margin; cauda II-IV, dorsal aspect of dorso-lateral keels convex cauda I-V, width percentage of length 103% (100-106%) for I, 93% (90-96%) for II, 88% (84-92%) for III, 81% (78-84%) for IV, 73% (69-77%) for V. leg V, not reaching further than posterior end of cauda I. One of the larger species of Parabuthus, it is most closely related to new species B.

Description

The following account supplements Werner's original description, Hewitt's (1918: 108-111) supplement the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionately smaller and more slender with width sternite V/carapace length ratios 1,12 (1,07-1,17) for ♂ and 1,30 (1,26-1,35) for ♀; ♂ pedipalp fingers shorter, handback bulbous, wider and longer with movable finger length/handback length ratios 1,40 (1,36-1,44) for ♂ and 2,05 (2,00-2,10) for ♀ while mean chela length is proportionately 8% longer in ♂; first proximal middle lamella of each pecten sub-rectangular, mesially angular and not enlarged in ♂, sub-oval, mesially enlarged and lobate in ♀.

Males and females:

Colour: Body and appendages, except legs and pectines, dark orange yellow No. 72 to deep yellow brown No. 75, with carapace, tergites and telson usually darkest and sternites lightest; legs brilliant orange yellow No. 67; pectines light orange yellow No. 70.

Granulation: Tergites very finely and evenly granular. Carapace more coarsely granular than tergites, interocular surface granular in ♂ and ♀. Pedipalp chela smooth and matt. Lateral intercarinal surfaces of cauda I-III and lateral surfaces of cauda IV-V, matt, lightly to moderately and evenly granular; cauda IV, median lateral keel well developed; cauda V, accessory dorsal crest present, composed of distinct blunt tubercules.

Sternites: smooth and shiny. Sternite VII, median keels obsolete, lateral keels present but poorly developed.

Pectines: ♀ 29-32 and ♂ 33-36 teeth per pecten.

Setation: Cauda, legs and pedipalps lightly to sparsely pilose. Lateral and posterior margins of sternites with a row of sparsely distributed setae. Medial third of sternites III and IV with a few scattered setae arising out of small punctations. Cauda I-V and telson sparsely pilose. Trichobothria: As in fig. 4.19. Orthobothriotaxic for group A. Pedipalp chela: ó eb proximal to base of dentate margin; ó dt distal to et; ó db closer to est than esb. Pedipalp femur, fig. 4.19.e: ó d_2 on proximo-internal side of dorso-internal keel.

Paraxial organ and hemispermatophore: not differing diagnostically from those of related species and the P. villosus group.

Variation

Little or no variation between populations. Populations from localities in the northern and north-western regions of the species range are darker in overall colouration, deep yellow brown No. 75 to dark yellow brown No. 78 with the distal segments of the cauda and telson progressively darker.

Measurements

See diagnosis, figures and plates.

Carapace length of adult ♂ 8,0 mm (7,0-9,0 mm) of adult ♀ 10,5 mm (9-12 mm).

Type material

Werner's ♀ holotype is a juvenile but it undoubtedly belongs to this species. It is deposited in the Zoological collection of the Vienna University (Wiener Universität Sammlung, W.V.S.) and bears the following accession data: "Coll. Musei Vindobonensis Inv. No. 2080".

Material examined

♀ holotype, Windhoek, no date, no collector's name (W.V.S. 2080); 1♂, Ghaub, 19-30 November 1972, H.C. Strauss (S.M.N. 419); 1 juvenile ♀, Sukses Dam, 2 March 1969, B. Lamoral, R. Day (N.M. 10013); 1 juvenile ♂, Warmquelle, 7 October 1968. P. Olivier (S.M.N. 118); 2♂, Keres, 5 December 1960, P. Pretorius (S.M.N. 50) 1♂, 1♀, Onanis, 4 March 1960, P. Buys (S.M.N. 153); 1♀, Uis, 30 March 1969, J.J. Nel (S.A.I.M.R. 860); 1♀, 3 juvenile ♀, 3 juvenile ♂, Hoffnung 66, 3 February 1971 (S.M.N. 264); 2 juvenile ♂, Okawas, 5 March 1969, B. Lamoral, R. Day (N.M. 10015); 2 subadult ♀, Otjitambi 25, 14-15 February 1972, M-L. Penrith (S.M.N. 337); 1♀, 2 juvenile ♂, Sandamap farm, B. Lamoral, R. Day (N.M. 10017);

3♀, 1♂, Paulinenhof 72, 20-22 November 1972 (S.M.N. 403); 1♂, Ovambo Grens, October 1961, P.J. Buys (S.M.N. 148); 1♂, Windhoek, 6-13 June 1972, P.G. Olivier (S.M.N. 382); 3 subadult ♂, Sesfontein, 4 April 1976, B. Lamoral, L. Ferguson (N.M. 10858); 1♀, Hoffnung 66, 3 February 1971 (S.M.N. 265); 1♀, 1 juvenile ♀, Waltersdorf farm, 11-12 March 1969, B. Lamoral, R. Day (N.M. 10023); 1 subadult ♂, Windhoek, 16 December 1963, W. Snyman (S.M.N. 26); 1♂, Kangas 371, 14 March 1976, B. Lamoral (N.M. 10850); 1 juvenile ♂, Windhoek, 5 February 1962, W. Giess (S.M.N. 5); 1♀, Aus, 2-6 March 1969, B. Lamoral, R. Day (N.M. 10022); 1♀, Otjiwe, 30 April 1961, P. Buys (S.M.N. 144); 1 subadult ♂, Emeritus 123, 9 June 1967, Kapt. J.A. Pietersen (S.M.N. 64); 2♀, Gemsbokvlakte, 4 March 1969, B. Lamoral, R. Day (N.M. 10019); 1 juvenile ♂, Goreangab Dam, 19 December 1973, C.G.C., M-L. P., E.M., J.B., S. Oosthuizen (S.M.N. 502); 1 juvenile ♀, Gollschau 20, 14-17 December 1973. C.G. Coetzee (S.M.N. 495); 1 juvenile, Okahandja, May 1960, F. Gaerdes (N.M. 7304); 1 subadult ♀, Kranzberg, 23 March 1974, B. Lamoral, L. Ferguson (N.M. 10852); 1♂, Okahandja, March 1966, F. Gaerdes (N.M. 9114); 1♀, Welwitschia, January 1963, F. Gaerdes (N.M. 9050); 1♀, Okahandja, March 1966, F. Gaerdes (N.M. 9113); 1♂, Okahandja, May 1960. F. Gaerdes (N.M. 7310); 1♀, Okahandja, May 1960, F. Gaerdes (N.M. 7309); 1♀, Okahandja, May 1960, F. Gaerdes (N.M. 7308); 1♂, Otjitanda, 24 February 1973, J. Malan (S.M.N. 435); 1♀, Windhoek, July 1970, G. Newlands (T.M. 10430); 1♀, Sesfontein, 4 April 1976, B. Lamoral, L. Ferguson (N.M. 10732); 1 juvenile ♂, Windhoek, no date, no collector's name (W.U.S. 2079).

Distribution

Northern half of South West Africa, excluding the Namib and Kalahari sand systems. The southernmost record is from near the Tropic of Capricorn.

Bionomics

A moderately uncommon species, *P. kraepelini* though nocturnal is occasionally found wandering in the open in daytime. It is hemiedaphic, and digs shallow scrapes under rocks or fallen trees in moderately hard to hard soils in areas with vegetation types 4, 5, 6, 7, 8 and 10. It is occasionally sympatric with *P. villosus*, *granulatus* and *brachystylus*, but not *new sp. B*, its sister species.

Parabuthus kuanyamarum Monard, 1937

Figs 4.20, 4.13.b

Plates 4.18, 4.19

Parabuthus kuanyamarum Monard, 1937: 258-259

Diagnosis

The following combination of characters separates P. kuanyamarum from other species of the genus. Cauda, fig. 4.13.b: cauda V, distal half of ventro-lateral keels composed of weakly developed subspinose processes; cauda IV, antero-ventral margin smooth and not demarcated by a transverse row of granules; cauda II-III, postero-ventral margins not demarcated by a distinct transverse row of isolated, round granules; cauda IV, proximo-ventral surface smooth and shiny, remaining ventral and entire lateral surfaces finely granular and shiny, no traces of any longitudinal keels excepting faint traces of ventro-laterals in some specimens. One of the smaller species of Parabuthus, it is most closely related to brevimanus. These two are in turn most closely related to the new sp. A - new sp. C. group.

Description

The following account supplements Monard's original description, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: while only slightly smaller, males are more slender with width sternite V/ carapace length ratio 1.10 (1,04-1,16) for ♂ and 1,25 (1,21-1,31) for ♀ ; pedipalp hand, movable finger length/handback length ratio 1,10 (1,07-1,12) for ♂, 1,45 (1,40-1,49) for ♀ ; handback of ♂ distinctly bulbous, width and breadth respectively 18% and 16% greater than ♀ ; lateral intercarinal surfaces cauda I-III ♂ more heavily granulated than ♀ ; first proximal middle lamella of each pecten sub-triangular and truncate in ♂, sub-circualr and lobate in ♀ ; ♂ 28-32 and ♀ 20-24 teeth per pecten.

Males and females:

Colour: Overall, fairly uniform strong yellow No. 84 with the pedipalps, chelicerae, legs and telson slightly lighter.

Cauda: See fig. 4.13.b, plates 4.18 and 4.19. Dorsal surface of cauda I and II with well-developed stridulatory areas composed of granules reaching the posterior margins; cauda II-III and to a lesser extent cauda I, ventral and ventro-lateral keels costate; cauda I-III, ventral intercarinal surfaces smooth and shiny, excepting granular distal half of cauda III, lateral surfaces lightly granular, dorsal keels poorly developed to obsolete.

Trichobothria: See figs 4.20.a-f. Orthobothriotaxic for group A. Pedipalp hand: ♂ Esb dorsal to Eb_2-Et alignment. Pedipal femur, fig. 4.20.f: ♂ d_2 on proximo-internal side of dorso-internal keel; ♂ d_4 much closer to d_5 than to d_1; ♂ e_1 transversely halfway between d_4 and d_5; ♂ d_2 distal to i_1; ♂ d_3 closer to d_4 than to d_1.

Paraxial organ and hemispermatophore: As in P. brevimanus.

Variation

Little or no variation between populations from different localities except for the slightly darker overall colouration of populations in the southern regions of the species range. No infuscated patterns, as described for certain populations of P. brevimanus, have been observed.

Measurements

See figures and plates.

Carapace length of adult ♂ 5,0 mm (4,5-5,2 mm), of adult ♀ 5,3 mm (4,8-5,6 mm).

Type material

Monard's syntypes consited of 3♀ and 4♂ deposited in the Museum de Histoire naturelle de La Chaux de Fonds, Switzerland. 1♀ was found in the collection of the Museum National d'Histoire naturelle in Paris, France, and I have designated this specimen as the LECTOTYPE of Parabuthus kuanyamarum. The remaining syntypes could not be found in the Museum of the La Chaux de Fonds. They should be labelled PARALECTOTYPES.

Homotype

I have selected a ♀ homotype which is deposited in the Natal Museum collection (N.M. 10430).

Material examined

♀ lectotype, Mupanda, Angola, 1933 A Monard, (no accession number, M.N.H.P.); ♀ homotype, Mata Mata, 24 April 1970, B. Lamoral (N.M. 10430); 2♂, 2♀, 5 juveniles, Swartmodder farm, 25-26 February 1973, B. Lamoral (N.M. 10441); 4♂ Katima Molilo, October 1970, W.D. Haacke (T.M. 9969-T.M. 9972); 13♂, 2♀, juveniles, Ghobab, 12 March 1976, B. Lamoral (N.M. 10813); 2♀, Rhodesia, 1910, Ellenberger (M.N.H.P. 0365); 1♀ Gangwe Pan, 3 April 1972, W.D. Haacke (T.M. 10653); 2♂, Katima Molilo, October 1970, W.D. Haacke (N.M. 10695); 1♀, Gobabis, 4 March 1972, W.D. Haacke (T.M. 10636); 4♂, 1♀, 1 juvenile ♂, 1 juvenile ♀, De Waal farm, 17-18 March 1969, B. Lamoral (N.M. 10929); 1♀, juveniles Ghobab, 12 March 1976, B. Lamoral (N.M. 10812); 1♂, Farm Gemsbok, 23 February 1970, R.B. Huey (ex T.M. 10406); 1 juvenile ♂, Vaalbank, 19-22 May 1973, M-L. Penrith, J. Tebje (S.M.N. 452).

Distribution

Eastern regions of S.W. Africa, Kalahari Gemsbok Park, and south-eastern Angola, in association with the Kalahari sand system (see fig. 2.8).

No records of P. kuanyamarum have been published since Monard's original description based on material from Angola, 40 years ago

The list of material examined, given above has considerably extended the known range of the species. The presence of P. kuanyamarum in South West Africa was unsuspected before this revision. In addition, available material had been misidentified as P. brevimanus.

Bionomics

P. kuanyamarum is nocturnal, hemiedaphic, and digs burrows in the side of sand dunes (soil categories III-V of table 2.2) of the Kalahari sand system. It very seldom burrows in sandy interdune valleys and never under rocks in sandy areas or in regions of hard and gritty soils. Distinct sweep-like rows of long setae on the posterior edges of tibia, protarsi and tarsi as well as a dorso-ventral compression of these segments in legs I-III are evidence of psammophilous adaptations. P. brevimanus, a closely related species, is sympatric with kuanyamarum in some areas but new sp. A and new sp. C are allopatric.

Parabuthus laevifrons (E. Simon, 1887)
Fig. 4.21
Plate 4.20

Buthus laevifrons E. Simon, 1887: 379-380

Synonyms

Parabuthus ibelli Werner, 1916: 84-86; types 1♀ 1♂, Berseba (N.M.W. 1056 & 1057), South West Africa. All seen. NEW SYNONYM.

Parabuthus laevifrons australis Hewitt, 1918: 105, 177; types, 1♂1♀, South of Orange River, 1♂ Upington (A.M.), South Africa. All seen. NEW SYNONYM.

Diagnosis

The following combination of characters separates P. laevifrons from other species of the genus. Cauda, plate 4.20: cauda I, anteromedian surface of stridulatory patch sharply inclined to the anterior descending portion; cauda II, dorsal stridulatory patch reaching posterior margin; cauda II-IV, dorsal aspect of dorso-lateral keels convex; cauda I-V, width percentage of length 91% (86%-96%) for I, 83% (79-87%) for II, 79% (74-84%) for III, 68% (65-71%) for IV, 57% (55-59%) for V; cauda IV, median lateral keel obsolete; telson vesicle distinctly narrower than cauda V, width percentage of cauda V width 81% (77-85%); cauda IV, V and telson usually infuscated. Legs IV, not reaching further than posterior end of cauda II. One of the medium-sized species of Parabuthus, it is most closely related to stridulus.

Description

The following account supplements E. Simon's original description, Purcell's (1901: 151-155) comprehensive supplement, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ smaller but proportionately more robust, with width sternite V/carapace length ratios 1,17 (1,14-1,20) for ♂ and 1,08 (1,04-1,12) for ♀ ; ♂ pedipalp fingers shorter, handback much wider, unusually bulbous and longer with movable finger length/handback length ratios 1,15 (1,10-1,20) for ♂ and 1,47 (1,40-1,55) for ♀ while mean chela length is proportionatel 10% longer in ♂; first proximal middle lamella of each pecten sub-triangular, mesially obtuse but not enlarged in ♂, sub-oval, mesially enlarged and lobate in ♀.

Males and females:

Colour: Body and cauda I-III dark orange yellow No. 72; cauda IV-V and telson deep brown No. 56 to brown black No. 65; pedipalp light orange yellow No 70; legs light yellow No. 86, pectines pale yellow No. 89.

Granulation: Carapace granular, excepting interocular area in females only which is smooth or very sparsely granular. Tergites very finely granular in anterior two thirds, granular in posterior third. Pedipalp chela smmoth and shiny. Lateral intercarinal surfaces of cauda I-III and lateral surfaces of cauda IV-V smooth and shiny, rarely with a few scattered granules; cauda V, accessory dorsal crest obsolete to absent.
Sternites: smooth and shiny. Sternite VII, median and lateral keels obsolete
Pectines: ♀ 31-36 and ♂ 36-41 teeth per pecten.
Setation: Almost entirely apilose excepting as follows: ventral, and to a lesser extent lateral surfaces of caudal segments and telson with a few scattered setae, lateral and posterior margins of sternites with a sparse row of setae; posterior edge of tarsi, protarsi and tibia of legs I-II and to a lesser extent III with a row of long stiff setae; anterior edge of protarsi I-III with a similar, but less well endowed row of setae.

Trichobothria: As in fig. 4.21. Orthobothriotaxic for group A. Pedipalp chela: δ eb proximal to base of dentate margin: δ dt proximal to or rarely level with et; δ db closer to esb than est. Pedipalp femur, fig. 4.21e: δ d_2 on proximo-dorsal side of dorso-internal keel.
Paraxial organ and hemispermatophore: As for *P. kraepelini*.

Variation

Populations from localities listed under (i) in the list of material examined are all fairly typical and show little morphological variation. Specimens from localities under (ii) however, show the following differences caudal segments more slender and width percentages of lengths all fall within lower values of ranges supplied in diagnosis; cauda IV, V and telson not infuscated and the same colour as I-III; stridulatory patch of cauda II is narrower and is shallowly excavated; the handback of pedipalp chela in males is even more bulbous than in the typical forms.

Measurements

See diagnosis, figures and plates.

Carapace length of adult ♂ 6,7 mm (6,0-7,5 mm), of adult ♀ 8,5 mm (7,0-10,0 mm).

Type material

Simon's ♂ holotype was supposed to be in the collection of the Muséum national d'Histoire naturelle, Paris. A thorough search of the collection failed to yield the type. Prof. M. Vachon joined the search and communicated the following report:

PREMIERE NOTE VACHON-LAMORAL

Paris, Le 12 septembre 1975

Parabuthus laevifrons Simon (1887) décrit en 1887 sous le nom de Buthus laevifrons in: Ann.Soc. entom. France, 6ème sér. tome 7. P.379; le type est un ♂, collecté par le Dr. Hans Schlinz de Zurich. Station imprécise: sud-ouest Afrique.

Toutes mes recherches faites dans le matériel inventorié comme Parabuthus et Buthus me conduisent à admettre que le type est perdu.

J'ajoute à cette réponse négative, les renseignements suivants qui corroborent ce fait:

1°/ dans son catalogue des Scorpions du Muséum national d' Histoire naturelle de Paris in.Bull. Mus. hist.nat. Paris, 1901, No 6, PP.262-274; K.KRAEPELIN ne mentionne pas cette espèce aussi bien dans la liste des espèces de Buthus que dans celle des Parabuthus. Or. KRAEPELIN, en 1900 a revu tous le Scorpions du Muséum.

2°/ la consultation du cahier où Eugène SIMON inventoriait les espèces qu'il possédait et qui portaient toutes, un numéro (appelé par nous numéro collection Simon), aucune mention n'est faite d'un spécimen portant le nom de laevifrons.

Dans ces conditions, il faut créer un néotype en tenant compte du fait que, dans sa diagnose, E. Simon ne précise pas le lieu de capture.

The loss of the Simon's type therefore appears to have been established beyond reasonable doubt and the following specimen is hereby selected and designated as the NEOTYPE of Parabuthus laevifrons: 1♀, Hardap Dam, Mariental, October 1968, R.F. Lawrence (N.M. 10436). It has been labelled accordingly and is deposited in the type collection of the Natal Museum.

Simon's description of his type leaves no doubt that it was a ♀ and not a ♂ as stated by him. Taking into account that Simon did not supply a more definite locality other than "Sud-ouest Afrique", the neotype was selected so as to match as closely as possible Simon's original description.

Material examined

♀ neotype, Hardap Dam, October 1968, R.F. Lawrence (N.M. 10436).
The roman numerals used below refer to material discussed under variation

(i)

1♂, Onderste Narries farm, 23 January 1973, B. Lamoral (N.M. 10462); 1♀, Swartmodder farm, February 1971, B. Lamoral (N.M. 10438); 1 juvenile ♀, Vredenhof 301, 21 February 1976, B. Lamoral (N.M. 10785); 1♀, Kwang, 10 January 1972, I.R. Rautenbach (T.M. 10651); 1♀, Louwshoop farm, 4 February 1973, B. Lamoral (N.M. 10525); 1♂, Keimasmund farm 88, 25 May 1972, M.K. Jensen (N.M. 10428); 1♂, Twee Rivieren, 13 December 1962, Oosthuizen (T.M. 10006); 2♂, Noachabeb farm, 6 February 1973, B. Lamoral (N.M. 10050); 1 juvenile ♂, Neisip 34, 21 October 1970, F.A. Burger (S.M.M. 183); 3♀, 1♂, Belda farm, 1 February 1973, B. Lamoral (N.M. 10512); 1♂, Ortmansbaum 120, 18-21 October 1971, M-L. Penrith, P.G. Olivier, C.G. Coetzee (S.M.N. 307); 1♂, 1 juvenile ♂, Goodhouse, 30 January 1973, B. Lamoral (N.M. 10941); 1♂, Ortmansbaum 120, 19-22 October 1971 (S.M.N. 310); 1 ♂, Hardap Dam, October 1968, R.F. Lawrence (N.M. 10435); 1♂, Blinkoog 30, 14-18 October 1971, J. Batista (S.M.N. 368); 4♂, Noachabeb 97, 7-12 January 1972 (S.M.N. 324); 2♀, 1♂, 1 juvenile ♂, Koa Valley, 29-31 January 1973, B. Lamoral (N.M. 10522); 2♀, 1♂, 3 juveniles, Louwshoop farm, 3 February 1973, B. Lamoral, K. Porter (N.M. 10515); 3♂, 1♀, Hardap Dam, October 1968, R.F. Lawrence (N.M. 10942); 2♂, 1♀, 1 juvenile ♀, 1 juvenile ♂, Ortmansbaum farm, 26-28 January 1973, B. Lamoral, L. Raw (N.M. 10509); 1♀, Swartmodder farm, January 1972, Mr and Mrs Engelbrecht (N.M. 10437); 4♀, 2♂, 2 juvenile ♂, 1 juvenile ♀, Berseba, 27 February 1976, B. Lamoral (N.M. 10800); 8♀, 4♂, Tses, 23-24 February 1973, B. Lamoral, K. Porter (N.M. 10521); 4♂, 3 juvenile ♂, 1♀, Schwarzkuppen farm, 8 February 1973, Lamoral, Porter (N.M. 10510); 5 juveniles, Swartmodder farm, 25-26 February 1973, B. Lamoral (N.M. 10533); 1♂, Inkle Pan, 8 February 1970, W.D. Haacke (T.M. 9583); 1 juvenile ♂, Klein Spitzkoppe, 14 May 1972, O. Prozesky (T.M. 10491); 1♂, Kwang, 10 January 1972 (T.M. 10288).

(ii)

3♀ , 6♂, juveniles, Saffier 148, 4 March 1976, B. Lamoral (N.M. 10729); 2♂, 2♀ , 6 juveniles. Aandster 147, 6 March 1976, B. Lamoral (N.M. 10776); 1♀ , Farm Plateau, October 1973, H. Erni (N.M. 10498); 2 juvenile ♂, 2 juvenile ♀ , Okahandja, February 1963, F. Gaerdes (N.M. 8383); 1♀ , Avasib dunes, 29-30 January 1974, C.G.C., M-L. P., C.G. (S.M.N. 528).

Distribution

The southern half of South West Africa with the exclusion of the interior highland mountains (1500 metres plus in fig. 2.7) and the Namib and Kalahari sand systems. The northern-most records are Okahandja and Klein Spitzkoppe. *P. laevifrons* has also been recorded South and North of the Orange River in the northern Cape Province of South Africa.

Bionomics

Like *P. kraepelini*, *laevifrons* is a fairly uncommon species. It is hemiedaphic and digs shallow scrapes under rocks in soils ranging from condolidated sand to moderately hard and gritty soils in regions with vegetation types 4,7 (southern reaches) and 9. The rake-like rows of setae on the posterior edges of tibia, protarsi and tarsi and slight dorso-ventral compression of these segments suggest a semi-psammophilous adaptation. This adaptation probably explains why on occasion *laevifrons* marginally intrudes the sand systems of the Kalahari and the Namib. *P. laevifrons* is occasionally sympatric with *villosus*, *granulatus*, *schlechteri* and *brevimanus*.

Parabuthus new species B

Fig. 4.22

Plate 4.21

Diagnosis

P. new species B can be separated from the other species of the genus by the following combination of characters. Cauda, plate 4.21: cauda I, antero-median surface of stridulatory patch gently inclined to the anterior descending portion; cauda II, dorsal stridulatory patch reaching posterior margin; cauda II-IV, dorsal aspect of dorso-lateral keels subparallel; cauda I-V, width percentage of length 79% (77-81%) for I, 68% (65-71%) for II, 64% (63-65%) for III, 55% (54-56%) for IV and 51% (50-52%) for V, giving the cauda a slender appearance; cauda IV, V and telson deeply infuscated. Legs IV, long and slender, reaching posterior end of cauda III. One of the larger species of Parabuthus, it is most closely related to kraepelini.

Description

The type series consists of the ♀ holotype and 3 ♂ paratypes. The following description is based on the ♀ holotype, unless otherwise indicated, and supplements the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

Holotype and paratypes. In adults males differ from females in the following characters: ♂ pedipalp fingers shorter, handback longer, wider and swollen, with movable finger length/handback length ratios 1,58 (1,50-1,66) for ♂ and 2,19 (2,15-2,23) for ♀ while mean chela length is proportionately 9% longer in ♂; ♂ proportionately more slender with width sternite V/carapace length ratios 1,10 (1,08-1,12) for ♂ and 1,20 for ♀ ; first proximal middle lamella of each pecten subtriangular, mesially obtuse but not enlarged in ♂, sub-oval, mesially enlarged and lobate in ♀ ; ♂ with 42-47 and ♀ with 40-41 teeth per pecten.

Female holotype:

Colour: Tergites, carapace, chelicerae and sternites moderate olive brown No. 95; cauda I-III light olive brown No. 94, cauda IV, V and telson dark olive brown No. 96; pedipalps strong yellow No. 84; legs and pectines moderate yellow No. 87.

Granulation: Pedipalp: chela smooth and matt; tibia with granules and tuberles of keels as in fig. 4.22.e and f, ventral surface lightly granular, otherwise smooth and matt; femur with keels as in fig. 4.22.g, dorsal and inner surfaces lightly granular, otherwise smooth and matt. Legs I-IV smooth and shiny excepting outer surfaces of prefemora II-IV. Carapace moderately granular, interocular surface smooth with a few scattered granules. Tergites: I-VII, finely granular in anterior two thirds, more coarsely granular in posterior third; I-VI, median keel poorly developed; VII, median and lateral pairs of keels moderately developed. Coxae legs I-VI smooth and shiny. Sternites: II-VI smooth and shiny; VII, median and lateral pairs of keels poorly developed, surface between lateral keels smooth and shiny, surfaces between lateral keels and lateral margins lightly granular. Cauda: all keels well developed and granular, except anterior third of median lateral and posterior third of ventrals in cauda IV and medial third of dorsals in cauda V; cauda V, accessory dorsal crest present, consisting of 3-6 short, blunt tubercles; intercarinal surfaces of cauda I smooth and matt with a few scattered granules laterally, remaining segments progressively more granular with V evenly granular; telson bulbous, with four longitudinal rows of interspersed granules, lateral and dorsal surfaces lightly punctate and shiny; cauda I, dorsal stridulatory patch oblong in shape with a slight posterior constriction, composed of fine granules reaching posterior margin; cauda II, dorsal stridulatory patch narrow, shallowly excavated, reaching posteriormargin, composed of fine granules, a few of which posteriorly form short ridges which do not span more than halfway acroos the patch.

Pectines: 40-41 teeth per pecten. First proximal middle lamella of each pecten sub-oval, mesially enlarged and lobate.

Sternum: Sub-trapezoidal, greatest length equal to greatest width.
Setation: Overall sparsely to moderately pilose as for P. kraepelini. Posterior edges of tarsi, protarsi and tibia I and II with rake-like rows of long fine setae. Ventral surfaces of tarsi I-IV with pads of fine setae. Sternites III and VII with scattered fine setae. Lateral and posterior margins of sternites III-VII with a row of sparsely distributed setae.

Trichobothria: as in fig. 4.22.c for holotype. The trichobothriotaxy of the holotype does not differ from that of the ♂ paratype illustrated in figs 4.22.b and e-g. Orthobothriotaxic for group A. Pedipalp hand: ȯ eb level with or slightly distal to base of dentate margin. Pedipalp femur, fig. 4.22.g: ȯ d_2 on proximo-dorsal side of dorso-internal keel.

Paraxial organ and hemispermatophore: Not differing diagnostically from P.kraepelini and related species.

Variation

Excepting infuscated cauda IV, V and telson, all the ♂ paratypes are much lighter in colour, with tergites, carapace, sternites and cauda I-III strong yellow No. 84, pedipalps and legs brilliant yellow No. 83 and pectines light yellow No. 86.

Measurements

♀ holotype (in mm): pedipalp chela as in fig 4.22.c; pedipalp tibia width 3,8, length 7,8; pedipalp femur width 2,0, length 7,0; Carapace, length 8,8, anterior width 6,0, posterior width 9,2, distance of median eyes from anterior margin 3,8; sternite V width 10,4; cauda I to V width and length I 5,0 & 6,2, II 4,8 & 7,0, III 4,8 & 7,2, IV 4,8 & 8,2, V 4,6 & 9,2; telson vesicle height 4,0, width 4,4, length 6,2, aculeus length 4,6.

♂ paratype: as in figures and plates.

♀ holotype and 1♂ paratype (N.M. 10822) in Natal Museum collection, other paratypes in Transvaal Museum collection.

Type material

♀ holotype and 1♂ paratype (N.M. 10822) in Natal Museum collection, other paratypes in Transvaal Museum collection.

Material examined

♀ holotype and 1♂ paratype, 5 km North of Cape Cross on Skeleton Coast, 25 March 1976. B. Lamoral and L. Ferguson (N.M. 10822); 1♂ paratype, Gobabeb, January 1970, R. Jones (T.M. 9787); 1 subadult ♂ paratype, 32 km from Gobabeb on way to Mirabib, 28 February 1975, S. Enrödy Younga (T.M. 11086).

Distribution

Central and northern Namib Desert.

Bionomics

Verly little is known about the bionomics of this species. The holotype and paratype from Cape Cross were caught while collecting at night with an ultra-violet light on the gravel plains shown in plate 2.12. The soil surface was consolidated sand mixed with grit. No ecological data accompany the two paratypes from the Transvaal Museum collection.

Parabuthus new species C

Figs 4.23, 4,14.d-f and i-j
Plates 4.22, 4.23

Diagnosis

P. new sp. C can be separated from other species of the genus by the following combination of characters. Caudal segments, keels, granulation and surface texture as in P. new sp. A but dimensions proportionally 75% smaller in adutls of new sp. C. Cauda I: width percentage of length 91 (90-93) for adult ♂, 95 (94,0-96,5) for adult ♀ . Sternum greatest width/greatest length 1,00 for adult ♂ and ♀ (0,95-1,04). The smallest species of Parabuthus so far described, it is most closely related to new sp. A. These two are in turn most closely related to the brevimanus-kuanyamarum group.

Description

The type series consists of females and males. The following description is based on the holotype ♀ , unless otherwise indicated, and supplements the above diagnosis and pertinent plates and fitures.

Sexual dimorphism:

Holotype and paratypes. In adults, males differ very little from females, except in the following characters: Carapace and total body lengths 15% shorter. Although adult males are smaller than females, there are no proportional differences between ♂ and ♀ , consequently, adult specimens of equal size can be sexed only by the presence in ♂, and absence in ♀, of genital papillae. Pedipalp hand, fig. 4.23.a & b: movable finger length/handback length ratio 2,00 (1,93-2,08) for ♂ and ♀.

Female holotype:

Granulation: As for *P. new sp. A.* Sternites III-VI not wrinkled as in *P. new sp. A*, but with numerous shallow punctations over posterior half between sigmata; sternite VII with shallow punctations over two thirds of postero-median surface, withou lateral keels.

Colour: Overall, variably moderate yellowish brown No. 77, with surface between lateral and median eyes, dorsal and external distal half pedipalp femur, distal half prefemur I-IV very lightly infuscated.

Cauda: Ventrally as for *P. new sp. A.* Stridulatory patch; cauda I, consisting of fine granules, flaring anteriorly, narrowing medially and slightly flaring posteriorly, reaching posterior margin; cauda II almost obsolete and not reaching posterior margin.

Pectines: 24 and 24 teeth, fig. 4.14.j. In paratypes, ♀ 23-25, ♂ 23-25 teeth per pecten. First proximal middle lamella of ♂ and ♀ in alignment with middle lamella axis.

Sternum: Width equal to length and almost sub-pentagonal in shape.

Setation: As for *P. new sp. A*, but with setae on surface of sternites, arising out of shallow punctations described above.

Trichobothria: See diagnosis and fig. 4.23, orthobothriotaxic for group A. Pedipalp hand: δ Esb ventral to Eb_2-Et alignment. Pedipalp tibia: δ d_2 present and small. Pedipalp femur, fig. 4.23.g: δ d_2 on proximo-internal side of dorso-internal keel; δ d_4 much closer to d_1 than to d_5; δ e_1 very slightly distal to d_5; δ d_2 proximal to i_1; d_3 closer to d_1 than to d

Paraxial organ: As for *P. brevimanus*. Hemispermatophore, figs 4.14.d-f: pars reflecta one quarter of hemispermatophore length; pars recta as in *P. new sp. A*; outer lobe obtuse; basal lobe with a small inner process and subequal in length to median lobe not longer as in *P. new sp. A.*

Variation

Specimens from the southern parts (Belda farm, N.M. 10702) of the known species range have slightly darker infuscations than the holotype and the anterior half of each caudal segment lightly infuscated. Specimens from south of the Orange River (N.M. 10700 and 10703) and from the western margin of the species range (Tsirub farm N.M. 10772) are paler than the holotype in overall colouration and non-infuscated.

Measurements

See diagnosis, figures and plates.

Carapace length of adult ♂ 3.1 (2,9-3,3 mm), of adult ♀ 3,5 mm (3,3-3,8 mm).

Type material

Holotype and paratypes in Natal Museum collection. Paratypes have been deposited in the following institutions: State Museum, Windhoek, S.W. Africa; Museum National d'Histoire naturelle, Paris, France; Museum of Comparative Zoology, Harvard University, Cambridge, Massachussetts, United States of America.

Material examined

♀ holotype, Noachabeb farm, 6 February 1973, B. Lamoral (N.M. 10926); Paratypes; 1♂, Noachabeb farm, 6 February 1973, B. Lamoral (N.M. 10926); 2♂ Noachabeb farm, 6 February 1973, B. Lamoral (N.M. 10927); 1♂, 1 subadult ♀, 1 juvenile ♂, Noachabeb, 8 February 1973, B. Lamoral, K. Porter (N.M. 10698); 1 subadult ♂, Belda farm, 1 February 1973, B. Lamoral (N.M. 10701); 1♀, Louwshoop farm, 3 February 1973, B. Lamoral, K. Porter (N.M. 10699); 1♂, 1♀, Tsirub 13, 3 March 1976, B. Lamoral (N.M. 10772); 1♂, 1♀, 2 subadult ♂, Belda farm, 28 January 1973, B. Lamoral (N.M. 10702); 1♀, Goodhouse, 30 January 1973, B. Lamoral (N.M. 10700); 1♂, Goodhouse, 29-31 January 1973, B. Lamoral (N.M. 10703).

Distribution

South central parts of South West Africa and south of the Orange River in the north-western Cape Province of South Africa.

Bionomics

P. new sp. C is nocturnal, hemiedaphic and digs shallow burrows at the base of small shrubs and under rocks on consolidated sandy to gritty soils (soil categories IV-VI of table 2.2) in areas of vegetation types 9 and 3A. *P. brevimanus*, a fairly closely related species, is sympatric with new species C in the central parts of its range (Noachabeb farm N.M. 10926). but *kuanyamarum* and *new sp. A*, are allopatric.

Parabuthus raudus (E.Simon, 1887)

Fig. 4.24

Plate 4.24

Buthus raudus E. Simon, 1887: 377-378

Diagnosis

P. raudus can be separated from the other species of the genus by the following combination of characters. Caudal segments, plate 4.24: cauda I and II, dorsal stridulatory area as in *P. schlecteri*; adult ♂ & ♀, telson width 80% (75-85%) of cauda V width; cauda V, accessory dorsal crest composed of blunt tubercles in ♀ and spiniform ones in ♂, dorsolateral keels almost obsolete medially, ventral aspect of ventro-lateral keels sub-trapezoidal tapering posteriorly, posterior width 10% (7-13%) narrower than anterior width, otherwise as in *P. schlecteri*; cauda I-IV all almost the same width, cauda IV as wide as I, seldom slightly wider; cauda II and III, distal granules of ventral and ventro-lateral keels not enlarged and elevated, lateral and ventral intercarinal surfaces flat, fairly densely and evenly granulated, never smooth. One of the larger species of *Parabuthus*, it is most closely related to *P. schlecteri*.

Description

The following account supplements E. Simon's original description, Kraepelin's (1908: 252-254) supplement, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults males differ from females in the following characters: ♂ 20% (14-26%) smaller but not proportionately more slender since width sternite V/carapace length ratios are 1,30 (1,25-1,35) for both sexes; ♂ pedipalp chela fingers shorter, handback wider and longer with movable finger length/handback length ratios 1,65 (1,60-1,70) for ♂ and 2,25 (2,20-2,30) for ♀, while mean chela length is proportionately 7% longer in ♂.

Males and females:

Colour: Body and appendages, excepting pedipalps, legs and pectines, strong yellowish brown no. 74 to deep yellowish brown No. 75 with carapace and tergites usually darkest and sternites lightest; cauda V and telson or telson alone dark yellowish brown No. 78 in some specimens; pedipalps and chelicerae strong yellowish brown No. 74 to dark orange yellow No. 72; legs moderate orange yellow No. 71 to strong yellow No. 84; pectines light yellow No. 86.

Sternites: Smooth and shiny. Sternite VII, lightly granular between lateral longitudinal keels and lateral margins, smooth and shiny medially between lateral keels; lateral keels poorly developed, median keels obsolete to absent.

Cauda: Cauda I wider than long, width percentage of length 109% (106-112%); cauda II-IV narrower than long, width percentage of length 93% (90-97%) for II and III, 78% (74-82%) for IV;
Pectines: ♀ 34-45 and ♂ 38-50 teeth per pecten. Simon's lectotype ♀ has 36-37 teeth per pecten and not 26 as stated in his original description. Marginal and middle lamellae punctate.

Setation: Anterior margin and ventral surface of pectines, lateral and posterior margins of sternites moderately pilose. Femora, tibia, of legs I-IV and protarsi and tarsi of III-IV moderately pilose; protarsi of legs I-II ventrally apilose; posterior edges of tarsi, protarsi and tibia of legs I-II with a rake-like row of long stiff setae; ventral surfaces and dorsal median lobes of tarsi I-IV with thick vestitures of fine setae. All other body and appendage surfaces almost apilose.

Trichobothria: As in fig. 4.24. Orthobothriotaxic for group A. Pedipalp chela: ó eb proximal to basal dentate margin of fixed finger.

Paraxial organ and hemispermatophore: Notdiffering diagnostically from those of *P. schlecteri* and related species, very closely resembling those *P. villosus* (fig. 3.6.a).

Variation

Little or not variation between populations from different localities except as follows: Specimens from the northern regions of the species range have distinctly infuscated cauda IV and telsons. Within certain populations, ó est and et of pedipalp chela are separated by two outer flanking teeth instead of three as shown in fig. 4.24.a & b.

Measurements

See diagnosis, figures and plates.

Carapace length of adult ♂ 9,30 mm (8,25-10,00 mm) of adult ♀, 11,5 mm (10,0-13,0 mm).

Type material

The ♀ and ♂ syntypes of P. raudus were presumed lost according to to Hewitt (1918: 108) and Lawrence (pers. comm., 1976). The ♀ syntype was rediscovered in the collection of the Museum national d'Histoire naturelle, Paris. It is hereby selected as the LECTOTYPE of Parabuthus raudus and it has been labelled accordingly. The male syntype could not be found.

Homotype

I have selected a ♀ homotype which is deposited in the Natal Museum collection (N.M. 10444).

Material examined

♀ lectotype, no specific locality except " sud-ouest de l'Afrique" (South West Africa), 1884-1886, Hans Schinz; ♀ homotype, Mata Mata, April 1970, B. Lamoral (N.M. 10444); 1♂, 1♀ , Scheidthof 293, 14-17 November 1972 (S.M.N. 401); 2♀ , Kalahari Gemsbok Park, 24 April 1970, B. Lamoral (N.M. 10445); 1♀ , Otjituo, 3 August 1965, P. Mungonena (S.M.N. 232); 1♀ , Rundu, 30 July 1965, W. Steyn (S.M.N. 117); 1♀ , Swartmodder farm, 14 April 1976, B. Lamoral (N.M. 10433); 1♀, Frischgewaagd 289, 22 March 1976, B. Lamoral, L. Ferguson (N.M. 10912); 1♀ , Moorivier, 5 May 1969, H.D. Brown (T.M. 10401); 1♀ , Auob river (N.M. 10434); 11♂, 9♀ , Mata Mata, 24 April 1970, B. Lamoral (N.M. 10449); 2 juvenile ♂, 1 juvenile ♀ , Richthofen 126, 19 February-2 March 1975.(S.M.N. 561); 1♀ , Richthofen 126, 19 February-2 March 1975 (S.M.N. 560); 1♀ , Twilight 113, April 1973, L. Rothkegel (T.M. 10739); 1♀ , Avro, 10 June 1966, C. van der Hooven (S.M.N. 60); 1♂, Richthofen 126, 26 January-2 February 1975 (S.M.N. 555); 1♀ , Twee Rivieren, April 1970, B. Lamoral (N.M. 10427); 1♀ , Twee Rivieren, April 1970, B. Lamoral (N.M. 10427); 1♀ , Katima Molilo, July 1970, D. Badenhorst (S.M.N. 376); 1♂, Frischgewaagd 289, 20 March 1976, B. Lamoral (N.M. 10897); 3 juvenile ♂, 1 juvenile ♀ , Moravet, 24 April 1972, B. Lamoral (N.M. 10429); 1 juvenile ♂ , 1 juvenile ♀ Katima Molilo, October 1970, W.D. Haacke (T.M. 9964, 9965); 1 juvenile ♂, Katima Molilo, 24 October 1970 (T.M. 10190); 1♂, Twilight 113, April 1973, L. Rothkegal (T.M. 10740); 90♂ ♀ and juveniles, Ghobab 381, 12 March 1976. B. Lamoral (N.M. 10807); 1♂ Frischgewaagd 289, 20 March 1976, B. Lamoral (N.M. 10902); 2♂, 1♀ , Mata Mata, 24 April 1970, B. Lamoral (N.M. 10931); 1♂, Twee Rivieren, 1960-1970, Leriche and staff (N.M. 10432); 3♂, 2♀ , Swartpoort, February 1974, R. Faber (N.M. 10924); 1♂, Richthofen 126, Windhoek, 1-31 January 1975, M-L. P., M.J.P. (S.M.N. 549); 1♀, Richthofen 126, 2-19 February 1975, M.J.P., M-L.P. (S.M.N. 557); 1♀, Ramboekas Pan, 1 May 1970, B. Lamoral (N.M. 10506); 1♂, Richthofen 126, 16 February-2 March 1975, M.J.P., M-L.P. (S.M.N. 559); 1♂, Frischgewaagd 289, 20 March 1976, B. Lamoral (N.M. 10837); 1 juvenile ♀, Kalahari Gemsbok Park, 10 January 1972, E. Eastwood (N.M. 10431); 6♀, 8♂, 4 juveniles, Frischgewaagd 289, 20 March 1976, B. Lamoral (N.M. 10817); 1♂, 1♀, Na Sukkel, 8 November 1965, G. Chatwind (S.M.N. 135); 1♂, Rosh Pinah, January 1971, J. Botha (T.M. 10073); 1♂, Rosh Pinah, April 1971, J. Botha (T.M. 10106); 1♂, Nabas, September 1968, W.D. Haacke (T.M. 10411); 1♀, Rosh Pinah, 13 July 1969, Jan Botha (T.M. 10109); 1♂, Groot Aarpan, 30 January 1970, R.B. Huey (T.M. 9895); 1♂, Twee Rivieren, 1960-1970, Leriche family and staff (N.M. 10446); 3♂, Swartpoort, April 1967, W.D. Haacke (N.M. 10932); 75♂ and ♀ Swartmodder farm, 25-26 February 1973, B. Lamoral (N.M. 10533); 1 juvenile ♂, Sibinda, January 1974, K. Porter (N.M. 10933); 1♀, S.W.A. Administration Borehole 6453 (S.M.N. 249); 3♀, 7♂, Katima Molilo, October 1970, W.D. Haacke (T.M. 9954-T.M. 9963); 1♂ Gwaai River Hotel, 29 October 1970, W.D. Haacke (T.M. 9966); 1♂, 2♀, Katima Molilo, 29 October 1970, H.D. Brown (T.M. 10187-T.M. 10189); 1♂, Rooidag Gate, 8 April 1970, W.D. Haacke (T.M. 9840); 1 juvenile ♀, Rooidag Gate, 8 April 1970, W.D. Haacke (T.M. 9841); 1 juvenile ♂, Corner Beacon of W. Caprivi strip, 11 April 1970 (T.M. 9846); 1 juvenile ♀, Beacon 39, S.W.A.-Angola Border, 18 April 1970, W.D. Haacke (T.M. 9837); 1♂, Aarpan (T.M. 9896); 1♂, Farm Gemsbok, 23 February 1970, R.B. Huey (T.M. 10406); 1♂, Nossob-Auob junction, 28 November 1969, Huey (T.M. 9508); 1♀, Aarpan, 30 January 1970, Huey (T.M. 9890); 1♀, Aarpan, 29 January 1970, L.W. Coons (T.M. 9894); 1 juvenile ♀, Kuruman, 6 May 1969, L. Schultze (T.M. 10410); 1♀, Nossob camp, January 1972, I.L. Rautenbach (T.M. 10337); 1♀, Dankbaar, 16 January 1972, I.L. Rautenbach (T.M. 10475); 2♀, Dutlwe, Botswana, 17 June 1969, T.W. Schofield (N.M. 9951); 1♀, Ghanzi October 1961, W. Haacke (N.M. 8361); 1 subadult ♂, Kalahari, September 1920, Jacson (S.A.M. B5363); 1♂, Twee Rivieren, 3 January 1967, W.D. Haacke (B.M. 1972.703); 1♂, Mata Mata, April 1970, B. Lamoral (N.M. 10440).

Distribution

Most of Kalahari sand system (fig. 2.8), and sandy areas North and South of the Orange River in the North-western Cape Province of South Africa. All specimens collected in the south-western region of South West

Africa were found on sandy areas near Rosh Pinah but none were caught in the shifting sand dunes of the Namib sand system (fig. 2.8).

Bionomics

P. raudus is nocturnal, hemiedaphic, occasionally epigeic on shrubs while hunting, and digs shallow burrows at the base of shrubs in sandy soils in regions with vegetation types 11,12 & 13 (fig. 2.4). A few specimens have occasionally been found in shallow scrapes under rocks or fallen trees but never under the loose bark of such trees. P. raudus has never been found in regions of hard and gritty soils. Rake-like rows of long setae on the posterior edges of tibia, protarsi and tarsi of legs I, II and to a lesser extent III indicate a semi-psammophilous adaptation. P. raudus is the largest and most commonly found species of Parabuthus in the Kalahari sand system where it is occasionally sympatric with villosus, granulatus and kalaharicus.

Parabuthus schlecteri Purcell, 1899

Fig. 4.25

Plate 4.25

Parabuthus schlecteri Purcell, 1899: 434

Diagnosis

P. schlecteri can be separated from the other species of the genus by the following combination of characters. Caudal segments, plate 4.25: cauda IV with 10 distinct granular keels, ventrals almost obsolete posteriorly; cauda I and II, dorsal stridulatory area as in P. villosus; adult ♂& ♀ telson width 94% (90-98%) of cauda V width; cauda V, accessory dorsal crest composed of spiniform tubercles, dorso-lateral keel well developed throughout, distal half of ventro-lateral keels with moderately enlarged, laterally compressed sub-spinose processes; cauda V, ventral aspect of ventro-lateral keels sub-trapezoidal, tapering anteriorly, anterior width 15% (13-17%) narrower than posterior width; cauda I-IV progressively increasing in width, cauda IV 14% (8-20%) wider than I; Cauda I-III, distal granule of dorsal keel enlarged in ♂ only; cauda II-III, distal granules of ventral keels, and to a lesser extent ventro-lateral keels, distinctly enlarged, obtuse and elevated; cauda II & III, lateral and ventral intercarinal surfaces slightly concave, very sparsely granulated to smooth. One of the larger species of *Parabuthus*, it is most closely related to *P. raudus*.

Description

The following account supplements Purcell's brief original description, his (1901: 164-168) comprehensive supplement, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ little from females except in the following characters: ♂ pedipalp chela fingers shorter, handback wider and longer with movable finger length/handback length ratios 1,45 (1,40-1,53) for ♂ and 2,20 (2,14-2,28) for ♀ while mean chela length is proportionately only 3% less in ♂; ♂ cauda proportionally longer with caudal segments I-II of ♂ 16,0% (15,0-17,5%) and 12% (10,5-13,5%) and III to V 9,0% (7,5-10,5%) longer than ♀. First proximal middle lamella of each pecten sub-rectangular, mesially angular and not enlarged in ♂, sub-oval, mesially enlarged and lobate in ♀.

Males and females:

Colour: Body and appendates, excepting pedipalps, legs and pectines, dark brown No. 59 to brownish black No. 65 with carapace and tergites usually darkest and sternites lightest; pedipalps, deep yellowish brown No. 75 to strong yellowish brown No. 74; legs dark orange yellow No. 72 to light yellow No. 86; pectines moderate yellow No. 87.

Legs: Moderately pilose. Posterior edges of tarsi, protarsi and to a lesser extent tibia of legs I and II with a rake-like row of stiff setae.

Sternites: smooth and shiny. Male sternites very sparsely punctate. Sternite VII lightly granular, with traces of median and lateral longitudinal keels.

Cauda I-III wider than long, width percentage of length 118% (113-123%) for cauda I and 105% (103-107%) for cauda II and III; cauda IV narrower than long, width percentage of length 92% (87-97%); cauda V, width percentage of length 75% (70-89%); cauda II-IV, dorsal aspect of dorso-lateral keels distinctly convex.

Pectines: ♀ 38-45 and ♂ 44-52 teeth per pecten. Marginal and middle lamellae punctate.

Trichobothria: As in fig. 4.25. Orthobothriotaxic for group A. Pedipalp chela: δ eb proximal to basal dentate margin of fixed finger. Paraxial organ and hemispermatophore: Not differing diagnostically from *P. raudus* and related species.

Variation

Little or no variation between populations from different localities except in colour as follows: Populations from localities in the south-central regions of the species range, namely most of region with vegetation type 9 (fig. 2.4), are coloured as described earlier, while populations from localities south of the Orange river are much lighter in overall colour with the body deep yellowish brown No. 75 to strong yellowish brown No. 74.

Measurements

See diagnosis, figures and plates.

Carapace length of adult ♂ 10,0 mm (8,5-11,0 mm), of adult ♀ 11,8 mm (10,0-13,5).

Type material

Purcell described *P. schlecteri* on "A female (type, No. 2177) and a male from Little Bushmanland (between Henkries and Wolftoon, Max Schlecter). Also two others from Great Bushmanland." The only types remaining in the collections of the South African Museum are the former two, kept in the same jar and both with accession numbers 2177. They are unfortunately completely dismembered and it is impossible to allocate the various segments to any particular specimen. It is therefore impossible to designate a lectotype from Purcell's syntypes. As the specimens are not completely destroyed, one cannot designate a neotype, although this would be desirable.

Homotype

I have selected a ♂ homotype which was collected near the locality of the syntypes and it is deposited in the Natal Museum collection (N.M. 10935).

Material examined

1♀, 1♂ syntypes, between Henkries and Wolftoon, 1 December 1897, M. Schlecter (S.A.M. 2177); 1♂ homotype, South of Goodhouse, 30 January

1973, B. Lamoral (N.M. 10935); 1 subadult ♀, Daan Viljoen Game Reserve, February 1971, C.G. Coetzee (S.M.N. 302); 1♂, Tses, 23 February, B. Lamoral (N.M. 10934); 1 juvenile ♂, Berseba, 28 February 1976, B. Lamoral (N.M. 10770); 1♂, Huams farm. 1 February 1969, B. Lamoral, R. Day (N.M. 10061); 2 subadult ♂, Berseba, 24 February 1976, B. Lamoral (N.M. 10768); 1♂ Augrabies Falls, 4 February 1969, W. Bruwer (S.M.N. 215); 1♀, Upington, 27 January 1969, B. Lamoral, R. Day (N.M. 10062); 1♂, Schwarzkuppen farm, 8 February 1973, B. Lamoral, K. Porter (N.M. 10923); 2♀, 2♂, Noachabeb, 7-12 January (S.M.N. 322); 1♂, 1♀ 2 juveniles, Berseba, 27 February 1976. B. Lamoral (N.M. 10798); 1♀, 1 juvenile ♂, between Onanis & Walvis Bay, 4 March 1960, P. Buys (S.M.N. 153); 1♀ De Waal farm, 17 March 1969, B. Lamoral (N.M. 10060); 1♀, Mariental townlands, 5 March 1972, W.D. Haacke (N.M. 10936); 2 juvenile ♀, Keetmanshoop, 7-12 January 1972 (S.M.N. 325); 1 juvenile ♀, Neisip, 1 May 1972, L. Schultz, Prozesky (T.M. 10538); 1♂, Upington December 1962, W. Haacke (N.M. 9067); 1 juvenile ♀, Bethanie, August 1959, F. Gaerdes (N.M. 7278); 1♀, Upington, September 1920, Fr. Sollier (S.A.M. B5362); 1♂, Vogelfontein farm, April 1929, A.J. Hesse (S.A.M. B7311); 2♀, Fraserburg, January 1930, A.J. Hesse (S.A.M. B7329).

Distribution

Central regions of southern half of South West Africa (with northernmost record at the Daan Viljoen Game Reserve, west of Windhoek (S.M.N. 302), and northern regions of the Cape Province in South Africa.

Bionomics

Although fairly widespread in distribution within its range, P. schlecteri is not a commonly found species as indicated by the relatively low number of specimens collected. P. schlecteri is nocturnal, hemiedaphic and digs shallow scrapes under rocks, in soils of variable hardness and texture ranging from consolidated sand to moderately hard and gritty soils in regions with vegetation types 2, 4, 8 and 9. There are no records of schlecteri in regions with vegetation types 3, 3A, 12 and 13.

Parabuthus stridulus Hewitt, 1913

Fig. 4.26

Plates 4.26-4.29

Parabuthus stridulus Hewitt, 1914: 146-147

Synonyms

Parabuthus laevifrons concolor Hewitt, 1918: 176-177; types 2 ♀. Keetmansmanshoop (A.M.), South West Africa. All seen. NEW SYNONYM.

Parabuthus laevifrons militum Hewitt, 1918: 105; type ♂, Aus (A.M.), South West Africa. NEW SYNONYM.

Diagnosis

The following combination of characters separates P. stridulus from other species of the genus: Cauda, plates 4.26-4.29: cauda I, antero-median surface of stridulatory patch sharply inclined to the anterior descending portion; cauda II, dosrsal stridulatory patch reaching posterior margin and composed largely of transverse ridges some of which, particularly in the posterior half, extend across the surface; cauda II-IV, dorsal aspect of dorso-lateral keels sub-parallel; cauda I-V, width percentage of length 84% (81-87%) for I, 72% (69-75%) for II, 72% (69-75%) for III, 60% (58-62%) for IV, 50% (47-53%) for V, giving the cauda a slender appearance; cauda IV, median lateral keel weakly developed through entire length; telson vesicle very distinctly and deeply excavated along longitudinal half of dorso-proximal surface. Legs IV, long and slender, reaching anterior portion of cauda III. One of the medium-sized species of Parabuthus, it is most closely related to laevifrons.

Description

The following account supplements Hewitt"s original description, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ smaller and proportionately more slender with width sternite V/carapace length ratios 1,03 (1,00-1,06) for ♂ and 1,18 (1,15-1,21) for ♀ ; ♂ pedipalp fingers shorter, handback much wider, bulbous and longer with movable finger length/handback length ratios 1,28 (1,25-1,31) for ♂, 1,55 (1,49-1,61) for ♀ , while mean chela length is proportionately 13%

longer in ♂; first proximal middle lamella of each pecten sub-circular, mesially angular but not enlarged in ♂, sub-circular, mesially enlarged and lobate in ♀.

Males and females:

Colour: Carapace, chelicerae, pedipalps, tergites and sternites light olive brown No. 94 to dark orange yellow No. 72; cauda dark yellow No. 88 to strong yellow brown No. 74; legs and pectines moderate yellow No. 87 to moderate orange yellow No. 71.

Granulation: Intercarinal surfaces of cauda I-V lightly, evenly and finely granular; cauda V, accessory dorsal crest obsolete to absent, dorsal keels obsolete except in anterior one fifth. Pedipalp: chela smooth and shiny; tibia with keels, granules and tubercles as in fig. 4.26.d and e, outer surface smooth and shiny; femur with keels as in fig. 4.26.f, inner, dorsal and outer surfaces lightly granular. Carapace finely granular, interocular surface smooth and shiny, occasionally with a few scattered granules in ♀, finely granular in ♂. Tergites: I-VII finely granular throughout; I-VI, median keel poorly developed; VII, median and lateral pairs of keels poorly developed. Sternites: III-VI smooth and shiny; VII smooth and shiny medially, lightly granular laterally, median and lateral pairs of keels obsolet

Pectines: ♀ 31-37 and ♂ 37-42 teeth per pecten.

Setation: As for P. laevifrons.

Trichobothria: As in fig. 4.26. Orthobothriotaxic for group A. Pedipalp chela: δ eb proximal to base of dentate margin; δ dt distal to et. Pedipalp tibia fig. 4.26.e: δ esb$_2$ proximal to or level with esb$_1$. Pedipalp femur, fig. 4.26.f: δ d$_2$ on proximo-dorsal side of dorso-internal keel.

Paraxial organ and hemispermatophore: not varying diagnostically from those of related species.

Variation

Only in overall colour which fluctuates between the ranges describe above. One specimen from Tsirub farm, south-west of Aus, has cauda IV and V very lightly infuscated.

Measurements

See diagnosis, figures and plates.

Carapace length of adult ♂ 9.5 mm (8-11,0 mm), of adult ♀ 12,3 mm (10,0-14,5 mm).

Type material

Hewitt's holotype ♂ is in good condition in the collection of the Transvaal Museum and bears the accession number T.M. 1868 (ex 1030).

Material examined:

♂ holotype, Luderitzbucht, 26 November 1912, no collector's name (T.M. 1868); 1♂, Ugab river mouth, 18 February 1969, B. Lamoral (N.M. 10856); 1♀, Luderitzbucht, 1927, Tesdorff (N.M. 10006); 1♂, Henties Bay, May 1960, F. Gaerdes (N.M. 7307); 1 juvenile ♂, Chamais, June 1973, C.J. Coetzee (N.M. 10463); 1♀, Numaskluft, 12 October 1970, F. Burger (S.M.N. 186); 2♂, Saddle Hill, 2 November 1965, Dr Steyn (S.M.N. 257); 1♀, Grosse Bucht, 24 April 1965, W. Steyn (S.M.N. 72); 1 subadult ♀, Saddle Hill, 19 February 1966, W. Schauch (S.M.N. 230); 1♂, Saddle Hill, 2 November 1965, Dr W. Steyn (N.M. 10704); 1♀, Cape Cross, 25 March 1976, B. Lamoral, L. Ferguson (N.M. 10907); 1♀, Smithfield beach, June 1973, C.J. Coetzee (N.M. 10499); 2♂, Kolmanskop, March 1973, C.J. Coetzee (N.M. 10501); 1♀, Cape Cross, 25 March 1976, B. Lamoral, L. Ferguson (N.M. 10903); 1♂, Tsirub 13, 3 March 1976, B. Lamoral (N.M. 10778); 1♀, Cape Cross, 25 March 1976, B. Lamoral, L. Ferguson (N.M. 10898); 1♂, Cape Cross, 25 March 1976, B. Lamoral, L. Ferguson (N.M. 10904); 1♂ 1 subadult ♀, 1 subadult ♂, Ugab river mouth, 18 February 1969, B. Lamoral, R. Day (N.M. 10039); 3♀, 6 juveniles, Agate Beach, 13 February 1973, B. Lamoral, K. Porter (N.M. 10519); 2♀, 1♂, Agate Beach, February 1973, B. Lamoral (N.M. 10573); 2♂, 1♀, Swakopmund (A.M. 6421); 1♀ Swakopmund (A.M. 6486); 2♀, 1♂, Swakopmund (A.M. 6361); 2♂, 2♀, Swakopmund (A.M. 6387); 4♂, 3♀, Swakopmund (A.M. 6537); 1♂, Wlotzkabaken, 25 March 1971, J.H. Gaerdes (T.M. 10060); 1♂, Gobabeb, E. Holm (T.M. 10059); 1 subadult ♂, Sesriem, 2 May 1972, O. Prozesky (T.M. 10494); 1♀, Spencer Bay Water, 14 January 1974, W.D. Haacke (T.M. 10876); 1♂, Spencer Bay Water, 16 January 1974, W.D. Haacke (T.M. 10881); 1 subadult ♀, Spencer Bay Water, 15 January 1974, W.D. Haacke (T.M. 10886); 1 subadult ♀ , Spencer Bay Water, 16 January 1974, W.D. Haacke (T.M. 10883); 1♀ , Saddle Hill, 17 January 1974, W.D. Haacke (T.M. 19887); 1 subadult ♀ , Nordhuk, 11 January 1974, W.D. Haacke (T.M. 10865); 1 subadult ♀ , Spencer Bay Water, 11 January 1974, M.R. Kassel (T.M. 10871); 1♂, Nordhuk, 11 January 1974, W.D. Haacke (T.M. 10866); 1♀ , Spencer Bay Water, 14 January 1974, W.D. Haacke (T.M. 10878); 1♂ , Spencer Bay Water, 14 January 1974, W.D. Haacke (T.M. 10879); 3♂, Spencer Bay, 11 January 1974, W.D. Haacke (T.M. 10861-10863); 2♂, Spencer Bay Water, 13 January 1974. W.D. Haacke (T.M. 10872, 10873); 1♂, Spencer Bay Water, 14 January 1974, W.D. Haacke (T.M. 10877); 1♀ , Spencer Bay Water, 16 January 1974, W.D. Haacke (T.M. 10882); 1♂ , Spencer Bay Water, 15 January 1974, W.D. Haacke (T;M. 10885); 1♂ , Hottentot Bay, 10 January 1974, W.D. Haacke (T.M. 10860); 1♂, 1 juvenile ♀ , Saddle Hill, March 1973, C.J. Coetzee (N.M. 10508); 1 juvenile ♀ , Cape Cross, 25 March 1976, B. Lamoral, L. Ferguson (N.M. 10855); 2♂, Swakopmund, 24 March 1976, B. Lamoral, L Ferguson (N.M. 10853); 1♀ , Cape Cross, 25 March 1976, B. Lamoral, L. Ferguson (N.M. 10737); 1♂, Cape Cross, 25 March 1976, B. Lamoral L. Ferguson (N.M. 10756).

Distribution

The Namib sand system (see fig. 2.8) with the northernmost record being the Ugab River mouth and the southernmost just north of the Orange River. In the southern Namib the easternmost record is Tsirub Farm (south West of Aus) and in the central Namib, Gobabeb.

Bionomics

P. stridulus is nocturnal but specimens have occasionally been found wandering in the open in daytime. It is hemiedaphic, psammophilous and digs shallow burrows at the base of small dunes which have become consolidated by perennial vegetation such as shown in plates 2.11 and 2.12. and its distribution is confined to regions with vegetation type 2,3 and 3A. In addition, within these areas of distribution *stridulus* is seldom found far from the littoral zone where it is the most commonly found species of *Parabuthus*. At Cape Cross, *stridulus* is sympatric with *new species B* and *Uroplectes pilosus*. In vegetation zone 2 it is sympatric with *Opisthophthalmus litoralis*.

Parabuthus villosus (Peters, 1862)

Fig. 4.27-4.29
Plate 4.30

Buthus villosus Peters, 1862: 26

Diagnosis

The following combination of characters separates *P. villosus* from other species of the genus. Caudal segments, plate 4.30: cauda IV, with 10 distinct granular keels, ventrals posteriorly undefined; cauda I, dorsal stridulatory area, well developed, consisting of round to slightly crescent-shaped fine granules reaching the posterior margin; cauda II, dorsal stridulatory area narrow, finely granulated and not reaching posterior margin; cauda I-V and telson densely pilose. The largest specie of *Parabuthus* from South West Africa, *villosus* is most closely related to *P. brachystylus*, its sibling species.

Description

The following account supplements Peters' original description, Purcell's (1901: 158-162) comprehensive supplement, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionately smaller and slightly more slender with width sternite V/carapace length ratios 1,10 (1,06-1,14) for ♂ and 1,25 (1,20-1,31) for ♀ ; ♂ pedipalp chela fingers shorter, handback wider and longer with movable finger length/handback length ratios 1,55 (1,46-1,62) for ♂ and 2 (1,97-2,16) for ♀ while mean chela length is only 5% less in ♂; first proximal middle lamella sub-rectangular, mesially angular and not enlarged in ♂ , sub-oval, mesially enlarged and lobate in ♀ .

Males and females:

Colour: Specimens from localities within region ii in fig. 4,29 and list of material examined have the following colouration: body and appendages, excepting pedipalps, legs and pectines, dark brown No. 59 to brownish blac No. 65 with tergites and carapace usually the darkest; pedipalps, deep brown No. 56 to dark brown No. 59; legs, strong yellow No. 84 to dark oran yellow No. 72; pectines moderate yellowish brown No. 77. Specimens from region i have brownish black No. 65 bodies and appendages. Specimens from region iii have dark brown No. 59 to brownish black No. 65 bodies but brilliant yellow No. 83 to strong yellow pedipalps, legs and pectines while the sternites are intermediately lighter than the body but darker than the appendages. Specimens form region iv are similar to those from region iii but have progressively darker appendages towards the coastal areas, some specimens being nearly as dark as those from region i. Specimens from all four regions have a wide triangular pallid marking medially on the posterior margin of sternite V.

Sternites: In ♀ only, sternite I, with a prominent antero-medial subcircular gibose swelling, pallid in most specimens.

Cauda: adult ♂ & ♀ , telson width 97% (94-101%) of cauda V width; cauda V, accessory dorsal crest composed of spiniform tubercles, distal half of ventro-lateral keels with moderately enlarged, laterally compressed subspinose processes; cauda I-IV progressively decreasing in width, cauda IV 9% (8-10%) narrower than I; cauda I-III longer than wide, width percentage of length 95% (92-98%) 85% (80-89%) and 82% (78-85%) respectively; cauda V, width percentage of length 60% (56-64%); cauda II-IV, dorsal aspect of dorso-lateral keels subparallel; cauda I III, distal granule of dorsal keel enlarged; cauda II-III, distal granule of ventral keels, and to a lesser extent ventro-lateral keels, distinctly enlarged, obtuse and elevated.

Pectines: ♀ 34-41 and ♂ 36-42 teeth per pecten.

Trichobothria: As in fig. 4.27. Orthobothriotaxic for group A. Pedipalp chela: o̍ eb distal to basal dentate margin of fixed finger; o̍ db much clos to est than esb. Pedipalp femur, fig. 4.25.e: o̍ d_2 on proximo-internal side of dorso-internal keel; o̍ d_3 level with to slightly distal to d_2; o̍ d_4 closer to d_3 than d_5.

Paraxial organ and hemispermatophore: Hemispermatophore as in fig. 3.6.a, not differing diagnostically from related species.

Haemolymph electrophoresis

Phoregrams were prepared from haemolymph of specimens collected from three different localities in each of regions i to iv delimited in fig. 4.29. The distribution and number of bands obtained are illustrated in text fig. 4.28.b. No significant differences were found between males and females and between samples from the four different regions. R_m values were found to be consistent. The differences between the phoregrams of

P. villosus and brachystylus are discussed in the description of brachystylus.

Variation

Mainly in colouration as described earlier.

Measurements

See figures and plates.

Carapace length of adult ♂ 11 mm (10-13), of adult ♀ 15 mm (13-17).

Type material

Peters' syntypes were presumed lost. They were rediscovered in the collection of the Zoologisches Museum Berlin, in east Berlin. It is not known how many syntypes there are. One ♂ from sample Z.M.B. 2303 was examined and is hereby selected as the LECTOTYPE of Parabuthus villosus and it has been labelled accordingly.

Homotype

I have selected a ♂ homotype which is deposited in the Natal Museum collection (N.M. 10531).

Material examined

♂ lectotype, "Neu Barmen" (Note: this locality cannot be found in any gazetteer or map consulted) no date, Hahn (Z.M.B. 2303); ♂ homotype, Vioolsdrift, February 1973, B. Lamoral.

The Roman numerals used below refer to material from the different regions in fig. 4.29.

(i)

1♀, Gobabeb, February 1973, B. Lamoral (N.M. 10740); 1♂, Gobabeb, February 1973, B. Lamoral (N.M. 10765); 1♂, id. (N.M. 10764); 1♀, Gobabeb, February 1972, B. Lamoral (N.M. 10527); 1♂ Emeritus farm, 18 March, 1968, Kapt. F.A. Pietersen (S.M.N. 67); 1♀, Gonab, 16 September 1971, P.G. Olivier (S.M.N. 355); 1♀, Gobabeb, 1 December 1971, R.H. Taylor (N.M. 10535); 1♂, Gobabeb, 25 November 1971, A. Durr (N.M. 10535); 1♂, 1♀, 1 juvenile ♂, Gobabeb, 5 March 1963, P. Buys (S.M.N. 105); 1 subadult ♂, 1 juvenile ♂, 1 juvenile ♀, Gobabeb, 6 March 1963, P. Buys (S.M.N. 103); 2♂, 1♀, Albrechtshohe, 9 March 1970, H. Mittendorf (S.M.N. 160); 1♀, Aus, 16 January 1972, Eastwood and Gauchal (N.M. 10451); 1♂, Namibflache, 1938, Dr G. Ross (N.M. 10093); 1♀, Uis Tinmyn, 3 September 1963, Mr Hass (S.M.N. 82); 1♀ Uis, December 1968, J.J. Nel (T.M. 10046);

1♀ , Uis, 1969, J. Bezuidenhout (T.M. 10110); 1♂, Uis (T.M. 9393); 1♀ , Rooiberg, 17 July 1970, G. Newlands (T.M. 10126); 1♀ , Ugab-drif, 6 March 1966, P.S. Swart (S.M.N. 127); juvenile ♀ , Cape Cross, 8 June 1963, H. Els (S.M.N. 69); 1♂, Gobabeb, February 1972, B. Lamoral (N.M. 10528); 1♂ , Cape Cross, 22 December 1965, S.M. Steyn (S.M.N. 71); 1♀ , Gobabeb, February 1973, B. Lamoral (N.M. 10761); 1♀ , Gobabeb, May 1959, R.F. Lawrence, R. Paulian (N.M. 7264); 1♂ , Gobabeb, December 1963, C. Koch (N.M. 9061); 1 juvenile ♂ , Namib, January 1962, F. Gaerdes (N.M. 8334); 1♂, Swakopmund, March 1962, F. Gaerdes (N.M. 8373); 1♂, Gobabeb, December 1963, C. Koch (N.M. 9060); 1 juvenile ♀ , Tchab, May 1959, R.F. Lawrence (N.M. 7266); 2♂, Gobabeb, December 1963, C. Koch (N.M. 9062-N.M. 9063).

(ii)

1♀ , Portsmut 33, 19 September 1972, Jones & Strydom (T.M. 10467); 1♂, Valencia 42, March 1970, A.C, Kemp (T.M. 9873); 1♀ , Valencia, March 1970, A.C. Kemp (T.M. 10058); 1♂ , Wlotzkabaken, 25 March 1971, J.H. Gaerdes (T.M. 10061); 1♀ , Valencia 42, March 1970, A.C. Kemp (T.M. 9874); 1♂, Rosh Pinah, April 1971, J.J. Nel (T.M. 10105); 1♀ , Tumas Mountain, 9 May 1972, Mr & Mrs Prozesky (T.M. 10487); 1♀ , Swakopmund, 24 June 1971, Ben Benade (T.M. 10081); juvenile ♀ , Valencia 42, 7 March 1970, A.C, Kemp (T.M. 9875); 1 juvenile ♀ , Portsmut 33, 19 April 1972, Jones & Strydom (T.M. 10466); 1 juvenile ♀ , Portsmut 33, 19 April 1972, Jones & Strydom (T.M. 10468); 1♀ , Plateau, 1972, H. Erni (T.M. 10524); 1♂, Plateau 1972, H. Erni (T.M. 10526); 1♀ , Portsmut 33, 19 April 1972, Jones & Strydom (T.M. 10471); 1♀ , Plateau, 1972, H. Erni (T.M. 10523); 1♀ , Aus, Erni (T.M. 9735); 1 juvenile ♀ , Swartbank, 20 January 1971, A. Strydom (T.M. 10025); 1♂ , Rosh Pinah, December 1972, A. Maritz (T.M. 10672); 1♀ , Rosh Pinah, December 1972, A. Maritz (T.M. 10673); 1♀, Gobabeb, Erni, (T.M. 9737); 1 juvenile ♂, Portsmut 33, 19 April 1972, Jones & Strydom (T.M. 10469); 1♀ , Rosh Pinah, 9 June 1971, A. Maritz (T.M. 10119); 1 juvenile ♀ , Portsmut 33, 19 April 1972, Jones & Strydom (T.M. 10470); 1♀ , Rosh Pinah, January 1971, A. Maritz (T.M. 10243); 1♀ , Rosh Pinah, March 1971, J. Botha (T.M. 10050); 1♀ , Windhoek, 12 December 1966, J.J. Boshoff (S.M.N. 42); 1♀ , Kochenau, 11 March 1971 (S.M.N. 267); 2 juvenile ♂, 1 juvenile ♀ , Portsmut 33, 19 April 1972, Jones & Strydom (N.M. 10526); 2♀ , Portsmut, 7 February 1969, B. Lamoral & R. Day (N.M. 10074); 1♀ , 2♂ , Valencia, 6 February 1969, B. Lamoral & R. Day (N.M. 10025); 1♂, Valencia, 6 February 1968, A. Port (N.M. 10024); 2♀ , Aar 38, 16 October 1970, P.J. Buys (S.M.N. 179); 1♀ , Windhoek, Graf zu Castell (S.M.N. 37); 1♀ , Rostock 393, 29 August 1966, J. Hugo (S.M.N. 51); 1♀ , 1♂, Lichtenstein Mitte, 1 September 1962, E. Rush (S.M.N. 86); 1♂, Windhoek, J. Tromp (S.M.N. 34); 1♀ , Matchless Myn, 8 September 1961, P.J. Buys (S.M.N. 65); 1♀ , Windhoek, September 1961, Mr Schenker (S.M.N. 18); 1♀ , Daan Viljoen Gane Reserve, 21 July 1966, N. du Plessis (S.M.N. 88); 2♀ , Tantus, 8 February 1966, W.T.H. Mannengresser (S.M.N. 56); 1♂, Windhoek, October 1961, J. Honguta (S.M.N. 28); 1♀ , Berseba, 18 August 1965, W. Steyn (S.M.N. 75); 1♀ , Klein Windhoek, 16 March 1971 (S.M.N. 266); 1♀ , Windhoek, 21 March 1963, J. Cloete (S.M.N. 38); 1♀ , Windhoek, 5 February 1962, W. Giess (S.M.N. 41); 1♀ , Windhoek, February 1971 (S.M.N. 273); 1♀ , Windhoek, 25 September 1962, W. Giess (S.M.N. 6); 1♀ , Alte Feste, 25 August 1967, A. Isaacs (S.M.N. 1); 1 juvenile ♀ , Tantus, 16 November 1966, W.J.H. Kannegiesser (S.M.N. 48); 1♀ Windhoek, 11 March 1963 (S.M.N. 19); 1♂, Eros, 3 November 1963, Mr Erasmus (S.M.N. 13); 1♂, Kranzberg, 23 March 1976, B. Lamoral & L. Ferguson (N.M. 10911); 1 juvenile ♂, Lichtenstein Mitte, 21 January 1960, E. Rusch (S.M.N. 87); 2♀ , Goreangab Dam, 19 December 1973, C.G.C., M-L.P., E.M., J.B.S. Oosthuizen (S.M.N. 499); 1 juvenile ♂, Goreangab Dam, 12 February 1971 (S.M.N. 271); 1♀ , Daan Viljoen Game Reserve, C.G. Coetzee (S.M.N. 302); 2♀ , 2♂, Goreangab Dam, 18 May 1972, P.G.O. (S.M.N. 380); 1 subadult ♂, Windhoek, 2 July 1970, J. Viljoen (S.M.N. 157); 1 juvenile ♀ , Windhoek, 5 November 1964, J. Angula (S.M.N. 15); 1♂, Windhoek, 28 June 1961, W. Giess (S.M.N. 7); 1 juvenile ♂, Otjombane, 8 September 1961, P.J. Buys (S.M.N. 142); 2♀ , 145 km along Uspass Road from Gobabeb side (22° 50' S, 16° 50' E), 15 November 1974, S. Enrödy-Younga (T.M. 11092 and 11094); 1♂, Rudenau Nord, 14 March 1974, J. Tebje, V. Stewart, W. Williams (S.M.N. 518); 1 juvenile ♂, Djab, 14 August 1961, E. Rusch (S.M.N. 143).

(iii)

1♀ , Fish River Canton, 16 July 1971, S. Reynders (N.M. 10529); 1♀ , Hardop Dam, 15 November 1967 (S.M.N. 375); 1♀ , Naus, 6 October 1972, H.C. Strauss (S.M.N. 390); 1♀ , Sandmund, December 1968, C.H. Steenkamp (N.M. 10536); 1♀ , Neisip, 18 October 1970, I. Mokgoabone (S.M.N. 193); 1♂, Kuibis North 168, 28 February 1976, B. Lamoral (N.M. 10775); 1♀ , Fish River Canyon, 25 June 1974, J. Lensing (S.A.I.M.R. 870); 1 juvenile ♀ , Fish River Canyon, 8 April 1976, B. Lamoral & L. Ferguson (N.M. 10831);

1 subadult ♀ , Guruchab River, 10 February 1974, L. Wingate (N.M. 10545); 1♂, Narudas Sud 268, 22 January 1976, B. Lamoral (N.M. 10774); 1♀ , Gorrasis 99, 29 January 1974, C.G.C., C.G., M-L.P., J.B., E.M. (S.M.N. 509); 2♀ , Blinkoog, 14-17 October 1971 (S.M.N. 314); 1♂, Upington, 25 January 1971, S. Engelbrecht (N.M. 10530); 1♀ , Ai Ais, 29 April 1966, Natuurbewaring (S.M.N. 177); 1♂, Ortmansbaum farm, 26-28 January 1973, Lamoral & Raw (N.M. 10517); 1♀ , Amnisfontein, 21 November 1975, E. Griffin (S.M.N. 568); 1♀ , Swartmodder farm, January-February 1973, Mrs S. Engelbrecht (N.M. 10514); 1♀ , Richtersveld, July 1973, van Dyck (N.M. 10534); 1 juvenile ♀ , Narudas Sud 268, December 1975, MrMaritz (N.M. 10773); 1 juvenile ♀ , Narudas Sud 268, 23 February 1976, B. Lamoral (N.M. 10784); 2 juvenile ♀ , Barby 26, 2-8 October 1972, State Museum staff (S.M.N. 391); 1♀, 1♂, Bethanie, August 1959, F. Gaerdes (N.M. 7275-N.M. 7276).

(iv)

1♀ , Rosh Pinah, April 1971, J. Botha (T.M. 10055); 1 subadult ♀ , Swartberg, June 1973, C.J. Coetzee (N.M. 10497); 1♀ , juvenile ♀ , 1 juvenile ♂, Bakers Bay, June 1973, C.J. Coetzee (N.M. 10507); 3♀ , 1♂, Plateau 38, 29 February 1976, B. Lamoral (N.M. 10805); 1♀ , Kubub 15, 2 March 1976, B. Lamoral (N.M. 10779); 2♀ , 1♂, Tsirub 13, 3 March 1976, B. Lamoral (N.M. 10730); 3♀ , Plateau farm, 14 February 1973, B. Lamoral (N.M. 10461); 1♂, Aar 16, 29 February 1976, B. Lamoral (N.M. 10780); 1♂, Namuskluft 88, 11 September 1970, F. Burger (S.M.N. 185); 1♀, Plateau, 15 -18 January 1972 (S.M.N. 320); 1♀ , Baker's Bay, 30 April 1972, C.J. Coetzee (S.M.N. 367); 1♂, Rosh Pinah, February 1971, J. Botha (N.M. 10921); 1♀ , Zuidsrivier, February 1972, B. Lamoral (N.M. 10532); 1 nymph ♀ , Koichab pan, 20 July 1966, P. Wiplinger (S.M.N. 170); 1♂, 6♀ , Plateau farm, October 1973, H. Erni (N.M. 10503); 1♀ , 1 juvenile ♂, Namuskluft 88, 21-22 September 1973, M-L. Penrith, J. Tebje (S.M.N. 486); 1♀ , Namuskluft 88, 20 September 1973, M-L. Penrith (S.M.N. 489); 1 juvenile ♂, Obib Dunes, 16-20 September, E. Mokgoabone (S.M.N. 485); 1♀ , Richtersveld, June 1923, Smith (N.M. 11034).

Distribution

North western Cape Province and as in fig. 4.29 for South West Africa.

Bionomics

P. villosus is predominantly nocturnal but specimens have occasionally been found wandering in the open around midday in the Namib Desert Park. It is hemiedaphic, digs shallow scrapes under rocks in soils of widely variable hardnesses and texture, ranging from consolidated sand to hard and gritty soils. This wide adaptability probably accounts largely for its extensive distribution in South West Africa. With *P. granulatus*, *villosus* is one of the more commonly found buthid scorpions of South West Africa and both are often cosmopolitan. *P. villosus* is often sympatric with *granulatus*, and occasionally *kalaharicus*, *schlecteri* and *raudus*.

Parabuthus brachystylus
Lawrence, 1928

Fig. 4.28, 4.29

Parabuthus brachystylus Lawrence, 1928: 270-273

Diagnosis

Parabuthus brachystylus is a sibling species of *P. villosus*, but can be separated from the latter by the following combination of morphological characters: dorsal stridulatory area of cauda II reaching posterior margin; cauda I wider than long, width percentage of length 106% (103-109%). The two species are further separated by the differences in the number of haemolymph protein bands in phoregrams as shown in fig. 4.28.

Description

Lawrence's original description was based on 2♀ and 3♂. Access to additional material from a wide selection of localities has shown that most of the diagnostic characters selected by Lawrence are so variable as to bridge the particular character sets proposed by him for *P. brachystylus* and *villosus* and that the only reliable morphological characters available are those listed in the diagnosis.

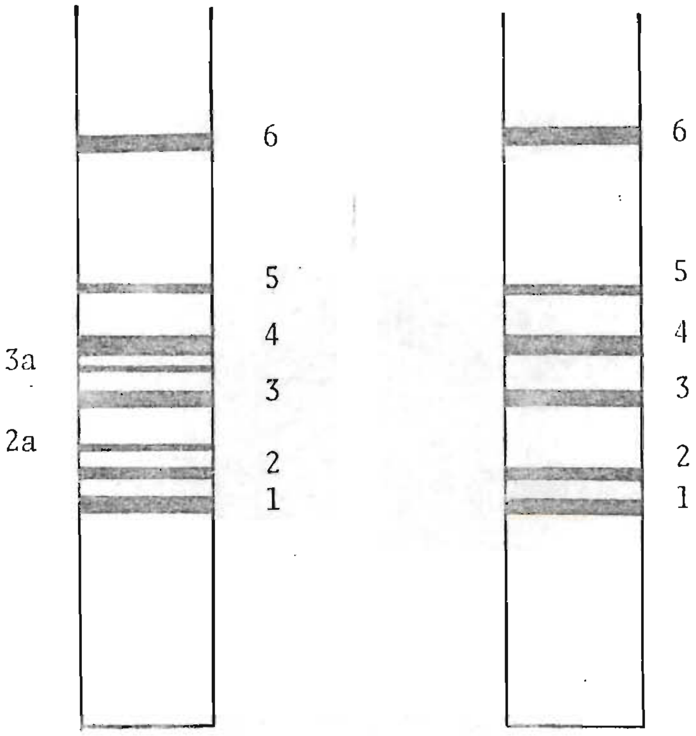
Males and females:

Colour: Specimens from localities near the southern limits of the species range have a slightly lighter overall colour than that described by Lawrence and they do not differ markedly from specimens of *P. villosus* from adjacent region i in fig. 4.29.

Trichobothria and hemispermatophore: As for *P. villosus*.

Haemolymp electrophoresis

Phoregrams were prepared from haemolymph of specimens collected from four different localities across an approximately North-South axis of the species range. The distribution and number of bands obtained are shown in text fig. 4.28.a. No significant differences were found between



(a) (b)

Fig. 4.28. Diagrammatic representation of phoregrams from haemolymph of: a, *Parabuthus brachystylus*; b, *P. villosus*.

males and females and the R_m values were found to be consistent. Fig. 4.28.a shows that *P. brachystylus* has two additional bands, labelled 2a and 3a, which are not present in phoregrams of *P. villosus*.

Goyffon (1973: 138-144 and fig. 1) has shown that in zones of sympatry, serological hybrids are occasionally found. *P. brachystylus* and *villosus* have identical R_m values for bands 1-6 and hybrids would therefore be impossible to detect. In any case, from available locality records, the two species appear to be allopatric. Finally no indication could be found that the differences in number and distribution of bands are clinal between the two species. On the above evidence, it is concluded that *P. brachystylus* and *villosus* are not conspecific, and that they are sibling species.

Variation

Mainly in colouration as described earlier.

Type material

The type series consists of 2♀ and 3♂ syntypes, no holotype having been designated. The ♀ from Kamanjab (S.A.M. 6087) is hereby selected as the LECTOTYPE of *Parabuthus brachystylus* and the remaining specimens are PARALECTOTYPES. This material has been labelled accordingly and is deposited in the South African Museum.

Material examined.

♀, lectotype, Kamanjab, 1926, R.F. Lawrence (S.A.M. 6087); 1♀, 3♂, paralectotypes, Kaoko Otavi, 1926, R.F. Lawrence (S.A.M. 6794). 1♂, Equimina, 15 October 1970, I.D. Connell (T.M. 10034); 1♀, Hoas, 1971, J. Labuschagne (T.M. 10143); 1♂, Twyfelfontein, 25 June 1963, Dr Scherz (S.M.N. 104); 1 juvenile ♀, Kaoko Otavi, 27 November 1970, P.G. Olivier (S,N,B, 238); 2♀, 1 juvenile, Kaokoveld (S.A.M. 6794); 1♀, Kamanjab, 5 April 1976, B. Lamoral & L. Ferguson (N.M. 10833); 1♂, Grootberg 191, 2 April 1976, B. Lamoral & L. Ferguson (N.M. 10913); 1♀, Orupembe, 14 November 1965, W. Steyn (S.M.N. 114); 1♀, Messum Crater area, 26 March 1976, B. Lamoral & L. Ferguson (N.M. 10823); 1♂, 1 subadult ♀, Kamanjab, 25 February 1969, B. Lamoral & R. Day (N.M. 10044); 1♂, Kaoko Otavi, 27 November 1970, P.G. Olivier (S.M.N. 237); 1♀, Orupembe, June 1965, P. Buys (S.M.N. 113); 1 juvenile, Welwitschia, August 1960, F. Gaerdes (N.M. 7321); 1♀, Kaoko Otavi, April 1966, W.G.H. Coaton (N.M. 9116); 1 juvenile ♀, Messum Crater 26 March 1976, B. Lamoral & L. Ferguson (N.M. 10846); 1♂, Ohopoho, March 1972, Erasmus (S.M.N. 344); 1 subadult ♂, Sesfontein, 3 April 1976, B. Lamoral, L. Ferguson (N.M. 10733).

Remark. The following locality should be regarded as extremely dubious: 1♂, Gobabeb, no date, no collector's name (T.M. 9363).

Distribution

As in fig. 4.29. Also see appendix 3.

Bionomics.

Although one of the larger species of Parabuthus, P. brachystylus is not a commonly occurring species, as indicated by the relatively low number of specimens collected. It is nocturnal, hemiedaphic, occasionally epigeic on shrubs and small trees when hunting, and digs shallow scrapes under rocks or fallen trees, in soils of variable hardness and texture, ranging from consolidated sand to moderately hard and gritty soils. A few specimens have been found under the loose bark of fallen trees, sharing this habitat with Buthotus conspersus.

4. Genus *Uroplectes* Peters, 1861

Type species: *Uroplectes ornatus* Peters, 1861

Diagnosis

Uroplectes is separated from the other genera of the family Buthidae by the following combination of characters: no teeth on ventral proximal margin of fixed finger of chelicerae; no stridulatory area on dorsalsurface of cauda I and II; telson vesicle with or without subaculear tubercle; tergites with a median keel, with or without lateral accessory keels; carapace without keels or with only vestigial posterior median keels; carapace anterior margin always very slightly recurved, with a very small median projection; granular rows of fixed and movable fingers of pedipalp with at least one inner and one outer flanking tooth; sternum subtriangular in shape; distal end of hemispermatophore of male with pars recta and pars reflecta to flagellum.

Distribution

Most of Afrotropical region (excepting Zaire basin and regions west and north-west of Cameroun) and Oriental faunal region.

Key to the South West African species of *Uroplectes*

1. Pedipalp femur, figs 4.38. f, 4.40.e, 4.41.f: ♂ on proximo-dorsal side of dorso-internal keel. Pecten, fig. 4.32. f, plates 4.37, 4.39, 4.41: first proximal tooth of ♀ falciform and much longer than adjacent teeth 2

\- Pedipalp femur, figs 4.30.f, 4.34.f, 4.35.e, 4.36.f, 4.37.f, 4.39.f: ♂ d_2 on proximo-internal side of dorso-internal keel.

Pecten, fig. 4.32.e, plates 4.31-4.36, 4.38: first proximal tooth of ♀, much wider than but never longer than adjacent teeth, rarely completely unmodified 4

2. Caudal segments, plates 4.39, 4.40, fig. 4.33.c: cauda III and IV, deeply infuscated to black; cauda IV, ventral keel obsolete to absent; cauda V, ventro-median keel distinct, composed of fine granules; caudal segments distinctly long and slender, with cauda IV length/width ratios 3,3 in ♀, 3,1 in ♂. Pedipalp hand, fig. 4.40.a: movable finger length/handback length ratios 2.85 in ♀, 2,55 in ♂; ȯ Esb distal to or level with Est. Pedipalp tibia, fig. 4.40.c-d: length/width ratio 3,5 in ♀; ȯ et level with or proximal to est; ȯ em markedly proximal to et; ȯ esb_2 almost level with esb_1. Pedipalp femur, fig. 4.40.e: ȯ e_1 level with d_5; distance between ȯ d_5 - e_2 equal to that between d_1 - d_3. Pectines: ♀ 36-40 and ♂ 40-44 teeth per pecten ... . *teretipes* Lawrence

\- Caudal segments, plates 4.37, 4.39, figs 4.33. a-b: cauda III and IV same colour as other segments, never blackened; cauda IV, ventral keels either costate or granular; cauda V, ventro-median keel indistinct; caudal segments not distinctly long and slender, with cauda IV length/width ratios 2,0-2,2 in ♀, 2,5-2,7 in ♂. Pedipalp hand, figs 4.38.a-c, 4.41. a-c: movable finger length/handback length ratios 1,5-1,9 in ♀, 1,40-1,60 in ♂; ȯ Esb distinctly proximal to Est. Pedipalp tibia, figs 4.38. d-e, 4.41.d-e: length/width ratios 2,3-2,7 in ♀; ȯ et markedly distal to est; ȯ em almost level with et; ȯ esb_2 markedly distal to esb_1. Pedipalp femur, figs 4.38. f, 4.41.f: ȯ e_1 proximal to d_5; distance between d_5 - e_2 double that between d_1 - d_3. Pectines: ♀ 17-26 and ♂ 24-28 teeth per pecten 3

3. Pedipalp hand, fig. 4.38.a-c: almost apilose; movable finger length/handback length ratios 1,80 (1,70-1,90) in ♀ , 1,55 (1,50-1,60) in ♂; handback laterally compressed, upper margin distinctly lobate in adults with handback length/handback ventral width ratio 1,85 (1,80-1,92) in ♀ & ♂ and handback width/handback ventral width 1,80 (1,75-1,86) in ♀ & ♂; inner surface of handback flat and smooth. Pedipalp tibia, fig. 4.38.d: moderately broad in ♀ , length/width ratio 2,7 (2,65-2,75). Caudal segments, fig. 4.33.b, plate 4.37: cauda IV, ventro-lateral and ventral keels poorly developed, consisting of shallowly costate rows of fine granules; cauda V, ventro-lateral and ventro-median keels as in cauda IV; cauda V, ventro-lateral keels moderately diverging from each other; telson vesicle ventrally aggranular and moderately punctate, sub-oval in lateral outline. Hemispermatophore, fig. 4.31.f: basal lobe, subtriangular in outline, pars recta length/inner lobe length ratio 10 (9-11) .... planimanus (Karsch

- Pedipalp hand, fig. 4.41.a-c: distinctly pilose; movable finger length/handback length ratios 1,50 (1,45-1,55) in ♀ ; 1,40 (1,35 - 1,45) in ♂; handback laterally bulbous, upper margin not lobate in adults, handback length/handback ventral width ratio 1,40 (1,35-1,45) in ♀ and ♂ and handback width/handback ventral width 1,1 (1,0-1,2) in ♀ & ♂ ; inner surface of handback distinctly convex and granulated. Pedipalp tibia fig. 4.41.d; distinctly broad in ♀ , length/width ratio 2,30 (2,25-2,35). Caudal segments, fig. 4.33.a, plate 4.41: cauda IV, ventro-lateral and ventral keels well developed, consisting of elevated rows of distinct granules; cauda V, ventro-lateral and ventro-median keels as in cauda IV; cauda V, ventro-lateral keels sub-parallel to each other;

telson vesicle ventrally, moderately granular, subcircular in lateral outline. Hemispermatophore, fig. 4.31.i: basal lobe , sub-lobate in outline, pars recta length/inner lobe length ratio 5 (4-6) ... <u>new species A</u>

4. Caudal segments: cauda II-V, median-lateral, ventro-lateral and ventral keels completely absent, dorso-lateral and dorsal keel almost completely absent, represented only by a distal granule and sometimes in cauda II-III by a row of small granules. Tergites I-VI, without traces of a lateral keel on each side posteriorly, in addition to the median keel. Pedipalp hand, fig. 4.36.a-c: ♂ eb extremely basal in position and almost level with et; ♂ Eb_3 always proximal to Eb_2; ♂ Eb_2 much closer to Eb_1 than Eb_3. Pedipalp tibia: figure 4.36. e. ♂ em distinctly proximal to est. Hemispermatophore, fig. 4.31.c: outer margin of basal lobe serrated; pars recta short, pars recta length/inner lobe length ratio 3,5 or less 5

\- caudal segments: cauda II-V, ventro-lateral, dorso-lateral and dorsal keels always present and ranging from poorly to well developed. Tergites I-VI, with traces of a lateral keel on each side posteriorly, in addition to the median keel. Pedipalp hand, figs 4.30.a-c, 4.34.a-c, 4.35.a-b, 4.37.a-c. 4.39.a-c: ♂ eb never extremely basal in position or almost level with Et; ♂ Eb_3 either level with or distal to Eb_2; ♂ Eb_2 much closer to Eb_3 than Eb_1. Pedipalp tibia, figs 4.30.e, 4.34.e, 4.35.d, 4.37.e, 4.39.e: ♂ em either almost level with or distal to est. Hemispermatophore, figs 4.31. a-b, d & g: outer margin of basal lobe never serrated; pars recta length/inner lobe length ratios 4,5-8,0 6

5. Telson vesicle without a subaculear tooth. Pectines: ♀ 14-15, ♂ 15-17 teeth per pecten. Tergites I-VII, with a dark median band ... ... <u>otjimbinguensis</u> (Karsch

- Telson vesicle with a distinct subaculear tooth. Pectines: ♀ 19-20, ♂ 20-22 teeth per pecten. Tergites I-VII, with a pale median band flanked by a dark lateral band on either side ... ... vittatus (Thorell)

6. Pedipalp hand, fig. 4.30.a-c: movable finger length/handback length ratio 1,55 or less in adult ♀ & ♂; proximo-mesial cutting edge of movable finger distinctly procurved in ♀, distinctly recurved in ♂; proximo-mesial cutting edge of fixed finger sub-linear in ♀, distinctly recurved in ♂. Pedipalp tibia, fig. 4.30.e: length/external width ratio 2,55 in ♀, 3,2 in ♂. Caudal segments of adults: short and wide, length/width ratio for cauda I 1,05 (1,0-1,10) in ♀, 1,30 (1,25-1,35) in ♂ and for cauda IV, 1,75 (1,70-1,80) in ♀, 2,20 (2,10-2,30) in ♂; cauda II-IV, dorsal, dorso-lateral, ventro-lateral and ventral keels well developed, consisting of elevated rows of distinct granules; cauda V, ventro-lateral keels well developed along their entire length, consisting of spiniform tubercles. Tergites I-VII and posterior region of carapace, plate 4.31: with a dark median band; tergites I-VI with reticulate dark markings laterally between the lateral keels and lateral margins almost forming a continuous band. Carapace: interocular surface with a dark triangular marking ... ... carinatus (Pocock)

- Pedipalp hand, figs 4.34.a-c, 4.35.a-b, 4.37.a-c, 4.39.a-c: movable finger length/handback length ratio 1,90-2,30 in ♀ and 1,80-2,00 in ♂; proximo-mesial cutting edge of movable finger and fixed fingers sub-linear to slightly procurved in ♀ and ♂, never recurved. Pedipalp tibia, figs 4.34.e, 4.35.d, 4.37.e, 4.39.e: length/external width ratios 4,0-4,3 in ♀, 4,1-4,5 in ♂. Caudal segments of adults: varyingly elongated, length/width ratio for cauda I 1,25-1,60 in ♀, 1,70-1,90 in ♂ and for cauda

IV, 1,80-2,50 in ♀ , 2,50-3,30 in ♂; cauda II-IV, dorso-lateral, ventro-lateral and ventral keels moderately to poorly developed, consisting of costate rows or sub-linear rows of granules; cauda V, ventro-lateral keels as in cauda IV. Tergites I-VII and posterior region of carapace: median and lateral keels infuscated in some species, but without median and lateral bands as in carinatus. Carapace: interocular surface very seldom with a dark triangular marking 7

7. Caudal segments, figs 4.32.c-d, plates 4.32, 4.38: cauda I-V sparsely pilose; cauda III-IV, ventro-lateral and ventral keels moderately to well developed, always distinguishable. Pedipalp hand, figs 4,34.a-c and 4.39.a-c: handback inner surface markedly procurved, handback length/handback ventral width ratio 1,55-1,75 in adult ♀ and ♂; handback, inner surface near fixed finger base with a few scattered granules. Pedipalp tibia, figs 4.34.d-e & 4.39.d-e: dorso-internal keel moderately to well developed along entire length; δ est, et & em triangular in distribution. Pedipalp femur, fig. 4.34.f & 4.39.f: dorso-internal and dorso-external keels well developed along entire length, consisting of enlarged granules 8

- Caudal segments, fig. 4.33.d, plates 4.33 & 4.36: cauda I-V densely pilose; cauda III-IV, ventro-lateral and ventral keels obsolete to poorly developed or undistinguishable from adjacent granules. Pedipalp hand, figs 4.35.a-b & 4.37.a-c: handback inner surface slightly procurved, handback length/handback ventral width ratio 1,90-2,15 in adult ♀ and ♂; handback inner surface near fixed finger base smooth. Pedipalp tibia, figs 4.35.c-d & 4.37.d-e: dorso-internal keel proximal one quarter absent, remaining length obsolete; δ est, et and em falciform in distribution. Pedipalp femur, figs. 4.35.e & 4.37.f: dorso-internal and dorso external keels poorly developed. 9

8. Caudal segments, fig. 4.32.c, plate 4.32: cauda V, ventro-median keel indistinct from adjacent granules, ventro-lateral keel granular; cauda IV, ventral keels clearly defined in anterior half only, ventro-lateral keels granular and distinctly recurved in posterior half; cauda IV, adults, length/width ratios 1,90 (1,75-2,05) in ♀ 2,45 (2,35-2,55) in ♂; cauda II-III, ventro-lateral and ventral keels granular. Pedipalp hand, fig. 4.34.a-c: δ eb level with mesial base of fixed finger; distance δ et-dt > est-et. Pedipalp tibia, fig. 4.34.d: distance δ d_1 - d_2 equal to half of distance δ d_3 - d_4. Hemispermatophore as in fig. 4.31.a. ... ... *gracilior* Hewitt

- Caudal segments, fig. 4.32.d, plate 4.38: cauda V, ventro-median keel distinct, consisting of a slightly elevated twin row of small granules, ventro-lateral keel consisting of small costate granules; cauda IV, ventral and vento-lateral keels costate granular, the latter not distinctly recurved in posterior half; cauda IV, adults, length/width ratios 2,5 (2,4-2,6), in ♀, 3,20 (3,10-3,30) in ♂; cauda II-III, ventro-lateral and ventral keels costate. Pedipalp hand, fig. 4.33.a-c: δ eb distinctly distal to mesial base of fixed finger; distance δ et-dt < est-et. Pedipalp tibia fig. 4.39.d: distance δ d_1 - d_2 equal to one quarter of distance δ d_3 - d_4. Hemispermatophore as in fig. 4.31. g. ... ... *schlechteri* Purcell

9. Pedipalp hand, fig. 4.35.a-b: movable finger length/handback length ratio 2,30 in adult ♀ and ♂; δ it level with first outer distal flanking tooth; δ dt and et separated by two outer flanking teeth; δ est halfway between 5th and 6th outer flanking teeth. Pedipalp tibia, fig. 4.35.d: δ est

distinctly proximal to et, em level with et. Cauda IV, in adults, length/width ratio 2,60 in ♀, 2,90 in ♂ ... ... longimanus Werner

- Pedipalp hand, fig. 4.37.a-c: movable finger length/handback length ratio 1,95 (1,90-2,00) in ♀ and ♂; ȯ it proximal to first outer distal flanking tooth; dt and et separated by one outer flanking tooth; ȯ est level with 6th outer flanking tooth. Pedipalp tibia, fig. 4.37.e: ȯ est level with et, em proximal to et. Cauda IV in adults, length/width ratio 2,40 in ♀, 2,70 in ♂ ... ... pilosus (Thorell)

Uroplectes carinatus (Pocock, 1890)

Figs 4.30, 4.31.b, 4.32.a-b and e.

Plates 4.31

Lepreus carinatus Pocock, 1890: 129

Synonyms

Uroplectes alstoni Purcell, 1901: 180-182: 1♀, 1 ♂ syntypes (S.A.M. 477). from Touws River Station, Cape Province, South Africa. Seen. NEW SYNONYM.

Uroplectes carinatus mediostriatus Kraepelin, 1908: 257-258; numerous syntypes (sexes not given) (ZMB 14806-14813) from Severelela, Sekgoma Khakhea, Lehututu, Kalahari, Botswana 2 ♀ (Z.M.B. 14807) and 2 ♂, 3 ♀ (Z.M.B. 14806), seen. NEW SYNONYM.

Remarks

(1) Although I have not seen all the types of U. carinatus mediostriatus, Kraepelin's detailed original description which states that his species is closely related to U. alstoni Purcell and examination of syntypes Z.M.B. 14806 and 14807, leave no doubt that mediostriatus is conspecific with U. carinatus.

(2) See remark (1) under U. gracilior.

(3) Purcell (1901: 175-180) extensively redescribed both sexes of the species he believed to be Uroplectes carinatus on 84 specimens in the South African Museum, without examining Pocock's ♂ holotype. Pocock's holotype of carinatus had been presumed lost for many years but was recently rediscovered in the dry collections of the British Museum (Natural History). Comparison of this type with Purcell's material and his redescription showed that the latter represented a non-conspecific and hitherto undescribed species. However, comparison of the material used by Purcell in his redescription of carinatus (1901: 175-180) with Hewitt's types of U. carinatus gracilior (1918: 119) has shown these to be conspecific, with the exception of one of Hewitt's ♂ types (T.M. 1865 ex 1036) from Kuibis (Quibis) which provec to be conspecific with U. schlecteri Purcell, 1901.

Diagnosis

The following combination of characters separates U. carinatus from other species of the genus. Pedipalp hand, fig. 4.30.a-c: movable finger length/handback length ratio 1,55 or less in adult ♀ & ♂ ; proximo-mesial cutting edge of movable finger distinctly procurved in ♀ , distinctly recurved in ♂; proximo-mesial cutting edge of fixed finger sub-linear in ♀, distinctly recurved in ♂. Pedipalp tibia, fig. 4.30.e: length/external width ratio 2,55 in ♀ , 3.2 in ♂. Cauda II-IV, dorsal, dorso-lateral, ventro-lateral and ventral keels well developed, consisting of elevated rows of distinct granules. Carapace, plate 4.31: interocular surface with a dark triangular marking. Pecten, fig.4.32.e, plate 4.31: first proximal tooth of ♀ much wider, but never longer than adjacent teeth, sub-oval in shape. U. carinatus is most closely related to U. variegatus (C.L. Koch 1845), an extralimital species found in the north-western and south-western Cape, but never recorded north of the Orange River.

Description

The following account supplements Pocock's original description, Purcell's (1901: 180-182) description of alstoni, Kraepelin's (1908: 257) description of carinatus mediostriatus, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionally smaller and more slender with width sternite V/carapace length ratios 1,05 in ♂ and 1,25 in ♀ ; ♂ caudal segments longer with cauda IV length/width ratios 2,20 in ♂ and 1,75 in ♀ ; ♂ pedipalp hand fingers shorter, with movable finger length/handback length ratios 1,40 for ♂ and 1,55 for ♀ , while chela length is only 3% less in ♂ ; first proximal tooth of each pecten sub-oval in ♀ , undifferentiated in ♂ ; ♂ 23-26, ♀ 20-22 teeth per pecten.

Males and females:

Colour: Overall colouration, ranging from dark orange yellow No. 72 to strong yellowish brown No. 74; legs brilliant orange yellow No. 67. The following with very light reticulate infuscations: whole of pedipalp chela handback, dorsal and external surfaces of pedipalp tibia, medial three fifth of dorsal, lateral and ventral surfaces of cauda V. All granular keels on pedipalps, legs, carapace, tergites, cauda I-V, lightly to strongly infuscated. Postero-lateral region of carapace and surfaces between the lateral keels and lateral margins of tergites I-VI, with reticulate dark markings almost forming a continuous band. Anterior margin of chelicerae lightly infuscated.

Tegites: See plate 4.31. Tergites I-VI, with a lateral keel on each side posteriorly, in addition to median keel; tergites I-VII and posterior region of carapace, with a dark median band; tergites I-VI with reticulate dark markings laterally between lateral keels and lateral margins almost forming a continuous band.

Cauda: Caudal segments of adults, fig. 4.32.a-b: short and wide, length/width ratio cauda I, 1,05 (1,0-1,10) in ♀, 1,3 (1,25-1,35) in ♂, and for cauda IV, 1,75 (1,70-1,80) in ♀ , 2,20 (2,10-2,30) in ♂; cauda V, ventro-lateral keels well developed along their entire length, consisting of spiniform tubercles.

Setation: Pedipalps, legs, lateral margins of sternites II-VII and caudal segments sparsely pilose.

Trichobothria: See diagnosis and fig. 4.30. Orthobothriotaxic for group A. Pedipalp chela: ȯ eb distinctly distal to mesial base of fixed finger; ȯ Eb_3 distal to Eb_2; ȯ Eb_2 much closer to Eb_3 than Eb_1. Pedipalp tibia: ȯ em distal to est and almost level with et. Pedipalp femur, ȯ d_2 on proximo-internal side of dorso-internal keel.

Variation

Mainly in extent of infuscations and intensity of dark markings on carapace and tergites with these very light to absent in juveniles and adults south of Orange River in Cape Province of South Africa and in the syntypes of *U. carinatus mediostriatus* Z.M.B. 14806 and 14807 examined All material examined from South West Africa exhibits the typical colouration and patterns described.

Measurements

See diagnosis, figures and plates.

Type material

Holotype ♂ in British Museum (Nat. Hist.) collection. It was found in the dry collection, reclaimed and transferred to the wet type collection.

Homotype

I have selected a ♂ homotype which is deposited in the Natal Museum colection (N.M. 7303).

Material examined

♂ holotype, South Africa near tropic of Capricorn, no date, no collector's name, (B.M. 46.33); 1 ♂ homotype, Okahandja, April 1960, F. Gaerdes (N.M. 7303); 2 subadult ♀, 2 juvenile ♀, 2 juvenile ♂, De Waal, 17 March 1969, B. Lamoral (N.M. 10028); 1 ♀ Lichtenstein Mitte, 21 January 1960, E. Rusch (S.M.N. 87); 1 ♀, 1 ♂, juveniles, Augrabies Falls, 7-12 April 1970. B. Lamoral (N.M. 10583); 1 ♀, Claratal, 27 January 1971 (S.M.N. 262); 1 ♀, Okahandja, April 1960, F. Gaerdes (N.M. 7303); 1 ♂, De Jager, 10 September 1972, P.G.O. (S.M.N. 388); 1 juvenile ♀, 2 juveniles, Sukses Dam, 2 March 1969, B. Lamoral, R. Day (N.M. 10071); 2 subadult ♂, Steinkopf, 11-13 March 1973, C.G.C. M.J.P., M-L. P. (S.M.N. 442); 1 juvenile ♀, Otjikoko Süd, 10-13 February 1972, C.G.C., M.-L.P., E.M. (S.M.N. 336).

Distribution

Eastern two-thirds of South West Africa and southern Angola, Botswana and northern regions of Cape Province in South Africa.

Bionomics

All specimens collected were found under rocks or dead vegetation on hard ground in daytime. There were no traces of shallow burrows or scrapes. *U. carinatus* is hemiedaphic, presumably nocturnal, and is sympatri with *gracilior*, *schlecteri*, *longimanus* and *new sp. A.*

Uroplectes gracilior Hewitt, 1913, NEW STATUS
Figs 4.34, 4.31.a, 4.32 c
Plate 4.32

Uroplectes carinatus gracilior Hewitt 1913: 147-148

Remarks

(1) Hewitt, 1918: 117, refers to a variety of *Uroplectes carinatus* which he names *australis* without designating definite types, except for broad reference to material recorded by Purcell (no date) "in the Western half of Cape Colony" and the following statement: "We have specimens which seem to be referable to this form from Steytlerville neighbourhood (Miss A. Geard) I have not been able to find and examine the material referred to by Hewitt but his very brief description of *australis* suggests that it is conspecific with either *gracilior* or *carinatus* as here revised.

(2) Hewitt's ♂ type TM 1865 (1036) of *Uroplectes carinatus gracilior* from Kuibis (Quibis) is conspecific with *U. schlecteri* Purcell. See synonyms under this species.

(3) See remark (3) under *U. carinatus*.

Diagnosis

The following combination of characters separates *U. gracilior* from other species of the genus. Pedipalp hand, fig. 4.34.a-c: in adults movable finger length/handback length ratio 1,95 (1,90-2,00) in ♀ and 1,85 (1,80-1,90) in ♂; handback, inner surface near fixed finger base, with a few scattered granules; ȯ eb level with mesial base of fixed finger: distance ȯ et-dt > est-et. Caudal segments fig. 4.32.c, plate 4.32: cauda , ventro-median keel indistinct from adjacent granules, ventro-lateral keel granular; cauda IV, ventral keels clearly defined in anterior half only, ventro-lateral keels granular and distinctly recurved in posterior half; cauda IV, adults, length/width ratios, 1,90 (1,75-2,05) in ♀ , 2,45 (2,35-2,55) in ♂; cauda II-III, ventro-lateral and ventral keels granular. *U. gracilior* is most closely related to *schlecteri*. These two are in turn most closely related to the *longimanus-pilosus* group.

Description

The following supplements Hewitt's very brief and inadequate original description, Purcell's (1901: 175-180) extensive redescription of what he believed to be U. carinatus, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

Adult males differ from females in the following characters: ♂ proportionally smaller and more slender with width sternite V/carapace length ratios 1,05 for ♂ and 1,30 for ♀ ; ♂ caudal segments longer, with cauda IV length/width ratios 2,5 in ♂ and 2,0 in ♀ ; ♂ pedipalp hand fingers shorter, with movable finger length/handback length ratios 1,80 for ♂ and 2,00 for ♀ while chela length is only 5% less in ♂; first proximal tooth of each pecten, sub-circular in ♀ undifferentiated in ♂; ♂ 22-27, ♀ 19-23 teeth per pecten.

Males and females:

Colour: Adult ♂ & ♀ . Overall dark orange yellow No. 72; legs and pectines strong yellow No. 84; pedipalp keels lightly infuscated; carapace median eye tubercle, lateral eyes and anterior margin, lateral and dorsal margins of tergites I-VI, ventro-lateral and ventral keels cauda I-V, lightly to moderately infuscated; cauda IV and V slightly darker as in plate 4.32; telson vesicle yellow No. 84. Adult specimens from Namaland, Keetmanshoop and Karasburg districts with pedipalp hand and anterior two thirds of cauda V fairly strongly infuscated. Juveniles and occasionally subadults from most areas similarly infuscated.

Pedipalps: Chela: proximo-mesial cutting edge of movable finger and fixed finger sub-linear to slightly procurved in ♀ and ♂, never recurved; handback inner surface markedly procurved, handback length/handback ventral width ratio 1,65-1,75 in ♀ and ♂. Pedipalp tibia, fig. 4.34.d-e: in adults, length/external width ratios 4,0-4,3 in ♀ , 4,1-4,5 in ♂: dorso-internal keel well developed along entire length. Pedipalp femur, fig. 4.34.f: dorso internal and dorso-external keels well developed along entire length, consisting of enlarged granules.

Setation: Pedipalps, legs, lateral margins of sternites III-VII and caudal segments sparsely pilose.

Trichobothria: See diagnosis and fig. 4.34. Orthobothriotaxic for group A.

Pedipalp tibia: δ est, et and em triangular in distribution; distance δ $d_1 - d_2$ equal to half of distance $d_3 - d_4$. Pedipalp femur, fig 4.34.f: δ d_2 on proximo-internal side of dorso-internal keel.

Hemispermatophore: See fig. 4.31.a.

Variation

Mainly in the degree of infuscation which is more pronounced in populations from south-eastern South West Africa. Populations from the southern quarter of South West Africa show a tendency for greater size in adults, and females tend to have a distinctly larger telson vesicle and a shorter aculeus than in populations further north.

Measurements

See diagnosis, figures and plates.

Type material.

The type series consists of 2 ♀ and 2 ♂ syntypes, no holotype having been designated. One ♀ (T.M. 1864 ex 1033) from Narudas Süd, is hereby selected as the LECTOTYPE of <u>Uroplectes gracilior</u> and the other ♀ and 2 ♂ as PARALECTOTYPES; This material has been labelled accordingly and is deposited in the Transvaal Museum collection.

Material examined

♀ lectotype, Narudas Süd (T.M. 1864 ex 1033); 1 ♀ paralecototype, Narudas Süd (T.M. 1863 ex 1032); 1 ♂ paralectotype, Narudas Süd (T.M. 1862 ex 1031); 1 juvenile ♂ paralectotype, Nakeis (Klein Karas), (T.M. 1866 ex 1037); 1 ♂, Blinkoog, 14-17 October 1971 (S.M.N. 313); 1 ♀, Kochenau, 11 March 1971 (S.M.N. 269); 4 ♀, 3 ♂, 6 juveniles, Schwarzkuppen, 8 February 1973, B. Lamoral, K. Porter (N.M. 10568); 13 ♂, 6 ♀, 6 subadult ♀, 5 subadult ♂, 6 juvenile ♀, Aandster, 6 March 1976, B. Lamoral (N.M.10870); 7 ♀, 2 ♂, 2 subadult ♂, 1 subadult ♀, Vrede, 31 March 1976, B. Lamoral, L. Ferguson (N.M. 10839); 1 subadult ♀, 2 juvenile ♀, 2 juvenile ♂, Kamkas, 8 March 1976, B. Lamoral (N.M. 10874); 1 subadult ♀, 2 juvenile ♀, 6 juvenile ♂, Frischgewaagd 20 March 1976, B. Lamoral (N.M. 10875); 1 subadult ♂, 1 juvenile ♀, 1 juvenile ♂, Saffier, 4 March 1976, B. Lamoral (N.M. 10873); 1♀, Narudas Sud, December 1975, Mr Maritz (N.M. 10868); 1 subadult ♂, 1 subadult ♀, 2 juveniles ♂, Kranzberg, 23 March 1976, B. Lamoral, L. Ferguson (N.M. 11026); 1 ♂, 1 subadult ♀, Vredenhof, 21 February 1976 B. Lamoral (N.M. 10863); 1 juvenile ♀, Hanaus, 3 March 1959, Pocock (S.M.N. 78); 1 ♀, 1 ♂, Naruda Sud, 22 February 1976, B. Lamoral (N.M. 10864); 1 juvenile ♂, Narudas Sud, 23 February 1976, B. Lamoral (N.M. 10865); 7 juvenile ♀, 1 juvenile ♂, Berseba, 27 February 1976, B. Lamoral (N.M. 10958); 1 juvenile ♀, Narib, 9 March 1976, B. Lamoral (N.M. 10861); 1 subadult ♀, 1 juvenile ♂, Springbok, 21 February 1973, B. Lamoral (N.M. 10565); 1 subadult ♀, Chamais, June 1973, C.J. Coetzee (N.M. 10559); 1 subadult ♀, Louwshoop, 3 February 1973, B. Lamoral, K. Porter (N.M. 10555); 1 ♂, Aandster, 6 March 1976, B. Lamoral (N.M. 11025), 1 juvenile ♂, Louwshoop, 3 February 1973, B. Lamoral, K. Porter (N.M. 10560); 1 juvenile ♂, Us, 6 February 1973, B. Lamoral, K. Porter (N.M. 10563); 1 juvenile ♀, 1 juvenile ♂, Ortmansbaum, 26-28 January 1973, B. Lamoral (N.M. 10564); 2 subadult ♀ Plateau, 16 October 1970 (S.M.N. 217); 1 juvenile ♂, Windhoek, 6-13 June 1972, P.G. Olivier (S.M.N. 386); 1 subadult ♀, Rietfontein, 1-2 June 1972, M.J., M-L.P. (S.M.N. 373); 1 subadult ♀, 1 subadult ♂, 1 juvenile ♂, Swartbaas West, 19-22 April 1972, M-L.P., C.G.C., B.H., J. Batista (S.M.N. 360); 1 subadult ♀, Aroab, 1 June 1972, M.J., M-L.P. (S.M.N. 372); 1 ♂, 1 subadult ♂, 1 juvenile ♂, 2 juvenile ♀, Noachabeb, 22-28 April 1972, M-L.P., B.H., J.B. (S.M.N. 364); 1♂, Huns, 29 September - 4 October 1974, Museum staff (S.M.N. 525); 2 juveniles, Regenstein, 9 April 1972, M-L.P. (S.M.N. 354); 1 juvenile ♀, Otjinungua, 19-21 August 1973 (S.M.N. 469); 1 juvenile ♂, Trekkopje, 3 March 1974, M.J.P., M-L.P. (S.M.N. 515); 1 juvenile ♂, Hoogland, 1-4 February 1974, C.G.C., M-L.P., C.G., E.M., J.B. (S.M.N. 512); 1 juvenile ♂, Kuboos, 22 November 1975, E. Griffin (S.M.N. 573); 1 juvenile ♀, 1 juvenile ♂, Duineveld, 14 April 1974, M.J.P., M-L.P. (S.M.N. 520), 1 ♂, 1 ♀, Sesriem, June 1973, G. Sander (N.M. 10381); 1 subadult ♀, Namuskluft, 20 September 1968, W.D. Haacke (T.M. 10629); 2 ♂, 5 ♀, Aar, 29 February 1976, B. Lamoral (N.M. 10869); 3 ♂, 4 ♀, 6 juveniles Schwazkuppen, 8 February 1973, B. Lamoral, K. Porter (N.M. 10568)

Distribution

Virtually the whole of the southern half of South West Africa except the Namib and Kalahari soft sand systems. Also found in the northern regions of the Cape Province in South Africa.

Bionomics

U. gracilior is nocturnal, hemiedaphic and digs shallow burrows at the base of shrubs in sandy to consolidated sandy soils in areas of vegetation types 8 and 9. A few specimens have occasionally been found in shallow scrapes under rocks. Some specimens have sometimes been captured on shrubs or low vegetation at night. *U. gracilior* is one of the most common and widely distributed species of *Uroplectes* in the southern half of South West Africa and is sympatric with *schlecteri* (its sister species), *carinatus*, *longimanus*, *planimanus* and *new sp. A*.

Uroplectes longimanus Werner, 1936

Figs 4.35, 4.33.d

Plate 4.33

Uroplectes longimanus Werner, 1936: 179

Diagnosis

U. longimanus is separated from other species of the genus by the following combination of characters. Pedipalp hand, fig. 4.35.a-b: movable finger length/handback length ratio 2,30 in adult ♀ and ♂ ; handback inner median surface sub-parallel to outer median surface, handback length/handback ventral width ratio 2,10-2,15 in adult ♀ and ♂ ; ó it level with first outer distal flanking tooth; ó dt and et separated by two outer flanking teeth; ó est halfway between 5th and 6th outer flanking teeth. Pedipalp tibia, fig. 4.35.c-d: ó est distinctly proximal to et, em level with et. Pedipalp femur, fig. 4.35.e:ó d_2 on proximo-internal side of dorso-internal keel. Pecten as in fig. 4.35.f. *U. longimanus* is most closely related to *pilosus*. These two are in turn most closely related to the *gracilior-schlecteri* group.

Description

The following supplements Werner's original description, the above diagnosis and pertinent plates and figures. Werner's description was based on 2 ♀ . No other specimens of *longimanus* have been collected since then, except for 1 ♂. The male differs very little from the female and diagnostic differences are described here.

Sexual dimorphism

The adult male differs little from the adult female except in the following characters: ♂ proportionally more slender, with width sternite V/carapace length ratio 1,12 for ♂ and 1,25 for ♀ ; ♂ caudal segments longer with cauda IV length/width ratio 2,85 in ♂ and 2,55 in ♀ first proximal tooth of each pecten (fig. 4.35.f) suboval in ♀ , undifferentiated in ♂; ♂ 27-27, ♀ 26-26 teeth per pecten.

Male and female:

Colour: Overall, moderate orange yellow No. 71; legs and telson, light orange yellow No. 70; pectines, pale orange yellow No. 73; medial three fifths of dorsal, lateral and ventral surfaces of cauda V lightly infuscated; superciliary ridge of each median eye black and surface between each ridge medially moderate orange yellow as the rest of the carapace; lateral eyes black.

Pedipalps: Tibia dorso-internal keel with proximal ene quarter absent, remaining length obsolete. Femur dorso-internal and dorso-external keel poorly developed.

Carapace: matt, very finely shagreened with a few scattered small granules in ♀ , slightly more heavily granulated in ♂.

Tergites: matt, very finely shagreened with a few scattered granules in ♀ , more coarsely so in ♂ ; lateral keels present but poorly developed in both sexes.

Sternites: smooth and shiny in ♀ very finely granular and matt in ♂ ; posterior margin sternite V punctate in ♀ .

Cauda: See fig. 4.33.d and plate 4.33. Keels better developed in ♂ than ♀ ; distal enlarged granule of dorsal keel longer in ♂ than ♀ . Cauda III-IV, ventro-lateral and ventral keels obsolete to poorly developed; cauda IV, in adults, length/width ratio 2,60 in ♀ 2,90 in ♂.

Setation: Overall and particularly caudal vestiture ampler in ♂ than in ♀ with cauda almost as pilose as in <u>U. pilosus</u>.

Trichobothria: See diagnosis and fig. 4.35. ♂ as in ♀ . Orthobothriotaxic for group A.

Hemispermatophore: The only ♂ collected was in an extreme state of starvation when collected and did not survive in captivity. This probably explains the absence of hemispermatophores and the shrivelled paraxial organs.

Measurements

See diagnosis, figures and plates. In addition, ♂ in mm: Carapace length 4 posterior width 4,2; pedipalp hand movable finger and handback length 5,9 & 2,6; cauda I-V lengths 2,9 3,9 4,2 4,8 5,8; cauda IV widths 2 1,9 1,8 1,7 1,7; telson length and width 5,8 & 1,4; telson vesicle length 2,8, height 1,2. Total length (anterior margin carapace to distal end of aculeus] 42 mm.

Type material

Werner described *longimanus* on 2 ♀ and did not designate a holotype. I have examined one of these (sent on loan) and it is hereby selected as the LECTOTYPE of *Uroplectes longimanus* and it has been labelled accordingly. The other ♀ thus represents the PARALECTOTYPE of *U. longimanus* This material is deposited in the collection of the "Zoologisches Museum Hamburg".

Material examined.

♀ lectotype, Luderitzbucht, no date, no collector's name (Z.M.H.); 1 ♂, Hanaus, 8 April 1976, B. Lamoral (N.M. 11049).

Bionomics

No field data are available for this species, except for those on the only known ♂, collected from under a large stone on sandy ground, near the banks of the Fish River. It is the rarest species of *Uroplectes* from South West Africa.

Uroplectes otjimbinguensis (Karsch, 1879)

Figs 4.36, 4.31.c
Plates 4.34, 4.35

Lepreus otjimbinguensis Karsch, 1879: 125

Diagnosis

U. otjimbinguensis is separated from other species of the genus by the following combination of characters. Caudal segments, plates 4.34 & 4.35: cauda II-V, median-lateral, ventro-lateral and ventral keels completely absent, dorso-lateral and dorsal keels almost completely absent, only represented by a distal granule and sometimes in cauda II-III by a row of small granules. Telson vesicle without a subaculear tooth. Tergites: I-VI, without traces of a lateral keel on each side posteriorly, in additio to the median keel; I-VII, with a dark median band. Pedipalp hand, fig. 4.36.a-c: ♂ eb extremely basal in position and almost level with Et; ♂ Eb_3 always proximal to Eb_2, Eb_2 much closer to Eb_1 than Eb_3. One of the smaller species of Uroplectes, it is most closely related to vittatus, a species not yet recorded from South West Africa but found in Botswana at localities close to the north-eastern regions of South West Africa.

Description

The following account supplements Karsch's original description, Lawrence's (1955: 212) brief supplement, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionally smaller and more slender with width sternite V/carapace length ratios 1,05 for ♂ and 1, 28 for ♀ ; ♂ caudal segments exceptionall longer, cauda IV length/width ratios 3,90 in ♂ and 2,20 in ♀ ; ♂ pedipalp hand fingers shorter, movable finger length/handback length ratios 2,20 in ♂ and 2,40 in ♀ while movable finger length is only 6% less in ♂ . First proximal tooth of each pecten sub-oval to sub-cordate in ♀ , undifferentiated in ♂; ♂ 15-17, ♀ 14-15 teeth per pecten.

Males and females:

Colour: Adult ♂ & ♀. Tergites and pedipalps, dark orange yellow No. 72; cauda strong yellow-brown No. 74; legs and sternites moderate orange yellow No. 71; pectines, pale orange yellow No. 73; median one quarter and lateral margins of tergites infuscated, the former forming a continuous band from tergite I-VII; interocular area infuscated, forming a distinct triangular marking; median eye tubercle black; posterior median furrow, and medial one third of posterior margin of carapace infuscated. Caudal segments, plates 4.34 & 4.35: ventral anterior one quater of cauda II-III, whole anterior half of cauda IV and whole anterior three quarters of cauda V, distinctly infuscated. Chelicerae not at all infuscated.

Sternites: Smooth and shiny in ♀, occasionally very lightly shagreened and matt in ♂; sternite VII without traces of keels.

Setation: Almost entirely apilose.

Trichobothria: See diagnosis and fig. 4.36. δ eb of pedipalp chela is exceptionally basal in position and represents the most basal position encountered in any species of <u>Uroplectes</u> from South West Africa. Orthoboth-riotaxic for group A. Pedipalp tibia, fig. 4.36.e: δ em distinctly proximal to est. Pedipalp femur, fig. 4.36.f: δ d_2 on proximo-internal side of dorso-internal keel.

Hemispermatophore: See fig. 4.31.c: outer margin of basal lobe serrated; pars recta short, mean pars recta length/inner lobe length ratio 3,5 or less.

Variation

The only noteworthy variation encountered is in the shape of the proximal tooth of each pecten in ♀, which in specimens from the Windhoek district is more strongly sub-cordate than sub-oval. The amount and intens of infuscation described above also fluctuates within certain populations but this is erratic and does not appear to be correlated to specific populations.

Measurement

See figures and plates.

Type material

The type series consists of 3 syntypes. Karsch sexed them as 2 ♀ and 1 ♂ but indicated that he was not sure of this through the use of quest marks after these sexes. They are deposited in the Zoologisches Museum Berlin (Z.M.B. Nr. 3011) in east Berlin. I have been able to examine one ♀ (Z.M.B. 3011a) which is hereby selected as the LECTOTYPE of Uroplectes otjimbinguensis and it has been labelled accordingly. The remaining two specimens are PARALECTOTYPES.

Homotype

I have selected a ♀ homotype which is deposited in the Natal Museum collection (N.M. 11063).

Material examined

♀ lectotype, Otjimbingue, no date, Hahn (Z.M.B. 3011a); ♀ homotype, Gobabeb, February 1972, B. Lamoral (N.M. 11063);
2 ♀, Uis, 4 August 1969, P. Buys (S.M.N. 93); 1 ♀, Hentiesbaai, 14 August 1961, E. Rusch (S.M.N. 73); 1 ♀, Rocky Point, 1963, B. van Zyl (S.M.N. 129); 1 ♀, Swakopmund, 3 October 1965, P. Swart (S.M.N. 172); 2 ♀, Aus, 30 January 1960, P.J. Buys (S.M.N. 173); 1 subadult ♀, Hartmansberge, 18 August 1973 (S.M.N. 465); 1 juvenile ♂, Omatjenguma, 24 November 1970, E. Motgoabone (S.M.N. 225); 1 ♀, Purros, 21 February 1973, J. Malan (S.M.N. 436); 1 juvenile ♂, Hartmanberge, 18 August 1973 (S.M.N. 464); 1 ♂, Mara, 6-8 October 1974, Museum staff (S.M.N. 527) 1 ♂, 1 ♀, Windhoek, 5 December 1967 (S.M.N. 159); 1 ♂, 4 ♀, Döbra, September 1973 (N.M. 10399-N.M. 10403); 1 juvenile ♂, Molteblick, September 1973, G. Sander (N.M. 10404); 6 ♀, 3 ♂, Gobabeb, 25-26 January 1972 (N.M. 10580); 1 ♂, 1 subadult ♂, 1 juvenile ♀, Sesfontein, 3 April 1976, B. Lamoral, L. Ferguson (N.M. 10884); 1 ♂, Windhoek, 5 February 1969, B. Lamoral, R. Day (N.M. 10030); 2 ♀, 1 ♂, 4 juveniles, Gobabeb, February 1972, B. Lamoral (N.M. 10584); 4 ♀, 4 ♂, Kamanjab, 5 April 1976, B. Lamoral, L. Ferguson (N.M. 10896); 1 ♂, Annabis, 24-25 February 1969, B. Lamoral, R. Day (N.M. 10029); 1 subadult ♀, Gobabeb, February 1972, B. Lamoral (N.M. 10577); 1 juvenile ♂, Blasskranz, August 1974, G. Sander (N.M. 10949); 1 juvenile ♂, Numas valley, 3 August 1970, C.G. Coetzee (S.M.N. 94); 1 ♀, Erongo mountains, 3-4 August 1961, P.J. Buys (S.M.N. 174); 1 ♀, Narib, 9 March 1976, B. Lamoral (N.M. 10862); 1 ♂, 1 ♀, Gobabeb, May 1959, R.F. Lawrence (N.M. 7270); 1 ♂, Okahandja, September 1964, F. Gaerdes (N.M. 9080); 1 ♀, Okahandja, September 1962, W.G.H. Coaton (N.M. 8378); 1 ♀, Windhoek (S.M.N. 12).

Distribution

Predominantly in the Northern half of South West Africa, no specimens being recorded further south than Blässkranz in the Naukluft Mountains. One record of 2 ♀ from Aus (S.M.N. 173) is rather puzzling and it seems very likely that this material was collected from Aus in the Etosha Game Park rather than from Aus in the Luderitz district.

Bionomics

U. otjimbinguensis is nocturnal, epigeic and infracorticicolous. It is found under the bark of trees during the day, and moving around on vegetation ranging from shrubs to the largest trees, at night. One specimen was located with an ultra-violet lamp at night 6 metres above ground level near the top of an *Acacia* sp. tree. This species is rarely found on the ground at night. It is sympatric with *Buthotus conspersus* in part of its range.

Uroplectes pilosus (Thorell, 1876)

Figs 4.37, 4.31.d
Plate 4.36

Lepreus pilosus Thorell, 1876: 7-8

Diagnosis

The following combination of characters separates *U. pilosus* from other species of the genus: Pedipalp hand, fig. 4.37.a-c: movable finger length/handback length ratio 1,95 (1,90-2,00) in adult ♀ and ♂; handback inner surface slightly procurved, handback length/handback ventral width ratio 1,90-2,00 in adult ♀ and ♂; δ it proximal to first outer distal flanking tooth; δ dt and et separated by one outer flanking tooth; δ est level with 6th outer flanking tooth. Pedipalp tibia, fig. 4.37.d-e: δ est level with et, em proximal to et; Pedipalp femur, fig. 4.37.f: δ d_2 on proximo-internal side of dorso-internal keel.
Pecten: first proximal tooth of ♀ , much wider and shorter than adjacent teeth, sub-circular in shape. *U. pilosus* is most closely related to *longimanus*. These two are in turn most closely related to the *gracilior-schlecte*

group.

Description

The following supplements Thorell's original description, Lawrence's (1966: 4] supplement, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionally more slender with width sternite V/carapace length ratios 1,05 for ♂ and 1,25 for ♀ ; ♂ caudal segments longer, cauda V length/width ratios 2,70 in ♂, 2,40 in ♀ ; ♂ pedipalp hand fingers slightly shorter, movable finger length/handback length ratio 1,90 in ♂, 2,05 in ♀ while chela length is only 2% shorter in ♂; first proximal tooth of each pecten sub-oval in ♀ , undifferentiated in ♂; ♂ 28-30, ♀ 25-27 teeth per pecten.

Males and females:

Colour: adult ♂& ♀. Tergites and caudal segments moderate orange yellow No. 71; pedipalps, legs and sternites, light orange yellow No. 70; pectines and telson, pale orange yellow No. 73. Cauda very lightly infuscated; median eye tubercle blackened. No other infuscations elsewhere on habitus.
Pedipalps: Tibia dorso-internal keel with proximal one quarter absent, remaining length only represented by 7-8 granules. Femur dorso-internal and dorso-external keels poorly developed.
Tergites: II-VI, with traces of lateral keels posteriorly.
Sternites: Lightly punctate, smooth and shiny in♀ & ♂.
Cauda: See plate 4.36. Cauda III-IV, ventro-lateral and ventral keels obsolete and hardly differentiated from adjacent granules; cauda IV in adults, mean length/width ratio 2,40 in ♀ , 2,70 in ♂.

Setation: Pedipalps, legs, lateral and posterior margins of sternites, distal and middle lamellae of pectines and cauda I-V, densely pilose; telson moderately pilose; tarsi of legs I-IV with a dense vestiture of short stiff setae.

Trichobothria: See diagnosis and fig. 4.37. Orthobothriotaxic for group A.
Hemispermatophore: See fig. 4.31.d.

Variation

All material collected to date comes from Cape Cross and no striking variation has been diagnosed in this population.

Measurement

See diagnosis, figures and plates.

Type material

The type series consists of 2 ♂ (1 adult and much smaller subadult) no holotype having been designated. The larger (adult) ♂ is hereby selected as the LECTOTYPE of Uroplectes pilosus and the other ♂ as the PARALECT TYPE. This material has been labelled accordingly and is deposited in the Naturhistoriska Riksmuseet Stockholm (N.R.S. no. 211 & 214, "Collectio T. Thorell no. 17").

Material examined

♂ lectotype and ♂ paralectotype, "Caffraria," 1840-1848, J.A. Wahlberg (N.R.S. 211 & 214). 1 ♂, 1 ♀, Cape Cross, no date, C. Koch (T.M. 8924); 3 ♀, 1 ♂, Cape Cross, 25 March 1976, B. Lamoral, L. Ferguson (N.M. 10878); 1 ♀, Cape Cross, July 1954, C. Koch (N.M. 11033).

Distribution

All the material collected to date comes from Cape Cross and vicinity. Extensive collecting north and south of this locality during my 1976 expedition to the skeleton coast failed to yield specimens. It is, however, very likely that further collecting along the Skeleton Coast will yield specimens of pilosus which will probably be found to be distributed as far south as Swakopmund.

Bionomics

A nocturnal and hemiedaphic species, it digs shallow burrows in sandy soil at the base of shrubs in area of vegetation type 2, as illustrated in plate 2.12. U. pilosus is one of the rarer species of Uroplectes in S.W.A. and is sympatric near Cape Cross with otjimbinguensis and planimanus.

Uroplectes planimanus (Karsch, 1879)

Figs 4.38, 4.31.e-f, 4.33.b
Plate 4.37

Lepreus planimanus Karsch, 1879: 125-126

Synonym

Lepreus lunulifer E. Simon, 1887; see Lamoral, 1975: 532

Diagnosis

The following combination of characters separates *U. planimanus* from other species of the genus. Pedipalp hand, fig. 4.38.a-c, in adults: almost apilose; handback laterally compressed, upper margin distinctly lobate in adults, with handback length/handback ventral width ratio 1,85 (1,80-1,92) in ♀ and ♂ and hadback width/handback ventral width 1,80 (1,75-1,86) in ♀ and ♂; surface of handback flat and smooth; movable finger length/handback length ratios 1,80 (1,70-1,90) in ♀ , 1,55 (1,50-1,60) in ♂. Telson vesicle ventrally aggranular and moderately punctate, sub-oval in lateral outline. Pecten, plate 4.37; first proximal tooth of ♀ falciform and much longer than adjacent teeth. One of the larger species of *Uroplectes*, it is most closely related to *new sp. A*. These two are in turn most closely related to *teretipes*.

Description

The following supplements Karsch's original description, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionally only slightly smaller and more slender with width sternite V/carapace length ratios 1,0 for ♂ and 1,2 for ♀ ; ♂ caudal segments longer, with cauda IV length/width ratios 2,70 in ♂ and 2,15 in ♀ ; ♂ pedipalp hand fingers shorter, with movable finger length/handback length ratios 1,55 for ♂ and 1,80 for ♀ , while chela length is only 3% les in ♂; first proximal tooth of each pecten, falciform and much longer than adjacent teeth, undifferentiated in ♂; ♂ 24-28, ♀ 22-26 teeth per pecten.

Males and females:

Colour: Adult ♂ & ♀. Pedipalps, tergites and cauda ranging from moderate yellow No. 87 to moderate orange yellow No. 71; legs, ranging from light yellow No. 86 to light orange yellow No. 70; sternites and pectines ranging from pale yellow No. 89 to pale orange yellow No. 73. The following lightly to moderately infuscated; ventral and ventro-lateral keels of cauda I-V; anterior region of chelicerae; anterior and lateral margins of carapace; median keel and lateral margins of tergites I-VI; prefemur and femur keels of legs I-IV. The following with light to moderately infuscated reticulate patterns: outer median region of pedipalp handback; outer and dorsal surface of pedipalp tibia; lateral surfaces of carapace; lateral and ventral surfaces of cauda V.

Pedipalp: The distinctly lobate, laterally compressed handback is the most striking diagnostic character of this species. This character is less well developed in subadults and occasionally absent in juveniles to subadults. Pedipalp tibia, fig. 4.38.d-e: moderately broad in ♀, length/width ratio 2,7 (2,65-2,75).
Tergites: lateral keels poorly developed and almost indistinguishable in some adult specimens, particularly in ♀.
Sternites: Smooth and shiny. Sternite VII with traces of lateral keels.
Setation: Habitus almost entirely apilose except for femur, tibia, metatarsus and tarsus of legs I-IV.

Cauda: See fig. 4.33.b & plate 4.37. Cauda IV, ventro-lateral and ventral keels poorly developed, consisting of shallowly costate rows of fine granules; cauda V, ventro-lateral keels as in cauda V; ventro-median keel indistinct; cauda V, ventro-lateral keels moderately diverging from each other.
Trichobothria: See fig. 4.38. Orthobothriotaxic for group A. δ eb of pedipalp hand is unusually distal when compared with positions in other species of <u>Uroplectes</u> from South West Africa. Pedipalp chela: δ Esb distinctly proximal to Est. Pedipalp tibia: δ et markedly distal to est; δ em almost level with et; δ esb$_2$ markedly distal to esb$_1$. Pedipalp femur, fig. 4.38.f: δ d$_2$ on proximo-dorsal side of dorso-internal keel; δ e$_1$ proximal to d$_5$; distance between δ d$_5$ - e$_2$ double that between d$_1$ - d$_3$.
Hemispermatophore: See fig. 4.31.e-f.

Variation

Mainly in the extent of infuscations and infuscated reticulate patterns described above, with these more pronounced in populations near the northern limits of the species range.

Measurements

See diagnosis, figures and plates.

Type material

The type series consist of the following unsexed syntypes: 3 specimens, "S.O. Afrika, Merenski leg.", (Z.M.B. No. 3153) and 25 specimens, "S.O. Afrika, Merenski leg.", (Z.M.B. No. 3121). They are deposited in the Zoologisches Museum Berlin, in east Berlin. One ♀ from sample Z.M.B. 3121 is hereby selected as the LECTOTYPE of Uroplectes planimanus and the remaining syntypes as PARALECTOTYPES. These specimens have been labelled accordingly.

Homotype

I have selected a ♀ homotype which is deposited in the Natal Museum collection (N.M. 11064).

Material examined

♀ lectotype, 1 ♀ and 1 ♂ paralectotype, "S.O. Africa", no date, Merenski (ex. Z.M.B. 3121); 1 ♀ homotype, Groot Spitzkoppe Mountains, 11 February 1969, B. Lamoral; 1♀ , Tsotsana, 14-19 June 1971 (S.M.N. 276); 1♀ Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N.;284); 1 ♂ Gautscha Pan 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 286); 1 ♂ Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 296); 1 ♂, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 289); 4♀ , 1 ♂, many nymphs; Onguma, 17-18 February 1972, M-L. Penrith (S.M.N. 339); 1 ♂, Goreangab Dam, May 1970, H.C. Strauss (S.M.N. 253); 1 ♀ , nymphs, Windhoek, 19 September 1972 (S.M.N.359); 1♀, Windhoek, 6-13 June 1972 (S.M.N. 385); 1♀ 1 subadult ♀ , juveniles, Numaskloof, 5 August 1969, P. Buys (S.M.N. 97); 2 ♀ , 1 ♂, Elandshoek, 8 March 1969, B. Lamoral, R. Day (N.M. 10067); 1 ♂, 1 juvenile ♀ , Windhoek, 5 February 1969, B. Lamoral, R. Day (N.M. 10064), 1 ♂, 1 ♀, nymphs, Otjitundua 28 November 1970 (S.M.N. 210); 1 ♀ , 1 ♂, Windhoek, 4 July 1970, J. Viljoen (S.M.N. 158); 1 ♂, 1 ♀ , id. (N.M. 11037); 1 ♀ , Brandberg, 7 August 1969, P. Buys (S.M.N. 92); 1 ♂, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 288); 2 ♀ , Brandberg, 11 August 1969, P. Olivier (S.M.N. 98);

2 ♂, 1 ♀, Curocua river and Iona Road junction, 9-21 October 1969, C. Coetzee (S.M.N. 162); 1 ♀, 1 juvenile ♀, 26-31 August 1971, Popa Falls, M-L. P. (S.M.N. 304); 1 juvenile ♂, Kitiis, 1 June 1972, M.J., M-L. P. (S.M.N. 371); 2 ♀, 1 juvenile ♀, 1 juvenile ♂, Kake, 7 July 1969, P. Olivier (S.M.N. 137); 1 ♂, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 277); 1 ♀, Windhoek, 18 August 1961, W. Cloete (S.M.N.16); 1 juvenile ♀, Namib, 4 March 1960, P.J.Buys (S,M.N.145); 1 subadult ♂, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 297); 1 ♀, Andara, 1 July 1969, P. Olivier (S.M.N. 138); 2 ♀, 2 ♂, Ghaub, 19-30 November 1972, H.C. Strauss (S.M.N. 413); 3 ♀, Andara, 2 July 1969, P. Olivier, A. Isaacs (S.M.N. 136); 1 ♀, Dolondolo, 29-30 November 1974, M-L. P. E.M. (S.M.N. 548); 1 ♂, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 298); 1 ♂, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 290); 1 ♀, Andara, 2 July 1969, P. Olivier (S.M.N. 212), 1 ♂ Andara, 2 July 1969, P. Olivier (S.M.N. 213); 1 ♀ Omaho, 15 July 1969, B. Grobbelaar (S.M.N. 237); 1 ♀, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 282); 1 ♀, Gautsha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 300); 2 juvenile ♂, Gautscha Pan, 9 June 1971 (S.M.N. 343); 1 ♂, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 279); 1 ♂, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 291); 1 ♀, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 285); 1 ♀, Gautscha Pan 9-13 June 1971 (S.M.N. 277); 1 ♀, Orongo, October 1970, B.F. Kensley (S.M.N. 256); 1 ♀, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 292); 1 ♂, 1 ♀, Andara, 19-25 August 1971 (S.M.N. 303); 1 subadult ♂, Ganab, 26 September 1971, P.G.O. (S.M.N. 316); 1 ♀, Gautscha Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 280); 1 ♀, Oncocua, 6 September 1969, C. Coetzee (S.M.N. 165); 1 ♂, Capangombe, 17-20 November, M-L. P. (S.M.N. 531); 2 ♀, Windhoek, 30 April 1972, P.G. Olivier (S.M.N. 377); 1 ♀, Waterberg, 14-18 November 1972, H.C. Strauss (S.M.N. 425); 1 juvenile ♀, Dolondolo, 29-30 November 1974, M-L. P., E. Motgoabone (S.M.N. 546); 1 juvenile ♀, Plateau, 16 October 1970 (S.M.N. 217); 1 ♀, Okamiparara, 18 December 1973, B. Sande (N.M. 10574); 2 ♀, 1 juvenile ♂, Vrede, 31 March 1976, B. Lamoral, L. Ferguson (N.M. 10957); 1 juvenile ♂, F. Gaerdes Nature Park, 13-14 March 1969, B. Lamoral, R. Day (N.M. 10069); 1 subadult ♀, Swakop river canyon, 9 February 1972, B. Lamoral (N.M. 10585); 1 ♀, 1 juvenile ♀,

Ugab river bridge, 21 February 1969, B. Lamoral, R. Day (N.M. 10070); 2 ♀, Palmfontein, 26 February 1969, B. Lamoral, R. Day (N.M. 10063); 6 ♀, 1 juvenile ♂, Groot Spitzkoppe mountains, 11 February 1969, B. Lamoral, R. Day (N.M. 10066); 2 Juvenile ♂, Groot Spitzkoppe mountains, 11 February 1969, B. Lamoral (N.M. 10059); 2 ♀, 2 juvenile ♀, 7 juvenile ♂, Groot Spitzkoppe mountains, 11 February 1969, B. Lamoral (N.M. 10065); 3 ♀, 2 ♂, 3 juvenile ♂, 1 juvenile ♀, Aus, 2-6 March 1969, B. Lamoral, R. Day (N.M. 10569), 1 ♂, Annabis, 24-25 February 1969, B. Lamoral, R. Day (N.M. 10068); 1 ♀, Sissekab, 11 November 1933, Dr K. Jordan (B.M. 1934. 4.25); 1 ♀, 1 ♂ Makambu, 16 April 1970, G. Pretorius (T.M. 9831 - T.M. 9832); 1 ♀, Oshakati, W.O. Haacke (T.M. 9838); 1 ♀, Assuncao, 26 March 1971, W.D. Haacke (T.M. 10239); 2 ♂, 1 subadult ♂, 2 juvenile ♂, 2 juvenile ♀, Rietfontein, 29 December 1971, W.D.H. (T.M. 10643 - T.M. 10649); 1 ♀, Kutse Game, January 1972, W.D. Haacke (T.M. 10438); 1 juvenile ♀, Regenstein, 30 November 1972, P.G. Olivier, M-L. Penrith, B.A. Harding, C. Buys (S.M.N. 406); 1 ♀, 1 subadult ♀, 11 juvenile ♂, Sesfontein, 4 April 1976, B. Lamoral, L. Feguson (N.M. 10894); 1 ♀, Sesfontein, 3 April 1976, B. Lamoral, L. Ferguson (N.M. 10883); 1 ♂, 1 ♀, Rocky Hill, 27 November 1970, J. Batista, E. Motgoabone (S.M.N. 203); 2 ♂, Windhoek, 14 August 1973, A. du Toit (S.M.N. 478); 1 ♀, 3 ♂, 2 subadult ♀, 3 juvenile ♀, 1 juvenile ♂, Kamanjab, 5 April 1976, B. Lamoral, L. Ferguson (N.M. 10895); 1 juvenile ♀, Regenstein, 26 February 1973, M-L. Penrith (S.M.N. 431); 1 ♀, Ghaub, 19-30 November 1972, H.C. Strauss (S.M.N. 420); 1 ♀, Ghaub, 19-30 November 1972, H.C. Strauss (S.M.N. 418); 2 ♂, 1 ♀, Kranzberg, 23 March 1976, B. Lamoral, L. Ferguson (N.M. 10877); 1 subadult ♂, Otjikoko Süd, September 1973, G. Sander (N.M. 10556) 3 ♀, 1 ♂, 1 subadult ♀, 1 subadult ♂ Catumbela, Angola, 9 September 1970, J. Visser (N.M. 10001); 1 ♀, Viola, Mozambique, 9 February 1962, D.G. Broadley (N.M. 9952); 1♂, Cunene River, Angola, November 1960, F. Gaerdes (N.M. 7325); 1 ♀, Okahandja, September 1964, F. Gaerdes (N.M. 9081); 1 ♀, Welwitchia, August 1960, F. Gaerdes (N.M. 7323); 2 ♀, Lusulu, Rhodesia, August 1965, M. Bingham (N.M. 9097); 1 ♀, Welwitchia, January 1963, F. Gaerdes (N.M. 9052); 8 ♀, 2 ♂, Grootfontein, August 1962, F. Gaerdes (N.M. 8375); 1 juvenile ♂, Messum Crater area, 26 March 1976, B. Lamoral & L. Ferguson (N.M. 10879; 1 subadult ♀, Sesfontein, 26 April 1976, W.D. Haacke (T.M. 11219); 1 ♂, Etjo-Süd, 7 April 1976, W.D. Haacke (T.M. 11209); 1 ♀, Omborombonga, 21 April 1976, W.D. Haacke (T.M. 11210); 1 subadult ♀, Blaauwpoort, 30 April 1976, W.D. Haacke (T.M. 11211); 1 ♀, Kaokoveld (T.M. 11215).

Distribution

Southern Angola, Northern Botswana and the Northern half of South West Africa; no specimens recorded from south of the 23rd parallel.

Bionomics

U. planimanus is nocturnal, hemiedaphic and infralapidicolous in areas with consolidated sandy soil and hard to gravely surfaces. I have occasionally found specimens under the loose bark of dead trees. It is the most common species of *Uroplectes* encountered in the northern half of S.W.A. and is sympatric in some areas with *new sp. A* (its sister species), *carinatus*, *gracilior* and *otjimbiquensis*.

Uroplectes schlechteri Purcell, 1901, stat. nov.

Figs 4.39, 4.31.g, 4.32.d
Plate 4.38

Uroplectes schlechteri Purcell, 1901: 184-185

Uroplectes carinatus schlechteri Purcell: Hewitt, 1918: 118.

Synonyms

Uroplectes karrooicus Purcell, 1901: 182-184; 2 ♂, 3 subadult ♂ syntypes (S.A.M. 475) from Beaufort West, Cape Province, South Africa; seen. NEW SYNONYMY. *Uroplectes carinatus gracilior* Hewitt, 1913: 147-148; type ♂ (T.M. 1865 ex 1036) from Kuibis (Quibis); seen. NEW SYNONYMY; Also see remark(2) under *gracilior* and end of remark(3) under *carinatus*.

Diagnosis

The following combination of characters separates *U. schlechteri* from other species of the genus. Pedipalp hand, fig. 4.39.a-c: in adults, movable finger length/handback length ratio 2,05 (2,00-2,10) in ♀ and 1,95 (1,90-2,00) in ♂; handback inner surface near fixed finger base with a few scattered granules; ȯ eb distinctly distal to mesial base of fixed finger; distance ȯ et-dt < est-et. Caudal segments fig. 4.32.d, plate 4.38: cauda V, ventro-median keel distinct, consisting of a slightly elevated twin row of small granules, ventro-lateral keels consisting of small costate granules; Cauda IV, ventral and ventro-lateral keels costate granular, the latter not distinctly recurved in posterior half; cauda IV, adults, length/width ratios 2,5 (2,4-2,6), 3,2 (3,1 -3,3) in ♂; cauda II-III, ventro-lateral and ventral keels costate. *U. schlecteri* is most closely related to *gracilior*. These two are in turn most closely related to the *longimanus-pilosus* group.

Description

The following supplements Purcell's original description, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionally smaller and more slender with width sternite V/carapace length ratios 1,0 for ♂ and 1,3 for ♀; ♂ caudal segments longer, with cauda IV length/width ratios 3,2 in ♂ and 2,5 in ♀; dorso-distal surface of pedipalp handback (fig. 4.39).a & c), smooth in ♂, lightly granular in ♀; first proximal tooth of each pecten, sub-triangular in ♀, undifferentiated in ♂; ♂ 27-28, ♀ 22-23 teeth per pecten.

Males and females:

Colour: Adult ♀ & ♂. Pedipalps, carapace, tergites, sternites and caudal segments including telson, strong yellowish brown No. 74 to dark orange yellow No. 72; legs and pectines light orange yellow No. 70. Ventral and ventro-lateral keels of cauda III-V lightly infuscated; anterior two thirds of lateral and ventral surfaces of cauda V lightly to moderately infuscated, occasionally forming a reticular pattern. Median eye tubercle blackened.

Pedipalps: Pedipalp tibia, fig. 4.39.d: in adults, dorso-internal keel moderately developed along entire length, occasionally ill-defined medially; Pedipalp femur: dorso-internal and dorso-lateral keels moderately developed along entire length.

Tergites: Postero-lateral keels present but not strongly developed.

Sternites: Smooth and shiny in ♀ & ♂. Sternite VII, with traces of lateral keels.

Setation: Pedipalps, legs I-IV, lateral margins of sternites III-VI and caudal segments sparsely pilose. Legs I-IV, ventral surface of tarsi, with 2 rows of short stiff setae.

Trichobothria: See diagnosis and fig. 4.39. Orthobothriotaxic for group A. Pedipalp tibia: distance ȯ d_1 - d_2 equal to one quarter of distance ȯ d_3 - d_4. Pedipalp femur: ȯ d_2 on proximo-internal side of dorso-internal keel.

Hemispermatophore: See fig. 4.31.g.

Variation

No distinct variation observed in the few specimens available.

Measurements

See diagnosis, figures and plates.

Type material

Holotype ♀ in South African Museum collection (S.A.M. 2976).

Homotype

I have selected a ♀ homotype which is deposited in the Natal Museum collection (N.M. 10562).

Material examined

♀ holotype, Naroep, Great Bushmanland, 30 March 1898, Max Schlechter (S.A.M. 2976); 1 ♂, Namuskluft, 17 February 1973, B. Lamoral (N.M. 11041); 1 ♀, 15 km North of Pela Mission, 5 April 1970, B. Lamoral (N.M. 10562). 1 ♀, juvenile, Neisip, 26 October 1970, P.J. Buys (S.M.N. 219); 1 ♀, Bloeddrif, 20 November 1975, E.G. (S.M.N. 598); 1 ♂ juvenile, Bergkranz, 22 March 1976, B. Lamoral & L. Ferguson (N.M. 10876); 1 ♀, subadult, Vioolsdrift, 5 October 1966, F. Gess (N.M. 10581); 1 ♂, Huns, 29 September - 4 October 1974, State Museum Staff (N.M. 11042).

Distribution

Southern half of South West Africa (with northernmost record at Bergkranz, N.M. 10876) and northern Cape Province in South Africa.

Bionomics

U. schlechteri is nocturnal and hemiedaphic. All specimens collected were found either on low level shrubs or on the ground at night in areas of vegetation type 9. No specimens were found during daytime collecting and it is therefore not known where this species retreats during inactive periods. *U. schlecteri* is sympatric with *gracilior* at Huns in the Bethanien district.

Uroplectes teretipes Lawrence, 1966

Figs 4.40, 4.31.h, 4.33.c

Plates 4.39, 4.40

Lawrence, 1966: 1-4.

Diagnosis

The following combination of characters separates *U. teretipes* from other species of the genus. Pedipalp hand, fig. 4.40.a-b: finger distinctly elongated, movable finger length/handback length ratios 2,85 in ♀, 2,55 in ♂; δ Esb distal to or level with Est. Pedipalp tibia, fig. 4.40.c-d: length/width ratio 3,5 in ♀. Caudal segments, plates 4.39, 4.40, fig. 4.33.c: cauda III and IV deeply infuscated to black; cauda IV, ventral keels obsolete to absent; cauda V, ventro-median keel distinct, composed of fine granules; caudal segment distinctly long and slender in both sexes, with cauda IV length/width ratios 3,3 in ♀, 3,5 in ♂. Pecten, plate 4.39, 4.40: first proximal tooth of ♀ falciform and much longer than adjacent teeth. The largest species of *Uroplectes* found in South West Africa, it is most closely related to the *planimanus-new species A* group.

Description

The following supplements Lawrence's comprehensive original description, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

Adult males differ very little from females, except in the following characters: ♂ proportionally smaller and slightly more slender, width sternite V/carapace length ratios 1,10 for ♂ and 1,25 for ♀; ♂ caudal segments slightly longer, with cauda IV length/width ratios 3,5 in ♂ and 3,3 in ♀; ♂ pedipalp hand fingers shorter, movable finger length/handback length ratios 2,55 for ♂ and 2,85 for ♀, while chela length is only 5% less in ♂; first proximal tooth of each pecten, falciform and much longer than adjacent teeth, undifferentiated in ♂; ♂ 40-44, ♀ 36-40 teeth per pecten.

Males and females:

Trichobothria: See diagnosis and fig. 4.40. Orthobothriotaxic for group A. δ em and esb_2 of pedipalp tibia have the most basal position found in all the species of <u>Uroplectes</u> from South West Africa. The δ areolas and trichia are unusually small and short respectively, and difficult to locate. Pedipalp tibia: δ et level with or proximal to est; δ em markedly proximal to et; δ esb_2 almost level with esb_1 . Pedipalp femur, fig. 4.40.e: δ e_1 level with d_5; distance δ $d_5 - e_2$ equal to that between $d_1 - d_3$; δ d_2 on proximo-dorsal side of dorso-internal keel.

Hemispermatophore: See fig. 4.31.h.

Variation

In specimens from the northern regions of the species range cauda III is occasionally partially to completely unblackened, but cauda IV is then usually distinctly blackened.

Measurements

See diagnosis, figures and plates.

Type material

Holotype ♀ in Natal Museum collection (N.M. 9101).

Material examined

♀ holotype, Rocky Point, Hoarusib River mouth, Kaokoveld, October 1965, F. Gaerdes (N.M. 9101); 1 ♀, Cape Fria, 2 May 1970, H.D. Brown (T.M. 9849); 1 ♂, 1 ♀ Cunene River mouth, 23 October 1969, J. Batista (N.M. 10696); 1 ♂, Unjab River, 27 March 1976, B. Lamoral, L. Ferguson (N.M. 10763); 2 ♂, 3 subadult ♀, 3 subadult ♂, 4 juveniles, Möwebaai, 29 March 1976, B. Lamoral, L. Ferguson (N.M. 10840); 1 ♂, 4 juvenile ♂, 1 subadult ♂, Unjab River, 27 March 1976, B. Lamoral, L. Ferguson (N.M. 10880); 3 ♂, 2 ♀, Möwebaai, 28 March 1976, B. Lamoral, L. Ferguson (N.M. 10881); 1 ♂, 1 juvenile ♂, Torra Bay, 30 March 1976, B. Lamoral, L. Ferguson (N.M. 10882); 1 juvenile ♀, Rocky Point, 2 April 1964, S. Steyn (S.M.N. 123); 1 subadult ♂, Angrafria, 15 November 1970, E. Motgoabone (S.M.N. 213); 1 ♂, 1 ♀, Cunene River mouth, 23 October 1969, J. Batista (S.M.N. 229); 2 ♂, 1 ♀, Hoanib River, 5 June 1969, C.G.C. (S.M.N. 230-S.M.N.

232); 1 juvenile ♂, Möwe Bay, 29 May 1969, C.G. Coetzee (S.M.N. 231); 2 juvenile ♂, Sarusas West Mine, 31 May 1969, C.G.C. (S.M.N. 235, S.M.N. 236); 1 juvenile ♀, Hoanib River, 13 August 1973, State Museum (S.M.N. 456); 1 ♂, Möwe baai, 11-15 August 1973, J. Batista, E. Mokgoabone (S.M.N. 477); 1 ♀, Unjab River, 27 March 1976, B. Lamoral, L. Ferguson (N.M. 10760).

Distribution

Recorded only from the northern half of the Skeleton Coast Park with the southernmost record near the Unjab river mouth. U. teretipes has not been recorded from the Moçamedes desert in south-western angola.

Bionomics

U. teretipes is nocturnal, hemiedaphic and infralapidicolous on sandy to gritty plains (soil categories IV-V, table 2.2) in areas of vegetation type 1 such as shown in plates 2.9 and 2.10. Sweeplike rows of moderately long setae on the posterior surface of protarsi and tarsi of legs I, II and to a lesser extent III, suggest a semi-psammophilous adaptation. U. teretipes is sympatric with Parabuthus gracilis on the Skeleton Coast and with U. otjimbinguensis at Rocky Point.

Uroplectes new species A

Figs 4.41, 4.31.i, 4.32.f, 4.33.a
Plate 4.4.

Diagnosis

The following combination of characters separates U. new species A. from other species of the genus. Pedipalp hand, fig. 4.41.a-c. in adults: distinctly pilose; handback laterally bulbous, upper margin not lobate, handback length/handback ventral width ratio 1,40 (1,35-1,45) in ♀ and ♂ and handback width/handback ventral width 1,1 (1,0-1,2) in ♀ and ♂; inner surface of handback distinctly convex and granulated; movable finger length/handback length ratios 1,50 (1,45-1,55) in ♀, 1,40 (1,35-1,45) in ♂.

Telson vesicle ventrally, moderately granular, sub-circular in lateral outline. Pecten, fig. 4.32.f: first proximal tooth of ♀ falciform and much longer than adjacent teeth; U. new species A is most closely related to planimanus. These two are in turn most closely related to teretipes.

Description

The type series consists of females and males. The following description is based on the holotype ♀, unless otherwise indicated, and supplements the diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionally only slightly smaller and more slender, with width sternite V/carapace length ratio 1,05 for ♂ and 1,20 for ♀ ; ♂ caudal segments longer, with cauda IV length/width ratio 2,65 in ♂ and 2,10 in ♀ ; ♂ pedipalp hand fingers shorter, movable finger length/ handback length ratios 1,40 for ♂ and 1,55 for ♀ yet chela length is only 4% less in ♂; first proximal tooth of each pecten (fig. 4.32.f) falciform and much longer than adjacent teeth, undifferentiated in ♂; ♂ 23-26, ♀ 18-21 teeth per pecten.

Female holotype:

Granulation: Cauda, as in fig. 4.33.a, plate 4.41 and diagnosis. Pedipalps smooth and matt. Following surfaces smooth, shiny and agranular: chelicerae, legs I-IV, sternites and intercostal surface of cauda I-V, excepting ventral surface of cauda V which has scattered granules as in fig. 4.33.a. Telson vesicle lightly granular as in fig. 4.33.a. Carapace, moderately granular as in plate 4.41. Tergites I-VI: with a few scattered granules posteriorly between lateral keel and lateral margin; median and postero-lateral keels well defined. Caudal keels: well developed and costate; median-lateral keels, extending the full length of cauda I, anterior half in cauda II and anterior two thirds in cauda III missing, absent in cauda IV. Lateral keels sternite VII almost obsolete.

Colour: Overall, variably dark orange yellow No. 72, with tergites, carapace, prefemur and femur legs I-IV, caudal keels, lateral and ventral surfaces cauda V, infuscated and darkly pattened as shown in plate 4.41.

Ocular tubercle blackened. Chelicerae, dorsally with reticulate infuscation. Pectines, pale orange yellow No. 73.

Pedipalp: Tibia, fig. 4.41.d-e; distinctly broad in ♀, length/width ratio 2,30 (2,25-2,35).
Pectine: As in fig. 4.32.f. Right pecten with 21 teeth, left pecten, distal end missing.
Cauda: See fig. 4.33.a & plate 4.41. Cauda IV, ventro-lateral and ventral keels well developed, consisting of elevated rows of distinct granules; cauda V, ventro-lateral keels as in cauda IV, ventro-median keel indistinct; cauda V, ventro-lateral keels sub-parallel to each other.
Setation: Cauda moderately pilose as in plate 4.41. Pedipalps, legs and pectines sparsely pilose. Tarsi legs I-IV, ventrally, with two rows of short stiff setae.
Trichobothria: See fig. 4.41. Orthobothriotaxic for group A. Pedipalp chela: ♂ Esb distinctly proximal to Est. Pedipalp tibia: ♂ et, est and em as in planimanus. Pedipalp femur, fig. 4.41.f.: ♂ d_2 on proximo-dorsal side of dorso-internal keel; ♂ e, proximal to d_5; distance between ♂ d_5 - e_2 double that between d_1 - d_3.
Hemispermatophore: See fig. 4.31.i.

Variation

Mainly in the intensity of infuscation which in regions with a dark substratum tends to be more pronounced.

Measurements

See figures and plates.

Type material

Holotype in Natal Museum. Many paratypes, listed below, in Natal Museum and State Museum (Windhoek) collections.

Material examined

Holotype ♀, Bruckaros, 26 February 1976, B. Lamoral (N.M. 10866, type no 2125); all Natal Museum paratypes also have type no 2126.

The following are paratypes:

1 subadult ♂, Windhoek, 5 December 1967 (S.M.N. 242); 1 ♀ , 3 ♂, Hanaus, 3 March 1959, Pocock (S.M.N. 78); 3 ♀ , Klein Windhoek, February 1973, G. Sander (N.M. 10375); 1 ♂, Regenstein, 9 April 1972, M-L.P. (S.M.N. 353); 1 ♂, id. (N.M. 11040); 1 ♀ , Regenstein, 26 February 1973, B.A. Harding (S.M.N. 432); 1 ♀ , id. (N.M. 11039); 1 ♂, 1 ♀ , Portsmut, 7 February 1969, B. Lamoral, R. Day (N.M. 10572); 1 ♀ , Windhoek, 12 July 1961, S. Bredenmeier (S.M.N. 14); 1 ♂, Windhoek, 23 November 1973, W. Giess (S.M.N. 493); 1 ♀ , Mukorob, 12-14 April 1974, M.J. and M-L. Penrith (S.M.N. 519); 1 ♂, 1 ♀ , Avis Dam, 31 October 1972, C. Molier (S.M.N. 399); 1 ♀ , juveniles, Nubuamis, 2 June 1974, M-L.P. (S.M.N. 523); 1 ♀ , 1 ♂, Lichtenstein Mitte, 21 January 1960, E. Rusch (S.M.N. 87); 1 ♀ , 1 ♂, Witmanshaar, 8 October 1972, H.C. Strauss (S.M.N. 394); 1 ♀ , id. (N.M. 11035); 1 ♀ , Kub, 19 November 1971, P.G.O. (S.M.N. 317); 1 ♀ , Windhoek, 16 November 1962 (S.M.N. 207); 1 ♀ , id. (N.M. 11036); 2 ♀ , 2 ♂, Aar 29 February 1976, B. Lamoral (N.M. 11030); 1 ♂, Molepolole, Knobel (McGregor Museum, Kimberley); 1 ♂, Avis Dam, 29 October 1972, C.J. Molier (S.M.N. 410), 1 ♂, 1 ♀ , Portsmut, 19 April 1972, Jones, Strydom (N.M. 10579); 1 ♀ , juveniles, Windhoek, 8 April 1963, F.E. Daalen (S.M.N. 21); 1 ♀ , Heide, 10 June 1966, C. v.d. Hooven (S.M.N. 62); 1 ♂, 1 subadult ♂, 1 subadult ♀, 3 juveniles ♂, Berseba, 27 February 1976, B. Lamoral (N.M. 10872); 2 subadult ♂ , 1 juvenile ♂ , Kranzberg, 23 March 1976, B. Lamoral, L. Ferguson (N.M. 11031); 1 ♂, Augrabies Falls, 20 February 1976, B. Lamoral (N.M. 10871); 1 ♂, Koreangab Dam, 12 October 1972, H.C. Strauss (S.M.N. 398); 2 juveniles, Bruckaros, 26 February 1976, B. Lamoral (N.M. 11038); 1 ♂ Ameib, 1-2 February 1972, C.G.C., M-L.P. (S.M.N. 334); 1 ♂, Fish River Canyon, B. Lamoral (N.M. 11045)

Distribution

Central and southern half of South West Africa and northern Cape Province in South Africa.

Bionomics

U. new sp. A is nocturnal, hemiedaphic and digs shallow scrapes under rocks on consolidated sandy to hard gritty ground in areas of vegetation type 4, 8 and 9. It is sympatric with *planimanus*, *gracilior*, *carinatus* and *schlechteri* in part of their ranges.

Uroplectes vittatus (Thorell, 1877)

Lepreus vittatus Thorell, 1877: 121-122.

Diagnosis

The following combination of characters separates *U. vittatus* from *otjimbinguensis* to which it is most closely related. Telson vesicle with a distinct subaculear tooth. Pectines: ♀ 19-20, ♂ 20-22 teeth per pecten. Tergites I-VII, with a pale median band flanked by a dark lateral band on either side.

Remark

As *U. vittatus* has not yet been recorded from South West Africa and there is no doubt regarding the validity of this easily determined species, it is not redescribed and illustrated here. *U. vittatus* has, however, been recorded at localities in Botswana, close to the north-eastern regions of South West Africa and it seem likely that more extensive collecting in Kavango and the Caprivi Strip will reveal the occurrence of *vittatus* in those regions. Bearing this possibility in mind, *vittatus* has been included in the key to the South West African species of *Uroplectes*.

Family SCORPIONIDAE Pocock, 1893

Key to the South West African subfamilies of Scorpionidae

1. Leg tarsi with rounded lateral lobes distally .... SCORPIONINAE Pocock

- Leg tarsi with truncated lateral lobes distally 2

2. Carapace with an anterior median furrow .... ISCHNURINAE Pocock

- Carapace without an anterior median furrow .... LISPOSOMINAE Lawrence

Subfamily ISCHNURINAE Pocock, 1893

Genus *Hadogenes* Kraepelin, 1894

Type species: *Scorpio trichiurus* Gervais, 1843

Diagnosis

The following combination of characters separates *Hadogenes* from the other genera of the subfamily: pedipalp, external and ventral ȯ of handback and tibia numerous and intraspecifically variable in numbers and distribution; prosoma and mesosoma distincly compressed dorso-ventrally; carapace median eyes sunken in, ocular tubercle obsolete; caudal segments II-V and telson strongly compressed laterally and distinctly slender; hemispermatophore hook with two apices.

Remark

The genus *Hadogenes* needs extensive revision. As a result of this, study of interspecific relationships of the three South West African species will not be attempted in this study.

Distribution

South Africa, South West Africa, Botswana, Rhodesia and Mozambique

Key to the South West African species of Hadogenes

1. Cauda, plate 4.42: cauda I distinctly higher than wide, greatest height/greatest width ratios 1,15 (1,10-1,20) in ♀, 1,22 (1,20-1,24) in ♂; entire cauda 1,2 (1,1-1,3) times as long as trunk in ♀, nearly twice as long in ♂ .... phyllodes (Thorell)

2. Cauda, plates 4.43-4.44: cauda I distinctly wider to slightly wider than high, greatest height/greatest width ratio at most 0,95 in ♀ and ♂; entire cauda at most subequal to trunk length in ♀, at most one and a half times as long as trunk in ♂ 3

3. Sternite VII, figs 4.42 e & f: lateral margins slightly convex, posterior margin truncated; with distinct postero-lateral oval depressions; median keels present. Cauda, plate 4.43: entire cauda subequal to trunk length in ♀, nearly one and a half times as long in ♂ .... taeniurus (Thorell)

\- Sternite VII, figs 4.42. c & d: lateral margins strongly convex, almost forming a half circle with posterior margin; without any postero-lateral oval depressions; median keels absent. Cauda, plate 4.44: entire cauda only two thirds as long as trunk in ♀, three quarters as long in ♂ .... tityrus (E. Simon)

Hadogenes phyllodes (Thorell, 1877)

Figs 4.42. a, b and g.
Plate 4.42.

Ischnurus taeniurus phyllodes Thorell, 1877: 254-258

Diagnosis

H. phyllodes is separated from other species of the genus by the following combination of characters. Caudal segments, plate 4.42: cauda I higher than wide, greatest height/greatest width ratios 1,15 (1,10-1,20) in ♀, 1,22 (1,20-1,24) in ♂; entire cauda 1,2 (1,1-1,3) times as long as combined prosomal and mesosomal length in ♀, nearly twice as long in ♂. Pedipalp hand: movable finger length/handback length ratios 0,89 (0,85-0,93) in ♀, 0,85 (0,82-0,88) in ♂. Sternite VII, figs 4.42. a & b, lateral margins slightly convex. Hemispermatophore, fig. 4.42. g: percentage ha-w distance of dcr-w distance 31,5%; percentage w-bc distance of dcr-bc distance 25,0%; greatest width of distal lamina 1,0 mm.

Remark

Hadogenes gracilis namaquensis Hewitt, 1918 and gracilis fluvialis Lawrence, 1955, both described from the northern Cape are probably conspecific with phyllodes.

Description

The following account supplements Thorell's original description, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

No adult females have been collected yet and the following differences are based on subadult females, subadults and one adult male: Cauda of ♂ twice as long as trunk, of ♀ equal or slightly longer; first proximal middle lamella of each pecten mesially angular in ♂, shallowly curved in ♀; ♂ pectinal teeth twice as long as ♀; ♂ with 16-18 and ♀ with 13-14 teeth per pecten; ♂ genital operculum suboval, ♀ subpentagonal. Sternite VII of ♂ longer than wide, of ♀ wider than long, see fig. 4.42. a & b.

Males and females:

Colour: Varying within the colour ranges described for H. tityrus. Pale specimens tend to have darkened carapace, pedipalps and cauda.

Pedipalps: chelae of adult ♂ with a distinct mesial notch at base of fixed finger and a mesial lobe near base of movable finger. It is expected that these structures will also be found to occur in adult ♀ when specimens become available.

Trichobothira: As for H. tityrus, with no diagnostic differences in either numbers or distribution.

Paraxial organ and hemispermatophore: Paraxial organ as for H. tityrus. Hemispermatophore: distal half as in fig. 4.42.g; hook with two apices; differing diagnostically from taeniurus and tityrus as described in respective species diagnoses.

Variation

Pectinal teeth which in ♀ number 13-14 and in ♂ 16-18 teeth per pecten. Colour, as described above. Lack of further observations on variations is ascribable to the paucity of samples.

Type material

Thorell's ♀ holotype, originally a dry specimen, was deposited in the collection of the Göteborgs Naturhistoriska Museet (G.N.M.). A search of the collection has failed to yield the type. At the time of writing there was no positive proof that the holotype has been lost or destroyed and the search will go on, until satisfactory evidence has been obtained.

The current description of phyllodes is based on Thorell's original description and material thought to most likely be conspecific.

Material examined

1♂, Namaqualand, no date, (N.M. 9941); 1 subadult ♂, Huams, 1 February 1969, B. Lamoral, R. Day (N.M. 10027); 2 subadult ♂, 2 subadult ♀ , Bruckaros, 26 February 1976, B. Lamoral (N.M. 10718); 1 juvenile ♀ , Rosh Pinah, 7 October 1970, P.J. Buys (S.M.N. 181); 1 subadult ♀ , Kochenau, 11 March (S.M.N. 268); 1 juvenile ♂, Amnis Fontein, 21 November 1975, E. Griffin (S.M.N. 569).

Distribution

Rocky and mountainous regions of southern quarter of South West Africa and northwestern Cape Province of South Africa. The northernmost locality in South West Africa is Bruckaros crater.

Bionomics

As for H. tityrus. A poorly known and collected species.

Hadogenes taeniurus (Thorell, 1877)

Figs 4.42.e, f and h and 4.80.a
Plates 4.43

Ischnurus taeniurus Thorell, 1877: 254.

Diagnosis

H. taeniurus is separated from other species of the genus by the following combination of characters in adults. Caudal segments, plate 4.43: cauda I slightly wider than higher, greatest height/greatest width ratios 0,85 (0,75-0,95) in ♀ and ♂; entire cauda nearly as long as or occasionally as long as combined prosomal and mesosomal length in ♀, one and a half times as long in ♂. Pedipalp hand: movable finger length/handback length ratios 0,79 (0,75-0,83) in ♀, 0,83 (0,80-0,86) in ♂. Sternite VII, figs 4.42.e & f, lateral margins slightly convex; with distinct postero-lateral oval depresssions, median keels distinct. Hemispermatophore, fig 4.42.h: percentage ha-w distance of dcr-w distance 28,7% (28,6-28,8%); percentage w-bc distance of dcr-bc distance 25,8% (25,6-26,0%); greatest width of distal lamina 1,4 mm.

Description

The following account supplements Thorell's original description, Hewitt's (1918: 163) short supplement, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from ♀ in the following characters: ♂ proportionally smaller and more slender, with width sternite V/carapace length ratio 1,03 (1,00-1,06) for ♂ and 1,14 (1,10-1,18) for ♀; cauda of ♂ one and a half times as long as trunk, of ♀ subequal or equal to length of trunk; first proximal middle lamella of each pecten mesially distinctly angular in ♂, slightly obtuse in ♀; ♂ pectinal teeth twice as long as ♀; ♂ with 17-19 and ♀ with 13-15 teeth per pecten.

Males and females:

Colour: As for H. phyllodes.

Pedipalps: Chelae of adult ♀ & ♂ with a distinct mesial notch at base of fixed finger and a mesial lobe near base of movable finger as in H. tityrus These structures are undeveloped in subadults.

Trichobothria: As for H. tityrus, with no diagnostic differences in either numbers of distribution.

Paraxial organ and hemispermatophore: Paraxial organ as for H. tityrus. Hemispermatophore: distal half as in fig. 4.42.h; hook with two apices; differing diagnostically from phyllodes and tityrus as described in respective species diagnoses.

Variation

Little variation observed in studied material except in colour and number of pectinal teeth as reported above.

Haemolymph electrophoresis

The graphic record obtained on scanning the phoregram of H. taeniurus with a spectrophotometer is shown in fig. 4.80.a. See fig. 3.9 and relevant section on methods of interpretation of such records in chapter 3.

Type material

Thorell's ♀ holotype was examined. It is deposited in the collection of the Göteborgs Naturhistoriska Museet. There is no accession number on the original label inside the sealed glass jar, but the top bears the number 121 on the outside. The holotype is in good condition.

Material examined

♀ holotype, "S. Afrika", 28 November 1864, Ch. Anderson (G.N.M. 121 1 juvenile ♂, Welwitschia, January 1963 (N.M. 9049); 1 juvenile ♀, Okahan May 1960, F. Gaerdes (N.M. 7318); 1 subadult ♂, 1 subadult ♀, Benguela, 8 September 1970, J. Visser (N.M. 10002); 1♀ Okamiparara, 18 December 1973, B. Sander (N.M. 10670); 1 subadult ♂, Zebra Mountain, December-February 19 J. Menge (T.M. 10442); 1 subadult ♀, Assuncas, 26 March 1971, W.D. Haacke (T.M. 10240); 1 subadult ♂, Makukous Spring, 27 April 1976, W.D. Haacke (T.M. 11226); 1 subadult ♂, Uis River, 12 September 1962, B. Grobbelaar (S.M.N. 167); 1♂, Uitsig, 15 March 1963, C. de Wet (S.M.N. 61); 1 juvenile Portsmut, 7 February 1969, P.G. Olivier (S.M.N. 222); 1♀, Hentiesbaai, April 1970, J. Viljoen (S.M.N. 74); 1 juvenile, Goreangab Dam, May 1970, H. Strauss (S.M.N. 252); 2 juvenile ♂, Ameib, 1-2 February 1972, C.G.C., M-L.P. (S.M.N. 333); 1 juvenile ♂, Gorob Mine, no date, J. Tebje (S.M.N. 517); 1 subadult ♀, Orumana, March 1973, Mr Vermaak (S.M.N. 437); 1 juven

♂, Hoanibrivier, 11 November 1965, C. Brits (S.M.N. 130); 1 juvenile ♂, Waterberg, 5 April 1970 (S.M.N. 168); 1 subadult ♂, Albrechtshohe, 9 March 1970, H. Mittendorf (S.M.N. 160); 1 subadult ♀, Oncocua, 6 September 1969, C. Coetzee (S.M.N. 165); 1 ♀ subadult, Kamanjab, 5 April 1976, B. Lamoral (N.M. 10747).

Distribution

Rocky and mountainous regions of northern half of South West Africa and southern Angola.

Bionomics

As for *H. tityrus*.

Hadogenes tityrus (E. Simon, 1877)

Figs 4.42. c and d, 4.43
Plates 4.44

Ischnurius tityrus E. Simon, 1877: 383-384

Synonym

Hadogenes lawrencei Newlands, 1972: 133-134, figs 2-3, table 1; ♀ holotype and ♀ paratype (S.M.N.) and ♂ paratype, (all subadults), Harus waterhole in Uri-Hauchab Mountains, South West Africa. All seen. NEW SYNONYM. See list of variations further in text.

Diagnosis

The following combination of characters in adults separates *H. tityrus* from other species of the genus. Caudal segments, plate 4.44: cauda I wider than higher, greatest height/greatest width ratios 0,72 (0,69-0,75) in ♀ and ♂; entire cauda only two thirds as long as combined prosomal and mesosomal length in ♀, three quarters as long in ♂; Pedipalp hand, fig. 4.43.a & b: long and slender, dorsal and ventral margins of handback subparallel; handback long, fingers short, movable finger length/handback length ratios 0,68 (0,64-0,72) in ♀ , 0,62 (0,57-0,67) in ♂. Sternite VII, figs 4.42. c and d, lateral margins strongly convex. Hemispermatophore fig. 4.43.f: percentage ha-w distance of dcr-w distance 31,7% (31,6-31,8%); percentage w-bc distance of dcr-bc distance 32,2% (32,1-32,3%); greatest width of distal lamina 1,2 mm.

Description

The following account supplements E. Simon's original description, Lawrence's (1966: 5-7) supplement, Newlands' (1972: 133-134) description of H. lawrencei, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionally smaller and slightly more slender, with width sternite V/ carapace length ratios 1,0 (0,95-1,05) for ♂ and 1,10 (1,05-1,15) for ♀ ; cauda of ♂ three quarter as long as trunk, of ♀ two thirds as long; first proximal middle lamella of each pecten mesially angular in ♂ shallowly curved in ♀ ; ♂ pectinal teeth twice as long as ♀ ; ♂ with 11-17 and ♀ with 6-13 teeth per pecten; ♂ genital operculum sub-oval, ♀ subcordate.

Males and females:

Colour : Body and appendages ranging from brown black No. 65 to strong yellowish brown No. 74 with the telson in latter specimens strong orange yellow No. 68. In dark specimens, the genital operculum, pectines, pectinal plate, sternites III-VI are usually lighter in colour than the rest of the body.

Pedipalps: Chelae of adult ♀ and ♂ with a distinct mesial notch at base of fixed finger and a mesial lobe near base of movable finger as shown in fig. 4.43.a & b. Lawrence's (1966: 7) and Newlands' (1972: 134) reports that these structures occur only in ♂ are incorrect, and this only applies to immature specimens.

Trichobothria: As in fig. 4.43. a-d. Only the ό shown in these figures are stable in number and distribution. External and ventral ό of handback and tibia are numerous and numerically and distributionally too variable for diagnostic purposes.

Paraxial organ and hemispermatophore: As in fig. 4.43. e & f. Hemispermatophore: hook with two apices; distal lamina proportionately wider than in phyllodes and taeniurus; differing diagnostically from these two species as described in respective species diagnoses.

Variation

Pectinal teeth which number 6-13 teeth per pecten in ♀ and 11-17 in ♂, This character is subject to clinal variations along the western and northwestern regions of the species range. For instance, ♀ near the Brandberg mountains (S.M.N. 89 and 90) and from Sarusas, northern Skeleton Coast (S.M.N. 126) have 7-8 teeth and ♀ from Gorrasis farm, 65 km East of H. lawrencei's type locality (N.M. 10715), have 7-9 teeth per pecten. Pedipalp tibia length varies from subequal, to equal to and longer than carapace length ; femur length of leg IV varies from twice to two and a half times as long as maximum width, in samples from the same population. The above variations bridge the diagnostic character states used by Newlands (1972: 133-135) to separate H. Lawrencei from tityrus.

The colour variations described earlier do not appear to be clinal and available records indicate that populations from the northwest, the Naukluft, the southwestern regions of the species range and the Richtersveld are paler in colour.

Type material

Simon's ♀ holotype was examined. It is deposited in the collection of the Museum national d'Histoire naturelle, Paris (R.S. 0378). Its condition suggests that it was reclaimed from a dehydrated state. The right pedipalp and leg III are missing. It is a ♀ and not a ♂ as stated in E. Simon's original description.

Material examined

♀ holotype, Kalahari, no date, Schinz, (R.S. 0378, collection E. Simon 9618); 1♂, Windhoek, 22 August 1965, A.J.L. Mitchell (S.M.N. 40); 1♂, 2 subadult ♀ , 1 subadult ♂, Moltkeblick, 24 August 1968, A. Mitchell, C. Coetzee (S.M.N. 46); 1♀ , 2 subadult ♀ , Windhoek, 5 April 1964, P. Kellerman (S.M.N. 58); 1♂, Heusis, March 1966, F.W. Wagner (S.M.N. 59); 1♀ , Kuiseb Canyon, 17 October 1968, W. Steyn (S.M.N. 83); 1 subadult ♀ , Brandberg Wes, 29 April 1964, W. Steyn (S.M.N. 89); 1 subadult ♀ , 1 juvenile ♂, Brandberg Wes Myn, 27 March 1964, F. Motonane (S.M.N. 90); 1 subadult ♀ , Ais-Ais, no date, N. Hoan (S.M.N. 102); 1 juvenile ♀ , Twyfelfontein, 25 June 1963, Dr Scherz (S.M.N. 104); 1 juvenile ♀, Sarusas, 4 October 1965, C. Brits (S.M.N. 126); 1 subadult ♀, Zebrafontein, 14 October 1970, C.G. Coetzee, P.G. Olivier (S.M.N. 182); 1 subadult ♀, 1 juvenile ♂, 1 juvenile ♀, Rosh Pinah, 10 October 1970, P.G.O. (S.M.N. 192); 1 juvenile ♂, Moltkeblic, 12 May 1969, C.G. Coetzee (S.M.N. 259); 1 ♂, Molteblick 24 August 1968 (S.M.N. 275); 1♂, Regenstein, 30 November 1972, P.G. Olivier, M-L. Penrith, B.A. Harding, C. Buys (S.M.N.407); 2♀, 1 subadult ♀, 1 juvenile ♀, Regenstein, 26 February 1973, B.A. Harding (S.M.N. 433); 1 subadult ♀, 7 juveniles, Witmanshaar, 8 October 1972, H.C. Strauss (S.M.N. 395); 1♀, Obibwasser, 17 September 1973, E. Mokgoabone (S.M.N. 482); 1 juvenile ♀, Regenstein, 12 December 1973, C.G.C. M-L.P., J.T. (S.M.N. 498); 1 subadult ♀, Gorrasis, 25-29 January 1974, C.G.C., M-L.P., C.G., J.B., E.M. (S.M.N. 510); 2 juveniles, AmnisFontein 22 November 1975, E. Griffin (S.M.N. 570); 1 subadult ♀, AmnisFontein, 22 November 1975, E. Griffin (S.M.N. 571); 1 subadult ♀, AmnisFontein, 22 November 1975, E. Griffin (S.M.N. 572); 1 subadult ♂ AmnisFontein, 22 November 1975, E.G., M-L.P., E.M. (S.M.N. 574); 1 subadult ♀, Amnisfontein, 23 November 1975, E. Griffin (S.M.N. 575); 6 juveniles, AmnisFontein, 23 November 1975, E.G., M-L.P., E.M. (S.M.N. 576); 1 subadult ♀, AmnisFontein, 23 November 1975, E.G., M-L.P., E.M. (S.M.N. 577); 1 subadult ♀, AmnisFontein, 23 November 1975, E. Griffin (S.M.N. 578); 2 subadult ♀, AmnisFontein, 23 November 1975, E.G., M-L.P., E.M. (S.M.N. 579); 1 subadult ♀, AmnisFontein, 23 November 1975, E.G., M-L.P., E.M. (S.M.N. 580); 3 subadult ♂, AmnisFontein, 23 November 1975, E.G., M-L.P., E.M., (S.M.N. 581); 2♂, AmnisFontein, 23 November 1975, M-L.P., E.G., E.M. (S.M.N. 582); 1♂, AmnisFontein, 23 November 1975 (S.M.N. 583); 1 subadult ♀, AmnisFontein, 3 November 1975, E.G., M-L.P., E.M. (S.M.N. 584); 2 subadult ♂, 1 subadult ♀, AmnisFontein, 23 November 1975, E. Griffin (S.M.N. 585); 1 subadult ♂, 1 subadult ♀, AmnisFontein, 23 November 1975, E.G., M-L.P., E.M. (S.M.N. 586); 1 ♂, 1 subadult ♀, Lekkersing, February 1962, W. Haacke (N.M. 9100); 1♀, 1 subadult ♂, Otjikoko Sud, April 1973, G. Sander (N.M. 10374); 3♂, 5♀, Otjikoko Sud, April 1974, G. Sander (N.M. 10424); 2♂, 3 subadult ♀, Remhoogte, August 1974, G. Sander (N.M. 10425); 1♂, 1 subadult ♂, 4 subadult ♀, Dobra, September 1973, G. Sander (N.M. 10667); 1 subadult ♀, Plateau, October 1973, H. Erni (N.M. 10668); 2 juvenile ♀, Portsmut, 7 February 1969, B. Lamoral, R. Day (N.M. 10669); 1♂, 3♀, Windhoek, no date, B. Sander (N.M. 10671); 3 subadult ♀, 6 juvenile ♀, Gorrasis, 6 March 1976, B. Lamoral (N.M. 10715); 1♀, 1 subadult ♂, 9 juveniles, Kubub, 1 March 1976, B. Lamoral (N.M. 10716); 1 subadult ♂, 1 subadult ♀, 1 juvenile ♀, Aar, 29 February 1976, B. Lamoral (N.M. 10717); 1♂, Amnisfontein, 23 November 1975, M-L. Penrith, E.G., E.M. (N.M. 11065).

Distribution

Rocky and mountainous regions of southern two thirds of South West Africa.

Bionomics

H. tityrus is nocturnal, Hemiedaphic and lithoclasicolous. All the specimens collected personally, were found wandering about on rock surfaces near crevices and fissures at night. As in other species of Hadogenes these represent the only ecological data available.

Hadogenes bifossulatus Roewer, 1943

DUBIOUS SPECIES

Hadogenes bifossulatus Roewer, 1943: 232-234.

This species was described from 1♀ holotype collected in the Waterberg in South West Africa and deposited in the collections of the Senckenbergia Naturhistorische Museum in Senckenberg, Germany (6739/146 NMS).

I have been unable to examine this specimen which could not be found in the collection of this museum.

Lawrence (1955: 254), states that this is a dubious species, and Newlands, (1972: 135) that it may possibly be a synonym of Hadogenes taeniurus

Subfamily LISPOSOMINAE Lawrence, 1928

Genus Lisposoma Lawrence, 1928

Type species: Lisposoma elegans Lawrence, 1928

Diagnosis

The only genus in this subfamily, Lisposoma can be separated from other genera of the family Scorpionidae by the following combination of characters. Pedipalp chela: handback oval to normal in cross-section, without distinct finger or accessory keels, length greater than width; cutting edge of fixed and movable fingers with a single longitudinal row of small teeth flanked on the inner side by 5 to 6 (see fig. 4.44.c) or 14 to 16 larger teeth; δ Et_2, Et_1 and V_1 situated on the same transverse axis; δ Dt much closer to Db than Et_5. Pedipalp tibia: with 13 external δ; δ v_3 adjacent to external side of outer ventro-lateral keel. Carapace, fig. 4.45.c: anterior margin linear to shallowly procurved, median furrow obsolete to absent, devoid of any sutures; median eyes situated anteriorly of carapace centre; keels or granular rows absent. Tergites: I-VI without keels or rows of granules. Cauda, figs 4.45.d-e: segments I-V sub-hexagonal in cross section; ventral and lateral surfaces of telson agranular. Legs: tarsi lateral distal lobes sharply truncated and virtually obsolete, median dorsal lobes small; tarsi III-IV ventral surface with a median row of 11-16 short spicules flanked by a ventral anterior and a ventral posterior row of three spine-like setae each. Sternum subpentagonal in outline, width greater than length. Pectines with median lamella consisting of 8 to 15 rounded lobes.

Distribution

Endemic to Northern half of South West Africa.

Key to the two species of Lisposoma

1. Carapace: anterior margin sublinear, with a small but distinct median projection. Pedipalps: dentate margin of movable finger with an inner longitudinal row of 6 isolated teeth (see fig. 4.44.c); handback, suboval in cross section; dorso-posterior keel of tibia absent. Caudal segments: I-IV, dorsal keels obsolete to absent except for a single distal granule, dorso-lateral keels absent; I-IV without ventral or ventro-lateral keels in adults .... elegans Lawrence

\- Carapace: anterior margin sublinear, without a distinct small median projection. Pedipalps: dentate margin of movable finger with an inner longitudinal row of 10-16 isolated teeth; handback round in cross-section, distinctly globose; dorso-posterior keel of tibia granular. Caudal segments, figs 4.45.e-f: I-IV, dorso- and dorso-lateral keels granular; I-IV, with distinct, granular ventro-lateral keels in adult, these less well developed in subadults and juveniles .... new species A

Lisposoma elegans Lawrence, 1928

Figs 4.44 and 4.45.a-b

Plate 4.45

Lisposoma elegans Lawrence, 1928: 281-286.

Diagnosis

L. elegans is most closely related to L. new species A but can be separated from it by the following combination of characters. Carapace anterior margin sublinear, with a small but distinct median projection. Pedipalp chela, dentate margin of movable finger with an inner longitudinal row of 6 isolated teeth (see fig. 4.44.c). Caudal segments, I-IV, dorsal keels obsolete to absent except for a single distal granule, dorso-lateral keels absent.

Description

The following account supplements Lawrence's (1928: 281-286) comprehensive original description, the present diagnosis and pertinent plates and figures.

Sexual dimorphism:
In adults, males differ from females in the following characters: ♂ trunk is more slender, with width sternite V/carapace length ratios 0,9 for the one adult ♂ available and 1,10 (1,08-1,13) for ♀ ; ♂ pedipalp handback wider and globose, with width handback/carapace length ratios 0,58 for the one adult ♂ available and 0,40 (0,38-0,43) for ♀ ; ♂ with 15-16 and ♀ 12-16 teeth per pecten.

Males and females:

Pedipalps: In ♂ and ♀ , chela handback length is equal to movable finger length.

Carapace: Median eyes situated anteriorly with l.c./x ratios 2,19 (2,16-2,22) for ♂ and ♀ .

Cauda: Ventral surface of cauda V occasionally lightly granular and not always smooth as described by Lawrence in his original description.

Trichobothria: As in fig. 4.44. Orthobothriotaxic for group C with 13 external ȯ on pedipalp tibia and not 14 as in the genus *Opisthophthalmus*. Pedipalp tibia, figs 4.44. d-f: ȯ d_2 much closer to i than d_1; ȯ esb_2 smaller than esb_1; ȯ eb_4 equidistant from eb_1 and eb_5 and thus distinctly more proximal than in the genus *Opisthophthalmus*; ȯ v_3 adjacent to external side of outer ventro lateral keel. Pedipalp chela, fig. 4.44. a-c: ȯ Dt much closer to Db than Et_5; ȯ V_2 equidistant from V_1 and V_3; ȯ Et_2, Et_1 and V_1 situated on the same transverse axis.

Hemispermatophore: As in fig. 4.45. a-b. Differing diagnostically from the genus *Opisthophthalmus* in having atrophied basal, inner and outer lobes and in the shape of the median lobe and the foot. Differing diagnostically from its sister species *L. new species A* in the shape and size of distal lamina, hook notch, distal crest of distal lamina and in having an accessory crest on the ental side of the median lobe as shown in fig. 4.45.b. In addition the following percentages are diagnostic for *L. elegans* (S.A.M. B 6077):
(1) ha-w distance X100/dcr-w distance = 48,0%
(2) ha-bsh distance X100/ha-w distance = 66,1%
(3) ha-bsh distance X100/dcr-bsh distance = 38,2%

Variation

No distinctive variations in the material studied except in the presence or absence of granules on the ventral surface of cauda V as mentioned above.

Measurements

See plates and figures. Maximum recorded body lengths in adult ♂ 1,8 cm (carapace 2,0 mm) in adult ♀ 2,8 cm (carapace 3,3 mm).

Type material

The original type series consisted of "twenty two specimens from Outjo, Kaoko Otavi, Sesfontein" according to Lawrence (1928: 281) all of which are syntypes as Lawrence did not designate a holotype. Of these 12 ♀ and 4 ♂ were found in the collection of the South African Museum, the remaining six being lost. Out of the remaining syntypes, one adult ♀ (S.A.M. B 6980) is hereby designated as the LECTOTYPE of Lisposoma elegans and the remaining specimens as PARALECTOTYPES. These types have been labelled accordingly and are deposited in the collection of the South African Museum, in Cape Town.

Material examined

♀ paralectotype, no locality, date and collector's name (S.A.M. B 6980). The following paralectotypes: 1 ♂, 3 subadult ♂, Outjo, no date, R.F. Lawrence (S.A.M. B 6077); 7 subadult ♀, Sesfontein, 25 February 1925, R.F. Lawrence (S.A.M. B 6066); 1 ♀, 3 subadult ♀, Outjo, January 1925, R.F. Lawrence (S.A.M. B 6077). The following non-types: 1 subadult ♀, Orumana, Kaokoveld, 10 February 1975, no collector's name (S.M.N. 593); 1 ♀, Goreangab Dam, Windhoek, 19 December 1973, State Museum staff (S.M.N. 503); 2 ♂ and 1 ♀ subadults, Portsmut farm, Hakos Mountains, 7 February 1969, B. Lamoral and R. Day (N.M. 10035); 1 ♀, Annabis farm, Damaraland, 23 February 1969, B. Lamoral and R. Day (N.M. 10032); 7 ♀, 1 subadult ♀, Sesfontein, 4 April 1976, B. Lamoral & L. Ferguson (N.M. 10886); 2 ♀, Vrede, Damaraland, 31 March 1976, B. Lamoral & L. Ferguson (N.M. 10885).

Distribution

Kaokoland, Damaraland down to the Windhoek district in central South West Africa.

Bionomics

Specimens personally collected were found either resting on gritty to stony, hard surfaces at night or under small rocks on similar ground with surface hardness ranging from categories VIII-IX (table 2.2). It is not known whether this species is a burrower. The known localities fall within areas with vegetation types 5 and 8 (fig. 2.4). L. elegans is hemiedaphic and nocturnal.

Lisposoma new species A

Figs 4.45. c-f and 4.46
Plates 4.46

Diagnosis

L. new species A is most closely related to L. elegans but can be separated from it by the following combination of characters. Carapace (fig. 4.45.c), anterior margin sublinear, without a small median projection. Pedipalp chela, dentate margin of movable finger with an inner longitudinal row of 12-16 isolated teeth. Caudal segments, (fig 4.45. e-f) I-IV, dorsal and dorsolateral keels granular.

Description

The type series consists of 1 adult ♂ holotype, 1 subadult ♂ and 2 juvenile ♂ paratypes. The following description is based on the adult ♂ holotype, unless otherwise indicated, and supplements the above diagnosis and pertinent plates and figures.

Sexual dimorphism:
No ♀ available.

Male holotype:

Granulation: The following surfaces finely shagreened with a few scattered granules: upper anterior and inner pedipalp handback; dorsal and anterior pedipalp femur and tibia; posterior and ventral pedipalp femur; carapace and terigtes I-VI; anterior prefemora and femora of legs I-IV. Keels and granulation of caudal segments as in figs 4.45.d-f. Keels of pedipalp tibia as in figs 4.46.c-e. Pedipalp femur as for L. elegans in fig. 4.44.g.
Colour: Pedipalp chela and tibia strong brown No. 55; pedipalp femur, carapace and cauda I-IV with non infuscated surfaces strong yellowish brown No. 74; chelicerae telson, legs I-IV with non-infuscated surfaces dark orange yellow No. 72; sternites moderate yellow No. 87; pectines and genital operculum

pale yellow No. 89. Pedipalp chela: proximal portion of fixed and movable fingers lightly infuscated; although no keels are visible on handback, their normal position is indicated by longitudinal lightly infuscated bands. Keels of pedipalp tibia and femur, lightly to moderately infuscated. Anterior, dorsal and posterior surfaces of pedipalp tibia and femur with light reticulated infuscations. Dorsal surface of chelicerae handback with very light reticulated infuscations. Carapace, tergites I-VII and dorsal surfaces of cauda I-V with moderately dark reticulated infuscations forming symmetrical patterns. Posterior half of lateral and ventral surfaces of cauda IV and V strongly infuscated. Anterior and to a lesser extent posterior surfaces of prefemora and femora of legs I-IV, lightly infuscated.

Chelicerae: As for *L. elegans*, with no diagnostic differences.

Pedipalps: Handback globose. Dentate margins of movable and fixed finger with an inner longitudinal row of 12-16 isolated teeth. Width handback/carapace length ratio 0,72 and length movable finger/handback length ratio 0,93.

Carapace: As in fig. 4.45.c. Anterior margin sublinear, without either a median notch or projection. Median eyes large, situated anteriorly with l.c./x ratio 2,23. Three lateral eyes on either side.

Tergites and sternites: Without keels. Sternites smooth and shiny. Tergites lightly shagreened and matt.

Legs: As for *L. elegans*, with no diagnostic differences.

Cauda: As in figs 4.45.d-f.

Pectines: Much as in *L. elegans*. With 14-15 round middle lamella nodules. With 19-20 teeth per pecten. Pectinal teeth long, as long as medial combined width of middle and marginal lamellae.

Sternum: Subpentagonal in outline, with width 1,3 times greater than length.

Setation: As for *L. elegans*, a sparsely pilose species.

Trichobothria: As in fig. 4.46.a-e. Not differing diagnostically from distribution of ♂ described for *L. elegans* in this revision.

Hemispermatophore: As in fig. 4.46.f. Differing diagnostically from its sister species *L. elegans* in the shape and size of distal lamina, hook notch an distal crest of distal lamina. In addition the following percentages are diagnostic for this new species:

(1) ha-w distance X100/dcr-w distance = 41,1%
(2) ha-bsh distance X100/ha-w distance = 50,0%
(3) ha-bsh distance X100/dcr-bsh distance = 28,0%

Variation

No distinctive variations in the type series.

Measurements

See plates and figures. Measurements for holotype, not obtainable from plates or figures, as following in mm: maximum heights cauda I 1,7, cauda II-V 1,6. Total body length of holotype 2,7 cm.

Type material

Holotype ♂ (N.M. 10697) and 3 ♂ paratypes (N.M. 11110) in Natal Museum, Pietermaritzburg.

Material examined

Holotype ♂ (N.M. 10697), 1 subadult ♂ paratype and 2 juvenile ♂ paratypes (N.M. 11110) all from Elandshoek farm 771, Otavi Highlands, 8 March 1969, B. Lamoral and R. Day.

Distribution

Otavi Highlands in Tsumeb District.

Bionomics

The types were all found in burrows adjacent to the under surface of large rocks half imbedded in hard, slightly damp soil on south facing hills supporting a fairly dense mixed Mopane/Acacia forest in an area of vegetation type 6 (fig. 2.4). No specimens could be found from the south facing hills which support a less dense vegetation.

Subfamily SCORPIONINAE Pocock, 1893

Genus *Opisthophthalmus* C.L. Koch, 1837

Type species: *Scorpio capensis* Herbst, 1800

Synonym

Protophthalmus Lawrence, 1969: 105-106; see Newlands, 1972: 241.

Diagnosis

Opisthophthalmus is most closely related to the genus *Scorpio* Linnaeus, 1758 but can be separated from it and other genera of the subfamily by the following combination of characters: chelicerae handback with stridulatory setae on inner surface; sternite VII without distinct and well developed longitudinal keels; pedipalp tibia with 2 dorsal, 1 internal, at least 14 external and at least 3 ventral ȯ; in the majority of species males have a greater number of pectinal teeth than females.

Distribution

Southern Africa and southern East Africa.

Key to the South West African species of *Opisthophthalmus*

Remarks: Unless otherwise mentioned, the character states used in this key apply to adult ♂ and ♀. In most cases the key also works for subadults and juveniles, bearing in mind that in many species, juveniles exhibit colour patterns and infuscations of the appendages and caudal segments which do not occur in adults. In adults and juveniles the presence or absence of any structure such as keels is to be determined by the actual presence of the said structure and not darkening of the area concerned.

1. Carapace, figs 4.76, 4.77 and 4.78.a-d: anterior median furrow with a distinct longitudinal suture usually but not always bifurcating anteriorly; median ocular furrow with a longitudinal suture. (These sutures occasionally not clearly visible on external inspection become apparent on dissected carapace) 2

- Carapace, fig. 4.78.e-f: anterior median furrow without a bifurcating longitudinal suture; median ocular furrow without a longitudinal suture 17

2. Pedipalp chela: upper surface of handback, agranular and smooth to very shallowly reticular (* see footnote); finger keel distinctly costate to predominantly costate. Telson vesicle: ventral surface smooth (seldom, with very few scattered small granules in ♂) 3

- Pedipalp chela: upper surface of handback, either with scattered granules or with rounded to flattened tubercules (these occasionally anastomosing); finger keel granular, occasionally costate distally. Telson vesicle: ventral surface always lightly to heavily granular (except in <u>O. adustus</u> where this surface is smooth but telson is lightly to deeply infuscated) 9

3. Carapace, fig. 4.76.c & d: median eyes distinctly posterior in position with carapace length over anterior distance of median eyes ratio (l.c./x) falling between 1,30 to 1,45. Adults very large in size and with width telson distinctly greater than posterior width of cauda V 4

---

* Footnote: South-eastern populations of <u>O. carinatus</u> have the upper surface of handback very shallowly granular. Specimens from these populations could mistakenly be carried through to couplet 9 on this character state alone. The next two character states in this part of couplet 2 should ensure that such specimens are carried through to couplet 3.

\- Carapace, fig 4.76. a & b, e & f and 4.78.a: median eyes postero-medial in position with carapace length over anterior distance of median eyes ratio (l.c./x) falling between 1,60 to 1,90. Adults large to moderately large in size and with width telson equal to subequal to cauda V posterior width 5

4. Pedipalp chela, fig. 4.58.a-b: outer ventro-lateral keel of handback predominantly costate; ventral surface of handback with 4 V δ. Pedipalp tibia, fig. 4.58. c-e: with 14 e δ and 3 v δ (very rarely 4) ..... <u>gigas</u> Purcell

\- Pedipalp chela, fig. 4.59.a-c: outer ventro-lateral keel of handback predominantly granular; ventral surface of handback with 5 V δ. Pedipalp tibia, fig. 4.59.d-f: with 20-23 e δ and 9-12 v δ .... <u>haackei</u> Lawrence

5. Pedipalp tibia, fig. 4.49.c, g & j, with 9-13 v δ. Pedipalp chela, fig. 4.74.c, δ V_3 distinctly medial on outer longitudinal axis 6

\- Pedipalp tibia with 3 v δ (rarely 4). Pedipalp chela, δ V_3 within proximal half on outer longitudinal axis 7

6. Pedipalp tibia, fig. 4.49. a-c: δ esb with an accessory δ; δ v_1 with an outer accessory δ forming a basal pair; δ d_2 approximately equidistant from δ i and d_1. Hemispermatophore, fig. 4.49.d: hook notch shallowly excavated; position of hook apex almost halfway of total distal lamina length, with percentage ha-w distance of dcr-w distance 46% (44-48%) . ... <u>brevicauda</u> Lawrence

\- Pedipalp tibia, figs 4.49.e-j and 4.74.d-f: δ esb without an accessory δ; v_1 without an outer accessory δ; δ d_2 distinctly closer to δ i than d_1. Hemispermatophore, fig. 4.74.g: hook notch deeply excavated;position of hook apex distincly proximal on total distal lamina length, with percentage ha-w distance of dcr-w distance 35% (33-37%) .... <u>ugabensis</u> Hewitt

7. Caudal segments: II, ventro-lateral keels shallowly costate; III, ventral and ventro-lateral keels shallowly costate; IV, ventral and ventro-lateral keels costate granular; V, ventro-lateral keels composed of distinctly elongated, spiniform granules. Carapace: interocular surface smooth to occasionally only very sparsely granular. Legs: median dorsal lobe subequal to lateral lobes in length 8

\- Caudal segments: II to IV, ventral and ventro-lateral keels absent, ventral surfaces with transverse ridges in ♂, smooth in ♀; V, ventro-lateral keels composed of short spiniform granules. Carapace: interocular surface lightly to strongly granular. Legs: median dorsal lobe distinctly much shorter than lateral lobes .... cavimanus Lawrence

8. Pedipalp chela, fig. 4.50.a-b: outer ventro-lateral keel of handback predominantly costate; ȯ est distinctly distal to dst; distance between ȯ est and esb approximately equal to half that between esb and eb. Pedipalp tibia, fig. 4.50.c-e: ȯ d_2 approximately equidistant from d_1 and i; ȯ v_2 distinctly closer to v_1 than v_3. Legs: posterior surface of protarsi I and II with a row of 3 to 4 short spine-like setae; lateral claws short, strongly curved and of equal length .... carinatus (Peters)

\- Pedipalp chela, fig. 4.65.a & b: outer ventro-lateral keel of handback predominantly granular; ȯ est slightly distal to or level with dst; distance between ȯ est and esb approximately equal to that between esb and eb. Pedipalp tibia, fig. 4.65.d-f: ȯ d_2 distinctly closer to i than d_1; ȯ v_2 approximately equidistant to v_1 and v_3. Legs: posterior surface of protarsi I and II with scattered long stiff setae; lateral claws long, distally curved and of unequal length ...... litoralis Lawrence

9. Telson vesicle: lateral surfaces lightly to heavily granular .... 10.

\- Telson vesicle: lateral surfaces always smooth and shiny .... 11.

10. Pedipalp tibia, fig. 4.68.c: ό d_2 approximately equidistant from d_1 and i. Caudal segments: I, ventral keels obsolete to absent, ventro-laterals shallowly costate; II-III, ventral keels shallowly costate, ventro-laterals costate; IV ventral and ventro-lateral keels costate granular in ♀ and ♂; telson vesicle, posterior upper lateral surfaces with few to many spiniform granules but never including numerous minute spicules. Total body and carapace lengths of adults varying according to regions listed in table 4.4. .... *opinatus* (E. Simon)

\- Pedipalp tibia, fig. 4.53.d: ό d_2 distinctly closer to i than d_1. Caudal segments: I-II, ventral and ventro-lateral keels absent; III ventral and ventro-lateral keels obsolete to absent; IV ventral keels obsolete to absent, ventro-lateral keels obsolete in ♀ and ♂, but occassionally very shallowly costate granular in ♂; telson vesicle, posterior upper lateral surfaces with a moderate number of spiniform granules interspersed with numerous minute spicules. Total body length of adults not exceeding 65 mm (carapace 10,5 mm). Distribution range confined to western central and central regions of South West Africa .... *new species A*

11. Sternite VII and ventral surfaces of cauda I and II rasp-like, covered with large, non anastomosing crescent shaped granules. Carapace: anterior bifurcation very distinct and long, occupying almost one quarter of total carapace length. .... *setifrons* Lawrence

\- Sternite VII and ventral surfaces of cauda I and II smooth or covered with small round granules, these never large or rasp-like but occasionally anastomosing to form shallow transverse ridges. Carapace: anterior bifurcation obsolete to distinct, short and not occupying more than one sixth of total carapace length 12

12. Caudal segments:IV, ventral and ventro-lateral keels distinct, costate granular or granular; III, ventro-lateral keels shallowly costate 13

- Caudal segments: IV, ventral keels absent, ventro-lateral keels absent to occasionally very weakly costate; III, ventro-lateral keels absent 14

13. Pedipalp chela: outer ventro-lateral keel of handback granular. Caudal segments: IV, ventral and ventro-lateral keels costate granular, distal spine of dorsal keels moderately enlarged. Legs: lateral claws of III and IV long, distally strongly curved and of equal length. .... <u>intercedens</u> Kraepelin

- Pedipalp chela: outer ventro-lateral keel of handback distinctly costate. Caudal segments: IV ventral and ventro-lateral keels granular, distal spine of dorsal keels not enlarged. Legs: lateral claws of III and IV long, distally slightly curved and of unequal length .... <u>fitzsimonsi</u> Hewitt

14. Cauda V: ventral surface evenly granular throughout; ventral keel absent and not distinct from adjacent granules; ventro-lateral keels subparallel to each other; each of lateral halves of ventral surface with a mid-lateral seta not flanked by any enlarged granules. In ♂, (sternites III-VII and ventral surfaces of cauda I-III evenly granular to shallowly wrinkled. Habitus of ♀ unknown. .... <u>new species C</u>

- Cauda V: ventral surface sparsely and unevenly granular; ventral keel distinct and granular; ventro-lateral keels either divergent or convergent posteriorly; each of lateral halves of ventral surface with a mid-lateral seta flanked by 1-3 distinctly enlarged granules. In ♂ sternites III-VII and ventral surfaces of cauda I-III smooth and agranular 15

15. Caudal segments, plate 4.47. a & b and 4.76. a & b: IV, lateral profile of ventral surface sublinear, entire segment normally developed; V, ventro-lateral keels posteriorly predominantly divergent to each other. Pedipalp chela, figs 4.47.b, 4.71b. and 4.72.b: outer ventro-lateral keel of handback, predominantly granular. 16

- Caudal segments, plate 4.61. a & b: IV, lateral profile of ventral surface arcuate, entire segment unusually globose; V, ventro-lateral keels, posteriorly convergent. Pedipalp chela, fig. 4.57.b: outer ventro-lateral keel of handback predominantly costate .... *new species B*

16. Caudal segments II-IV, fig. 4.47.e: distal spines of dorsal keels distinctly elongated and spiniform. Telson vesicle, fig. 4.47.e: ventral surface smooth; entire telson lightly to strongly infuscated. Legs: protarsi I and II, posterior surface with a comb-like row of long stiff setae; tarsi III and IV without a ventral anterior row of spine-like setae; tarsi lateral claws of unequal length, long and distally only slightly curved .... *adustus* Kraepelin

- Caudal segments II-IV: distal spines of dorsal keels only slightly larger than preceding ones. Telson vesicle: ventral surface lightly granular; telson not infuscated. Legs: protarsi I and II, posterior surface with a row of three spine-like setae; tarsi III and IV with a ventral anterior row of 1-2 spine-like setae; tarsi lateral claws of equal length, short and strongly curved .... schultzei Kraepelin

17. Carapace: median eyes antero-medial to anterior in position with carapace length over anterior distance of median eyes ratio (l.c/x) falling between 2,10 to 2,50. Caudal segments: cauda II, dorsal keels obsolete to absent; cauda III, ventral surface either lightly to distinctly granular or punctate; cauda V, dorsal keels absent, ventro-lateral keels posteriorly convergent 18

\- Carapace: median eyes postero-medial to posterior in position with carapace length over anterior distance of median eyes ratio (l.c./x) falling between 1,50 to 1,90. Caudal segments: cauda II, dorsal keels present and distinct; cauda III, ventral surface smooth, agranular and not punctate; cauda V, dorsal keels either partially developed or distinct along entire length, ventro-lateral keels either posteriorly divergent or subparallel to each other 21

18. Pedipalp chela figs 4.60.b and 4.64.b: ventral surface of handback with 16-20 V δ 19

\- Pedipalp chela figs 4.54.c and 4.70.b: ventral surface of handback with 4 V δ 20

19. Pedipalp chela, fig. 4.60. a: handback of ♂ and ♀ moderately wide, with width handback/carapace length ration 0.53 (0,48-0,58); upper marginal keel of handback granular, composed of granules only slightly larger than those of upper surface of handback. Carapace, fig. 4.78.f: median eyes distinctly anterior in position with carapace length over anterior distance of median eyes ratio (l.c/x) falling between 2,35 to 2,50. Caudal segments: cauda III, dorsal keels present and distinct; cauda IV, ventro-lateral keels absent to obsolete;

cauda V, lateral profile of ventral surface sublinear to shallowly convex .... holmi (Lawrence)

\- Pedipalp chela, fig. 4.64.a & c: handback of ♂ (♀ unknown) distinctly wide, with width handback/carapace length ratio 0,70; upper marginal keel of handback composed of blunt spiniform tubercules which are distinctly much larger and longer than those of upper surface of handback. Carapace: median eyes antero-medial in position, with carapace length over anterior distance of median eyes ratio (l.c./x) 2,15. Caudal segments: cauda III, dorsal keels absent to obsolete; cauda IV, ventro-lateral keels costate granular; cauda V, lateral profile of ventral surface shallowly concave .... *jenseni* (Lamoral)

20. Pedipalp tibia, fig. 4.70.d-e: with 14 e ó and 3 v ó. Pedipalp femur, fig. 4.70. f: ó d distinctly distal to ó i. Caudal segments: cauda III and IV ventral and ventro-lateral keels absent to obsolete; cauda IV, ventral surface smooth and agranular; cauda V, ventro-lateral keels subparallel to each other. Legs: lateral claws equal in length within each pair; tarsi median dorsal lobe distinctly shorter than lateral lobes. *new species E*

\- Pedipalp tibia, fig. 4.54. e-f: with 21-25 e ó and 10-13 v ó. Pedipalp femur, fig. 4.54.g: ó d distinctly proximal to ó i. Caudal segments: cauda III, ventral and ventro-lateral keels costate granular; cauda IV, ventral keels granular, ventro-laterals costate granular; cauda IV, ventral surface granular; cauda V, ventro-lateral keels posteriorly convergent. Legs: lateral claws unequal in length within each pair; tarsi median dorsal lobe length at least equal to that of lateral lobes *concinnus* Newlands

21. Carapace, fig. 4.78.e: median eyes posterior in position with carapace length over anterior distance of median eyes ratio (l.c./x) falling between 1,50 to 1,60; carapace, medially with a distinct oval shaped depression anterior to the median eyes; lateral and posterior surfaces coarsely granular. Caudal segments: cauda IV, dorsal keels distal spine distinctly enlarged and spiniform. Legs: lateral claws long and distally sublinear; tarsi median dorsal lobe at least as long as lateral lobes, unusually broad and tumescent .... flavescens Purcell

\- Carapace: median eyes postero-medial in position with carapace lenth over anterior distance of median eyes ratio (l.c./x) falling between 1,70 to 1,95; carapace without a distinct depression anterior to the median eyes; lateral and posterior surface lightly to moderately granular. Caudal segments: cauda IV, dorsal keels distal spine at most moderately enlarged. Legs: lateral claws short or long but distally curved; tarsi median dorsal lobe either distinctly shorter or subequal to lateral lobes and not tumescent. 22

22. Pedipalp chela: upper surface of handback granular. Pedipalp tibia, fig. 4.52. f-g, with 20-23 e ȯ and 7-9 v ȯ . Caudal segments: cauda V, ventro-lateral keels spiniform, dorsal keels present and distinct along entire length, lateral profile of ventral surface shallowly concave. Legs: tarsi median lobe length subequal to lateral lobes chrysites Lawrence

\- Pedipalp chela: upper surface of handback smooth and agranular. Pedipalp tibia with 14 e ȯ and 3 v ȯ. Caudal segments: cauda V, ventro-lateral keels granular, dorsal keels obsolete or only partially present, lateral profile of ventral surface either sublinear or convex. Legs: tarsi median lobe distinctly shorter than lateral lobes 23

23. Telson: ventral surface of vesicle granular. Pedipalp chela, fig. 4.75.c, with ò V_2 close to the inner margin of the ventral surface of handback. Pedipalp tibia, with ò d_2 closer to d_1 than i. Caudal segments: cauda III, ventral and ventro-lateral keels costate; cauda IV, ventral keels granular, ventro-laterals costate granular. Legs: tarsi III and IV without a ventral anterior row of spine-like setae .... *wahlbergi* (Thorell)

\- Telson: ventral surface of vesicle smooth and agranular. Pedipalp chela, fig. 4.69.b, with ò V_2 submedial. Pedipalp tibia, with ò d_2 closer to i than d_1. Caudal segments: cauda III and IV with ventral and ventro-lateral keels absent to obsolete. Legs: tarsi III and IV with a ventral anterior row of 2-3 spine-like setae .... *new species D*

Opisthophthalmus adustus Kraepelin, 1908
Figs 4.47, a-h, 4.48.a and 4.77.e
Plates 4.47, 4.48-

Opisthophthalmus adustus Kraepelin, 1908: 260-261.

Synonym

Opisthophthalmus longiceps Lawrence, 1941: 401-403; holotype ♀ (T.M. 8628) from Oranjemund, South West Africa. Seer. NEW SYNONYM.

Diagnosis

O. adustus is most closely related to *O. schultzei* but can be separated from it and other species of the genus on the following combination of characters: Carapace, fig. 4.77.e: anterior median furrow with a poorly developed bifurcating longitudinal suture; median ocular furrow with an obsolete longitudinal suture. Colour: maxillary lobes I and II melanous; telson vesicle, cauda IV & V and occasionally parts of III melanous to infuscated. Pedipalp chela: upper and outer surfaces in ♂ and ♀ with flattened to coarse tubercules which occasionally anastomose. Ventral surface of telson vesicle smooth. Greatest body length of adult ♂ 11 cm of adult ♀ 10 cm.

Description

The following account supplements Kraepelin's original description, Lawrence's (1946: 401-403) description of *O. longiceps*, the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ proportionately more slender with width sternite V/carapace length ratios 0,75 (0,70-0,80) in ♂ and 0,94 (0,90-1,00) in ♀ ; ♂ carapace 10% longer, cauda and telson 15% longer, pedipalp chela 13% longer; ♂ handback narrower with handback width/carapace length ratios 0,60 (0,56-0,63) in ♂ and 0,75 (0,71-0,80) in ♀ ; genital operculum suboval, wider than long in ♂, subtriangular in ♀ with width equal to length; ♂ pectinal teeth twice as long as female; first proximal middle lamella of each pecten mesially angular in ♂, shallowly curved and devoid of teeth along proximal one quarter of total pecten length in ♀ ; ♂ with 21-24 and ♀ 13-19 teeth per pecten

Males and females (see also table 4.2):

Granulation: General granulation of body and appendages coarser and more pronounced in ♂ than ♀, particularly on tergites, inner surfaces of pedipalp hand and tibia, dorsal and ventral surfaces of femur, sternites and ventral surface of cauda I.

Colour: See diagnosis. In addition, with following patterns (plates 4.47 & 4.48): carapace with a subtriangular blackish marking extending from anterior margin and tapering posteriorly to a little beyond the median eyes, this marking occasionally but rarely missing or faint as in Kraepelin's types; anterior two thirds of tergites I-VII melanous; cauda III occasionally partly infuscated to melanous.

Pedipalps: Chela, figs 4.47.a-d: finger keel moderately developed in ♂ and ♀; secondary and accessory keels of upper and outer surfaces as in figs 4.47.a & d, subject to individual variation; movable finger length/handback length ratio 1,10 (1,05-1,16) in adult ♂ and ♀. Tibia and femur as in figs 4.47.f-h.

Carapace: Median eyes almost halfway between anterior and posterior margins, with l.c./x ratio 1,80 (1,75-1,95) for ♂ and ♀. Interocular area smooth except anterior third with a few (20-30) widely separated granules.

Cauda: See fig. 4.47.e. In adult ♂ and ♀: cauda I, ventral surface weakly tubercular, ventral and ventro-lateral keels absent; cauda II-III smooth and shiny, ventral and ventro-lateral keels absent; cauda IV smooth and shiny, ventral and ventro-lateral keels absent in ♀, obsolete to weak in ♂; cauda II-IV, dorsal keels well developed, posteriorly with 1-2 distinct, elongated and pointed spines; telson acculeus nearly straight, bulbus agranular, smooth and shiny.

Sternites: See plates 4.47.b & 4.48.b. Sternites IV-VII in ♂ and VI-VII in ♀ with flattened, broad tubercules occasionally forming interrupted transverse ridges.

Legs: Leg I-IV: lateral claws distinctly elongated, equal or almost equal to tarsus length, and almost straight.

Pectines: ♂ with 21-24 and ♀ 13-19 teeth per pecten.

Sternum: Subpentagonal in shape, with a deep, laterally compressed median furrow; length/width ratio 1,50 (1,47-1,54).

Trichobothria: As in figs 4.47.a-d and f-h. (+1) neobothriotaxic for Group C with 14 external ȯ on tibia. Chela: ȯ dst level with or more proximal than est; ȯ Et_4 small and in line with Et series; distance ȯ $V_4 - Et_1/V_3 - Et_1$ ratio 1,65 (1,60-1,70) in ♀ and ♂. Tibia: ȯ d_2 closer to i than d_1; ȯ et_1, est_1 and esb_1 axis in line with eb_2.

Setation: Pedipalps, chelicerae, legs, cauda and telson with numerous long setae; lateral margins of all sternites with a row of setae; femur, tibia protarsus and tarsus of legs I-II with a single longitudinal row of long stiff setae on anterior and posterior surfaces forming a regular brush-like structure undoubtedly associated with a psammophile habitat.

Hemispermatophore: As in fig. 4.48.a, sub-apical, ventro-lateral margin of hook (salmh) shallowly concave, undulated and long, percentage ha-bsh distance of ha-w distance 53% (52-54%); hook apex situated almost halfway of total distal lamina (DL) length, percentage ha-w distance of dcr-w distance 41,5% (41,0-42,0%); hook notch V-shaped; distal crest (dcrdl) of distal lobe narrow (one fifth of width of distal lamina at this level), not reaching the distal lamina (DL) lateral crest (lcr) ectally, but bending sharply medially to form the ectal crest (eccr) which is subparallel to the sagital axis of the hemispermatophore.

O. adustus differs distinctively from *O. schultzei* in the above character states.

Variation

Shape, size and intensity of blackish marking on prosoma variable markings occasionally, but rarely, missing or faint; size and density of granules on outer and upper surfaces of pedipalp hand and prosoma are subject to. variation within single populations. Males have 21-24 and females 13-19 teeth per pecten.

Measurements (in mm)

For measurements of types, see Kraepelin 1908: 261. Also see Lawrence 1946: 403. The following are measurements from the female and male homotypes (N.M. 10713). Male measurements in brackets after female's. Prosoma length 15,0 (16,8), posterior width 13,5 (14,3); length of hand back 12,5 (13,6), of movable finger 14,4 (17,3), of hand 23,5 (27,5); handback width 11,1 (9,9); lengths of caudal segments I 5,5 (6,5), II 5,5 (6,5), III 5,8 (7,5), IV 6,6 (7,9), V 11,4 (12,9); widths of these segments 4,9 (5,8), 4,5 (5,5), 4,2 (5,2), 3,6 (4,6), 3,4 (3,6). Maximum recorded body length of adult ♂ 11 cm (carapace 1,8 cm), of adult ♀ 10 cm (carapace 1,6 cm).

Type material

No holotype was designated by Kraepelin in his original description based on a male and female. This material was examined. The female is hereby selected and labelled as the LECTOTYPE of O. adustus Kraepelin, 1908 and the male syntype as the PARALECTOTYPE. These types are deposited in the collection of the "Zoologisches Institut und Zoologisches Museum Universität Hamburg", in Hamburg, Germany.

Homotypes

A ♂ and ♀ have been selected as homotypes and they are deposited in the Natal Museum collection (N.M. 10713).

Material examined

♀ lectotype, ♂ paralectotype, Deutsch-Südwestafrika, no date Prof. Fulleborn, (ZMH, no number); 1 ♂ 1 ♀ (Homotypes), 28 km East of Rosh Pinah, 18 February 1973, B. Lamoral. (N.M. 10713); 1 ♂, 1 ♀ 2 juvenile ♂, Namuskluft 88, East of Rosh Pinah, 13 October 1970, F. Burger & J. Batista (S.M.N. 191); 3 ♂, Namus Kluft 88, 10 km E of Rosh Pinah, 12 October 1970, P.G. Olivier, I. Mokgoabone, F.A. Burger and J. Batista (N.M. 10712); 1 ♂, Rosh Pinah Mine, December 1971, A. Maritz, (T.M. 10536); 1 ♀ Rosh Pinah Mine, January 1972, A. Maritz (T.M. 10537); 1 ♀ Chamais Gate, June 1973, C.J. Coetzee, C.D.M. (N.M. 10625); 1 ♂, 1 ♀ Namus Kluft 88, 10 km S of Rosh Pinah, 11 November 1970, P.J. Buys (S.M.N. 188); 2♂, 1 ♀, 2 ♂ & 2 ♀ juveniles, Rosh Pinah near golf course, 16-19 February 1973, B. Lamoral, (N.M. 10654); 3 ♂, 3 ♀, 1 ♂ & 1 ♀ subadults, Obib dunes, ± 16 miles WEst of Rosh Pinah, 17-19 February 1973 B. Lamoral (N.M. 10636); 1 ♀ Namus Kluft 88, 11-13 October 1970 (S.M.N. 200); 2 ♂ juveniles, Namus Kluft, 10 km N Rosh Pinah, 10 October 1970, I. Mokgoabone, (S.M.N. 189); 1 ♂ juvenile, Obib dunes ± 12 miles of W of Rosh Pinah, 18 February 1973, B. Lamoral, (N.M. 10592); 1 ♀ juvenile, 15 km E Rosh Pinah 7 October 70. P.J. Buys, C.G. Coetzee, M-L. Penrith (S.M.N. 195); 1 ♀ subadult, Namus Kluft 88, 10 km E Rosh Pinah 9 October 1970, P.J. Buys. (S.M.N. 184); 1 ♂, Tsirub 13, 3 March 1976, B. Lamoral (N.M. 10721); 1 ♀ Gorrasis 99, 25 January 1974, State Museum staff (S.M.N. 508); 1 ♂ & 1 ♀ subadults, Tsirub 13, 3 March 1976, B. Lamoral (N.M. 10791); 1 subadult ♂, Neuland 98, 4 March 1976, B. Lamoral (N.M. 10792); 1 ♀, Obib dunes, 18 February 1973, B. Lamoral (N.M. 11091); 1♂, 2 ♀, 11 ♂ and 2 ♀ juveniles, Kubub 15, 2 March 1976, B. Lamoral (N.M. 10725).

Distribution

O. adustus has so far only been recorded within the confines of vegetation area of type 3A (see fig. 2.4) and it has not been recorded at all south of the Orange River.

Bionomics

A psammophilous species which digs a deep (maximum depth recorded, 75 cm below ground surface) multi-directional burrow (plate 2.5) in sandy soils of categories V and VI (see table 2.2) in vegetation area of type 3A (desert and succulent steppe). No specimens have been found under rocks on sandy surfaces.

This species is nocturnal. Females are sedentary and seldom move far from their burrows, which they enlarge as they increase in size. Due to this, 95% of the females collected had to be dug out of their burrows
Males move about considerably at night, and most of them were captured while wandering away from their burrows. It is notknown whether adult males return to their burrows or dig a new one each night.

Opisthophthalmus brevicauda Lawrence, 1928

Figs 4.49. a-d and 4.76.a
Plates 4.49

Opisthophthalmus brevicauda Lawrence, 1928: 275-277.

Synonyms

Opisthophthalmus carinatus scabriceps Lawrence, 1966: 5; ♀ holotype (N.M. 9051) from Welwitschia, South West Africa. Seen. NEW SYNONYM.

Opisthophthalmus gaerdesi Lawrence, 1961:149-151; ♂ holotype (N.M. 8292) from mountains near Marienfluss valley, northern Kaokoveld, South West Africa. Seen. NEW SYNONYM.

Diagnosis

O. brevicauda is most closely related to O. ugabensis but can be separated from it and other species of the genus on the following combination of characters. Carapace fig.4.76.a: anterior median furrow with a poorly developed bifurcating longitudinal suture; median ocular furrow with an obsolete longitudinal suture. Colour: caudal segments and telson, tergites I-VII sternite VII, dorsal and lateral surfaces of pedipalp trochanter, femur and tibia, melanous to occasionally infuscated. Pedipalp tibia: 8-13 Vბ, ბ V_1 with an outer accessory ბ forming a basal pair; ბ esb_2 with an accessory ბ (fig. 4.49.b). Greatest body length of adult ♂ and ♀ 10 cm.

Description

The following account supplements Lawrence's (1928: 275-277) original description, Lawrence's original descriptions of the new synonyms listed above, the present diagnosis and pertinent plates and figures. Lawrence's original description was based on a subadult ♂ , that of O. carinatus scabriceps on an adult ♀ and that of gaerdesi on an adult ♂. Access to additional material and examination of the above types have shown that all the diagnostic characters selected by Lawrence are so variable as to bridge the particular character sets proposed by him to separate these species.

Sexual dimorphism:

In adults males differ from females in the following characters: ♂ trunk proportionally smaller and more slender with width sternite V/carapace length ratios 0,75 (0,70-0,80) for ♂ and 1,00 (0,90-1,10) for ♀. ♂ cauda equal or subequal to trunk length, in ♀ three-quarters as long while total body length is usually the same; pedipalp hand back of ♂ distinctly narrower and fingers longer than in ♀ ; first proximal middle lamella of each pecten mesially only slightly curved to angular with pectinal teeth along entire posterior margin in ♂, distinctly curved with proximal half of posterior margin devoid of teeth in ♀; ♂ with 22-26 and ♀ 16-20 teeth per pecten. ♂ genital operculum sub-oval, ♀ subcordate.

Males and females (See also table 4.2).

Pedipalps: Chela: upper surface in ♂ almost flat and smooth, in ♀ slightly convex and shallowly reticulated; finger keel well developed; outer surface granular, with accessory keel as shown in fig. 4.74. a & b for O. ugabensis; movable finger length/handback length ratio 1,50 (1,45-1,55) in adult ♂ and 1,35 (1,30-1,40) in adult ♀ ; handback of adults distinctly wider in ♀ than ♂ with handback width/carapace length ratios 0,70 (0,65-0,75) in ♀ and 0,50 (0,45-0,55) in ♂.

Carapace: Median eyes distinctly posterior in position l.c./x ratio 1,60 (1,50-1,70) for ♂ and ♀.

Sternites: Smooth and shiny, sternite VII occasionally very slightly wrinkled in ♂ .

Legs: Protarsi of legs I-II with three distinct spine-like setae on postero-lateral margins.

Cauda: Entire cauda distinctly shorter than trunk in ♀ , occasionally as long as trunk in ♂; ventral and ventro-lateral keels of cauda I absent, of II obsolete, of III present and costate, of IV costate granular; dorsal keels of I-IV well developed, distal spine enlarged; telson bulbus agranular, smooth and shiny.

Trichobothria: See diagnosis. In addition, pedipalp chela as shown for O. ugabensis in fig. 4.74. a-c; δ est distinctly distal to dst; δ esb distal to dsb; distance δ V_4-Et_1/V_3-Et_1 ratio 2,05 (1,95-2,15) in ♀ & ♂. Pedipalp tibia: as in fig. 4.49.a-c; single accessory δ to esb_2 and V_1 always present; distance between δ i and d_1 twice that between i and d_2.

Setation: Moderately pilose. ♂ pedipalp chela with thicker vestiture than ♀ . Legs II-IV: tarsi ventrally with an anterior row of 3-4 and a posterior row of 5-6 short, stiff spine-like setae.

Hemispermatophore: As in fig. 4.49.d. hook notch shallowly excavated; percentage ha-bsh distance of ha-w distance 45% (44-46%); position of hook apex almost halfway of total distal lamina length, with percentage ha-w distance of dcr-w distance 46% (44-48%).

Variation

Little variation observed in studied material, except in colour as reported in diagnosis.

Measurements

See plates & figures. Maximum recorded body length of adult ♂ 10,0 cm (carapace 1,7 cm), ♀ 10,0 cm (carapace 1,95 cm).

Type material

Lawrence's ♂ holotype is deposited in the collection of the South African Museum (S.A.M. B6090). It has become dismembered and is in poor condition.

Material examined

♂ holotype, Sesfontein, 1926 South African Museum expedition (S.A.M. B6090); 1 ♂ & 1 ♀ juveniles, Otjinungwa, 22 November 1970, P.G. Olivier (S.M.N. 250); 1 juvenile ♀, 6,5 km E. Sanitatas, 26 November 1970, M.-L. Penrith (S.M.N. 212); 1 ♀ juvenile, Otjinungwa, 19 August 1973, State Museum Staff (S.M.N. 468); 1 ♀, 1 subadult ♂, Sesfontein, 4 April 1976, B. Lamoral & L. Ferguson (N.M. 10827).

Distribution

O brevicauda has so far been recorded only from Kaokoland.

Bionomics

The only specimens personally collected were found at night, resting on the surface of gritty consolidated sandy soil of hardness category VII (table 2.2). No specimens were excavated from burrows.

Opisthophthalmus carinatus (Peters, 1861)

Figs 3.4, 4.48.b, 4.50 and 4.76.e
Plates 4.50, 4.51
Table 4.3.

Heterometrus carinatus Peters, 1861: 515

Synonyms

Petrovicus furcatus E. Simon, 1887; see Kraepelin, 1894: 85. ♀ type (R.S. 0230) seen and is hereby confirmed to be a synonym.

Opisthophthalmus histrio Thorell, 1877: 242-243; ♂ holotype (KM 42) from "Caffraria", (South West Africa). Seen NEW SYNONYM.

Opisthophthalmus carinatus scabriceps Lawrence, 1966: 5; ♀ holotype (N.M. 9051) from Welwitschia, South West Africa. Seen. NEW SYNONYM.

Diagnosis

O. carinatus is most closely to *O. litoralis* but can be separated from it and other species of the genus on the following combination of characters. Carapace, fig. 4.76.e : anterior median furrow with a distinct longitudinal suture, anterior bifurcation very distinct and moderately long, occupying at least one fifth of total carapace length; median ocular furrow with a distinct longitudinal suture bifurcating posteriorly. Pedipalp chela: upper surface of handback agranular and smooth to shallowly reticular; finger keel of ♀ and ♂ distinctly costate; outer ventro-lateral keel of handback predominantly costate. Cauda IV, ventral and ventro-lateral keels costate granular.

Description

The following account supplements Peters' (1861: 515) short original description, Hewitt's (1918: 131-132) comprehensive supplement, the original descriptions of the species synonymised above, the present diagnosis and pertinent plates and figures. *O. carinatus* is the most common and most widely distributed species of *Opisthophthalmus* in South West Africa.

Populations at opposite extremes of the species distribution range exhibit character states which could warrant non-conspecific status but it was found that all of these character states are subject to clines along intermediate regions. *O. carinatus histrio* and *scabriceps* have been synonymised with the typical form as a result of this. See table 4.3 for examples of the extremes and intermediate states of two characters.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ trunk proportionately smaller and more slender with width sternite V/carapace length ratios 0,90 (0,86-0,94) for ♂ and 1,10 (1,05-1,15) for ♀ ; ♂ cauda approximately 20% longer than trunk length, in ♀ equal to subequal while total body length is approximately only 10% greater in ♀ ; pedipalp handback of ♂ narrower and fingers longer than in ♀ with width handback/carapace length ratios 0,68 (0,64-0,71) in ♂ and 0,80 (0,76-0,84) in ♀ and length movable finger/handback length ratios 1,50 (1,45-1,55) in ♂ and 1,40 (1,34-1,44) in ♀ ; first proximal middle lamella of each pecten with mesial margin strongly angular while pectinal teeth are present along entire posterior margin of pecten in ♂ , very shallowly curved while proximal one fifth of posterior margin of pecten devoid of teeth in ♀ ; ♂ genital operculum suboval in outline, and twice as wide as long, ♀ subcordate with width one and a quarter times greater than length; in approximately the northern two thirds of South West Africa, most ♂ have sternite VII and ventral surfaces of cauda I and II transversely wrinkled and in ♀ these surfaces are smooth (see table 4.3); ♂ with 18-30 and ♀ 12-20 teeth per pecten.

Males and females (See also table 4.2):

Granulation: As following for specimens from the central regions of South West Africa. Carapace of ♀ & ♂ : interocular surface smooth and shiny, lateral surfaces moderately granular, posterior median surface lightly granular to smooth. Tergites: smooth in ♀ , finely shagreened in ♂. Cauda: I-V lateral surfaces, lightly and shallowly granular. Upper surface of handback of ♀ and ♂ very shallowly reticulated to very shallowly granular.

Colour: Females and males from near Windhoek and central South West Africa have the following colouration : Carapace and upper surfaces of pedipalp femur and tibia, strong brown No. 55; anterior two thirds of tergites I-VI and anterior half of tergite VII, dark yellowish brown No. 78, remaining posterior portions of these tergites moderate orange yellow No. 71; pedipalp chela fingers, handback finger keel, outer and inner ventro-lateral keels and keels of pedipalp tibia and femur dark reddish brown No. 44; upper, outer and inner surfaces of pedipalp handback, ventral surfaces of of pedipalp tibia and femur dark orange yellow; sternites and cauda I-V strong yellowish brown No. 74; legs and telson brilliant yellow No. 83; pectines light yellow No. 86.

Setation: As for specimens from the central region of South West Africa. ♀ with body and appendages nearly apilose, ♂ with body, legs, pedipalp femur and tibia and cauda with few setae, pedipalp chela and telson moderately pilose.

Trichobothria: As in fig. 4.50.a-e. (+ 1) neobothriotaxic for group C with 14 external δ on tibia. Chela: δ est distal to dst; distance between δ est and esb approximately equal to half that between esb and eb; V_3 situated in proximal half of ventral surface; δ Et_4 small, nearly in line with Et series and closer to Et_3 than Et_5. Tibia: δ d_2 approximately equidistant from d_1 and i; δ v_2 distinctly closer to v_1 than v_3. All the specimens in the list of material examined have 3 ventral δ on the pedipalp tibia with the notable exception of all the specimens from the mid-SW subregion. This aberration is discussed under the section on variation.

Hemispermatophore: As in figs 3.4. and 4.48.b.

Variation

Variation in the number of pectinal teeth and extent of wrinkling of sternite VII and ventral surface of cauda I is shown in table 4.3.
The list of material examined has been divided into broad subregions in which variation of the habitus can be referred to as follows:

- North western (NW): Coastal populations lighter in overall colour than in central region, upper surface of handback nearly smooth, caudal keels infuscated; inland populations with granulation as central region, overall colour almost uniformly strong yellow brown No. 74 and with little contrast between the various body parts and appendages.
- West (W): Intermediate between NW and central.
- Mid-south west (Mid-SW): Samples from this sub-region differ fairly uniformly from those of surrounding sub-regions as follows: Colour: entire surfaces of tergites I-VII, sternite VII and cauda I-V dark olive brown No. 96; Carapace interocular surface more lightly coloured than rest of carapace; legs dark orange yellow No. 72; telson deep orange yellow No. 69. Pedipalp tibia with 4 ventral δ instead of the normal 3. It is felt that these character state differences do not warrant conferring a different taxonomic status on this group until such time as additional material from adjacent areas can be studied to establish whether the differences are consistent enough and not variable.

- South West (SW): Only one specimen available. Overall colour much darker than in specimens from the central region, with anterior margin and portion of lateral surface of carapace infuscated; cauda I-V with reticulated infuscations; telson dorsally infuscated, lateral and ventral with a longitudinal, lightly infuscated band.
- North (N): Overall colour very dark with carapace, tergites and dorsal surfaces of pedipalp femur, tibia and chela fingers dark brown No. 59 to almost brown black No. 65; cauda I-V deep brown No. 56, and keels infuscated; telson strong brown No. 55 to brown orange No. 54, with longitudinal, lightly infuscated bands on latero-dorsal and ventral surfaces. Upper surface of handback smooth to obsoletely reticulated.
- Central: As treated earlier.
- South (S): Intermediate between SW and SE. Upper surface of handback very shallowly and sparsely granular.
- North east (NE): Tergites very dark as in specimens from N but with cauda, legs, carapace and pedipalp chela lighter. Upper surface of handback smooth to very lightly and shallowly reticular.
- East (E): Intermediate between NE and SE.
- South east (SE): Colour patterns and contrasts as for specimens from the central region but with all colours much darker. Upper surface of handback very shallowly granular.

Measurements

See plates and figures. Maximum recorded adult body lengths of ♂ 10,5 cm (carapace 1,6 cm), of ♀ 11,0 cm (carapace 1,7 cm).

Type material

At the time of writing all efforts to locate the type(s) of O. carinatus have failed to yield results. No definite proof that this material has been lost or destroyed could be obtained either.

It is felt that the designation of a neotype should be postponed until such proof has been received.

Material examined

NW

1♀, many juveniles, Kamanjab, 20 March 1966, H. Steenkamp (S.M.N. 107); 1♂, Plaas 6312? (moontlik 631), 30 March 1966, H. Steenkamp (S.M.N.107); 1♀, Orumana, 27 November 1970, F. Schutz (S.M.N. 218); 1 juvenile ♂, Sesfontein, 26 April 1976, W.D. Haacke (T.M. 11220); 1 juvenile ♀, Sesfontein, 26 April 1976, W.D. Haacke (T.M. 11225); 1♀, Warmquelle, January 1968, T.W. Botes (S.M.N. 128); 1♂, Swartboys Drift, December-February 1972, J. Menge (T.M. 10434); 1♀, Warmquelle, 16 January 1965, P. Buys (S.M.N. 112); 1♂, Hazeldene, J. Steenkamp (S.M.N. 106); 1♂, Ondorusu Falls, 17 October 1973 (S.M.N. 491); 1♀, Welwitchia, 17 February 1966, W.L. Smit (S.M.N. 134); 3 subadult ♀, 1 subadult ♂, 2 juvenile ♀, 5 juvenile ♂, Otjitambi 25, 14-15 February 1972, C. Schlettwein (S.M.N. 338); 1 juvenile ♂, Orumana, 10 February 1975 (S.M.N. 595); 1♀, Ohopoho, 6 November 1962, B. Marais (S.M.N. 111); 1 subadult ♀, Dunedin Star, 27 September 1968, P. Olivier (S.M.N. 125); many juveniles, Kaoko Otavi, 27 November 1970, J. Batista, E. Motgoabone (S.M.N. 202); 1 juvenile ♀, Purros, 6 October 1968 (S.M.N. 274); 2♀, 2♂, 1 juvenile ♀, Farm Kuyper, 5 May 1968 (S.M.N. 235); 1 subadult ♂, Onquati, 24 February 1962, E. von Koenen (S.M.N. 110); 2 juvenile ♀, 1 juvenile ♂, Truidia, March 1973, Dr Germs (S.M.N.. 446); 1♀, Hoas, 1971, J. Labuschagne (T.M. 10131); 1♂, 1 subadult ♂, Kaoko Otavi, 27 November 1970, P.G. Olivier (S.M.N. 236); 1 juvenile ♀, Otjikoko-Süd, 10-13 February 1972, C.G.C., M-L. P., E.M. (S.M.N. 335); 5♀, 6♂, 1 subadult ♀, 2 subadult ♂, Kaoko Otavi, 27 November 1970, J. Batista, E. Motgoabone (S.M.N. 201); 1 juvenile ♂, Hoas, 1971, J. Labuschagne (T.M. 10138); 1♀, Sesfontein, 26 April 1976, W.D. Haacke (T.M. 11218); 3 subadult ♀, 3 juvenile ♂, Annabis, 24-25 February 1969, B. Lamoral, R. Day (N.M. 10057); 5 juvenile ♀, 1 juvenile ♂, Groot Spitzkoppe Mts, 11 February 1969, B. Lamoral (N.M. 10045); 1♀, Grootberg, 2 April 1976, B. Lamoral, L. Ferguson (N.M. 10826); 1 juvenile ♂, 1 subadult ♀, 1 subadult ♂, Kamanjab, 25 February 1969, B. Lamoral, R. Day (N.M. 10052); 1 juvenile ♀, Ohopoho, 8 February 1975 (S.M.N. 591); 1♀, Sesfontein, 4 April 1976, B. Lamoral, L. Ferguson (N.M. 10828).

W

1♂, 1 juvenile ♂, 1 juvenile ♀, Spitskoppe, 4 March 1960, P.J. Buys (S.M.N. 152); 1♀, many juveniles, Kaap Kruis, 8 June 1963, A. Els (S.M.N. 156); 1♂, Emeritus, 9 June 1967, Kapt. J.A. Pietersen (S.M.N. 64); 1 juvenile ♂, Ameib, 1-2 February 1972, C.G.C., M-L.P. (S.M.N. 332); 1♀, Emeritus, 29 July 1965, J.A. Pietersen (S.M.N. 176); 1♀ , 1 juvenile ♀ , Emeritus, 18 March 1968, Kapt. J.A. Pietersen (S.M.N. 67); 1 juvenile ♀ , Gobabeb, C. Koch (S.A.I.M.R. 866); 1♀ , Gobabeb, 26 January 1975, S. Endrody Younga (T.M. 11113); 1♀ , Gobabeb, 26 January 1975, S. Endrody Younga (T.M. 11109); 1♂, Gobabeb, 26 January 1975, S. Endrody Younga (T.M. 11112); 1 subadult ♀ Gobabeb, 26 January 1975, S. Endrody Younga (T.M.11110); 1 subadult ♀ , Namib Desert Park, 17 March 1970, S.W. Goussard (N.M. 10656); 2 juvenile ♀ , Zebra Pan, 14 February 1972, Jenssen, Robinson (N.M. 10666); 1♀ , Sandamap, 13 February 1969, B. Lamoral, R. Day (N.M. 10047); 1♀ , Gobabeb 19 April 1972, M.K. Jensen (N.M. 10631); 1♀ , Swakopmund, June 1969, C. Koch (N.M. 10018).

Mid-SW

1♀ , 1 subadult ♂, Neisip, 21 October 1970, F.A. Burger (N.M. 11090); 1♀ , Zaris, 16 November 1971, P.G. Olivier (S.M.N. 318); 1 subadult ♀ , 7 juveniles, Neisip, 21 October 1970, F.A. Burger (S.M.N. 198); 1♂, 1♀ , 1 juvenile ♀ , Witmanshaar, 8 October 1972, H.C. Strauss (S.M.N. 396); 16 juveniles, Neisip, 21 October 1970, J. Batista, I. Mokgoabone (S.M.N. 190).

SW

1 subadult ♀ , Anenous Pass, May 1972, John Visser (N.M. 10637).

N

1 juvenile ♂, 1 juvenile ♀ , Ovambo Grens No. 1, October 1961, P.J. Buys (S.M.N. 148); 1 juvenile ♀ , Homob, 27 September 1965, T. Spence (S.M.N. 209); 1 juvenile ♂, Okondeka, October 1961, P.J. Buys (S.M.N. 68); 1 juvenile ♀ , Gaseb, October 1961, P.J. Buys (S.M.N. 216); 1 juvenile ♀ , Hoasas, November 1965, W. Steyn (S.M.N. 81); 1 juvenile ♂, SWA Administration borehole 6453 (S.M.N. 248); 2♂, Homob, October 1961, P.J. Buys (S.M.N. 239); 1♀ , Okaukuejo, October 1961, P. Buys (S.M.N. 108); 1♂, 1♀ , 1 juvenile ♀ , Government Borehole 6453, D. Fulkerson (S.M.N. 155); 1 subadult ♂, Hoasas, 27 November 1965, W. Steyn, C. Oelofse (S.M.N. 76); 1 juvenile ♂, Elorha Pfanne, June 1909, Prince G. von Bayern (R.S. 3564); 1 subadult ♂, Hoas, 1971, J. Labuschangne (T.M. 10150); 1 juvenile ♂, Sukses Dam, 2 March 1969, B. Lamoral, R. Day (N.M. 10046); 4 juvenile ♀ , 2 subadult ♀ , 2♀ , 1 juvenile ♂, 2 subadult ♂ , 1♂, Gemsbokvlakte, 4 March 1969, B. Lamoral, R. Day (N.M. 10058); 2♂, 1 juvenile ♂, 3♀ , Oncocua, Angola, 1947-1949?,

O.U. Gulf of Guinea Expedition (N.M. 10692); 4♀, 2♂, 3 juvenile ♂, 2 juvenile ♀, Aus, 2 March 1969, B. Lamoral, R. Day (N.M. 10685).

Central

1♀, Windhoek, 28 August 1970, Leslie McCullum (S.M.N. 175); 6♀, 7♂, 8 juvenile ♂, Keres, 5 December 1960, Mrs P. Pretorius (S.M.N. 140); 1♀, Windhoek, 20 October 1966, S.T. von Schalscha (S.M.N. 43); 1♂, Windhoek, 19 February 1962, P. van der Byl (S.M.N. 8); 1♀, Okahandja, 9 August 1965, Mev D. Schultze (S.M.N. 63); 1♀, Windhoek, 17 April 1964, Mev. Smit (S.M.N. 3); 1♂, 1 juvenile ♀, Windhoek, 10 August 1961, C. Campbell (S.M.N. 54); 3 juvenile ♂, Scheidthof, 14-17 November 1972, P.G.O. (S.M.N. 402); 1♂, Windhoek, 22 February 1966, W. Esterhuizen (S.M.N. 27); 1♀, Windhoek, 22 November 1965, K. Pieters (S.M.N. 23); 1♂, Pioneer's Park, 1 January 1974, M.J. Penrith, M-L. Penrith (S.M.N. 507); 1♀, Windhoek, 20 April 1957, Mnr K. Welch (S.M.N. 32); 1♀, 1 subadult ♀, 1 juvenile ♀, 3 juvenile ♂, Wasservallei, 21-23 December 1973, M-L.P. (S.M.N. 504); 1 juvenile ♂, Otjombane, 8 September 1961, P.J. Buys (S.M.N. 142); 2♀, Windhoek, 6-13 June 1972, P.G.O. (S.M.N. 383); 1♀, Tantus, 16 November 1966, W.I.H. Kannegiesser (S.M.N. 48); 2♀, Windhoek, 17 September 1963, P.A. Kellerman (S.M.N. 2); 1 juvenile ♀, 1 juvenile ♂, Koreangab Dam, 18 May 1972, P.G.O. (S.M.N. 381); 4♀, 4♂, 1 juvenile ♀, Keres, 15 February 1961, Mev. P. Pretorius (S.M.N. 154); 1♀, Windhoek, 1 June 1965, J.H. Steenkamp (S.M.N. 55); 1♀, Windhoek, 22 November 1965, R.F.M. Horn (S.M.N. 44); 1♂, Windhoek, 5 January 1967, P. Grobler (S.M.N. 39); 2♀, Windhoek, 5 December 1967 (S.M.N. 159); 1♀, Windhoek, 20 April 1965, W. Giess (S.M.N. 33); 1♂, Lichtenstein Mitte, 21 January 1962, E. Rusch (S.M.N. 53); 3♀, Windhoek, 15-16 April 1972, P.G.O.(S.M.N. 357); 1♂, Windhoek, 28 November 1962, H. de Waal (S.M.N. 10); 1 juvenile ♀, 1 juvenile ♂, Djab, 14 August 1961, E. Rusch (S.M.N. 143); 1♀, Windhoek, 16 March 1966, H. Göttert (S.M.N. 4); 1♀, Windhoek, 2 November 1958 (S.M.N. 22); 1 juvenile ♀, Aris, 10 June 1966, C. van den Hooven (S.M.N. 49); 1 subadult ♂, Tantus, 8 February 1966, W. Kannegiesser (S.M.N. 57); 1 juvenile ♂, Arnheim, 23-27 October 1972, H.C. Strauss (S.M.N. 397); 1♀, Goreangab Dam, 2 February 1974, Harms (S.M.N. 513); 2 juvenile ♂, 1 juvenile ♀, Windhoek, 16 November 1962 (S.M.N. 208); 1♂, Windhoek, January 1972, J. Slade (S.M.N. 330); 2 juvenile ♀ 2 juvenile ♂, Windhoek,27 November 1961, D.Campbell (S.M.N.17) 1♀, 1 juvenile ♀ Arnhem, 23 October 1972, H.C.S. (S.M.N. 412); 1 juvenile ♂, 1 juvenile ♀, Windhoek, 16 November 1962 (S.M.N. 206); 1♂, Brakwater, March 1976, B. Loutit

(S.M.N. 601); 1♀ , Windhoek, 16 December 1963, W. Snyman (S.M.N. 25); 1♂, Windhoek, 10 January 1966, A. Coombe-Davis (S.M.N. 85); 1 subadult ♂, Brakwater, May 1959, C. Buys (S.M.N. 240); 1♀ , Windhoek, 10 July 1970, C. Coetzee (S.M.N. 52); 1♂, Kamombonde, 5-7 January 1975 (S.M.N. 588); 2♂, 1♀ , Windhoek, 16 November 1962 (S.M.N. 205); 1♀ , Windhoek, 1 January 1973, Mr Dean (S.M.N. 417); 4 juvenile ♂, 1 juvenile ♀ , Regenstein, 30 November 1972, P.G. Olivier, M-L. Penrith, B.A. Harding, C. Buys (S.M.N. 408); 1 subadult ♂, 1 subadult ♀ , Windhoek, 27 December 1961, P. van der Byl (S.M.N. 9); 2 juvenile ♀ , Paulinehof, 20-22 November 1972, P.G.O. (S.M.N. 405); 2 juvenile ♂, Finkenstein, 21 March 1972, P.G. Olivier (S.M.N. 346); 2♂, Lichtenstein Mitte, 21 January 1960, E. Rusch (S.M.N. 87); 1♂, Windhoek, 26 November 1973, A. Bensen (S.M.N. 494); 1♂, Windhoek, 7 December 1966, Mr F. van Sittert (S.M.N. 20); 3 juvenile ♀ , 1 juvenile ♂, Windhoek, 6-13 June 1972, P.G.O. (S.M.N. 384); 1♂, 1 subadult ♀ , Windhoek, 16 November 1963, J. Nganga (S.M.N. 47); 1♀ , many juveniles, Windhoek, 11 January 1963, F.E. Daalen (S.M.N. 45); 2♀ , 1♂, Windhoek, 9 December 1963, P.A. Kellerman (S.M.N. 24); 1♂, Finkenstein, 21 March 1972, P.G. Olivier (S.M.N. 345); 2 juvenile ♂, Windhoek, 4 May 1972, P.G. Olivier (S.M.N. 378); 1 juvenile ♀ , Windhoek, 10 August 1961, W. Cloete (S.M.N. 16); 1 subadult ♂, Koreangab Dam, 18 May 1972, P.G.O. (S.M.N. 379); 1♂, Windhoek, 26 September 1973, E. Mokgoabone (S.M.N. 490); 1 juvenile ♂, Wasservallei, 1-3 April 1972, C.G. Coetzee (S.M.N. 350); 1 juvenile ♂ , Koreangab Dam, 12 February 1971 (S.M.N. 272); 3 juvenile ♀ , 2 juvenile ♂, Windhoek, 19 April 1972, P.G.O. (S.M.N. 358); 1 juvenile ♀, Wasservallei, 30 December 1973 - 2 January 1974, J. Wasserfall (S.M.N. 506); 1♀ Windhoek, 31 July 1967, F.G. Hoebel (S.M.N. 36); 1♀ , Windhoek, 3 May 1965, Dr J.S. Watt (S.M.N. 29); 1 juvenile ♂, Goreangab Dam, 20 February 1972 (N.M. 10652); 2♂ , 1♀ , Valencia, 6 February 1969, B. Lamoral, R. Day (N.M. 10686); 3♂ , 2♀ , 2 juvenile ♂ , 5 juveniles, Portsmut, 7 February 1969, B. Lamoral, R. Day (N.M. 10051); 2♀ , Windhoek, May 1977, S. Louw (N.M. 11060); 1♂, Ghobab, 12 March 1976, B. Lamoral (N.M. 10810); 1 juvenile ♂, Auas Mts., September 1973, G. Sander (N.M. 10600); 1 juvenile ♂, Okahandja, 13-14 March 1969, B. Lamoral, R. Day (N.M. 10056); 1 juvenile ♀ , Nauzerus, December 1973-January 1974, Chris Kingsley (N.M. 10550); 1 subadult ♂, Windhoek, 5 February 1969, B. Lamoral, R. Day (N.M. 10048); 1 juvenile ♂, Rehoboth, 17 January 1972, R. Taylor (N.M. 10655); 1 subadult ♀ , 10 juvenile ♀ , 6 juvenile ♂, Portsmut, 19 April 1972, A.F. Port (N.M. 10538); 1♂, 1♀ , Rehoboth, 15 November 1974, S. Enrody-Younga (T.M. 11073-T.M. 11074); 1♂, Windhoek, 30 December 1970, S. Brits (S.M.N. 260); 1♀ , Windhoek 9 August 1961, B.J. Verwey (S.M.N. 31); 1♀ , many juveniles, Windhoek, 10 November

1962, Mr Kühn (S.M.N. 30); 2♂, Windhoek, 12 April 1961, J. Jenkins (S.M.N. 11); 1♀, Windhoek, 16 December 1963, W. Snyman (S.M.N. 26); 1 juvenile ♂, 2 juvenile ♀, Regenstein, 12 December 1973, C.G.C., M-L.P., J.T. (S.M.N. 497); 1 juvenile ♀, Goreangab Dam, 19 December 1973, C.G.C., M-L.P., E.M., J.B.F. Oosthuizen (S.M.N. 500); 1♂, Windhoek, 1968, Mrs Smith (N.M. 9959); 2♀, Okahandja, March 1966, F. Gaerdes (N.M. 9108-N.M. 9109); 4♂, Okahandja March 1966, F. Gaerdes (N.M. 9110-N.M. 9111); 1♂, Okahandja, March 1966, F. Gaerdes (N.M. 9112); 2♀, Okahandja, May 1960, F. Gaerdes (N.M. 7312-7313); 3♂, Okahandja, May 1960, F. Gaerdes (N.M. 7314-N.M. 7316); 1♀, Okahandja, May 1960, F. Gaerdes (N.M. 7317); 1♂, 1 Juvenile ♂, Okahandja, August 1960, F. Gaerdes (N.M. 7320); 1 juvenile ♀, Hohenheim, May 1959, R.F. Lawrence (N.M. 7268).

S

2♀, 1 juvenile, Berseba, 27 February 1976, B. Lamoral (N.M. 10719); 1♂, Skaap River, March 1973, C.J. Coetzee (N.M. 10619); 1♀, Bethanie, August 1959, F. Gaerdes (N.M. 7277).

NE

1♂ Rundu, 10 January 1970, Capt Booysen (S.M.N. 261); 2♀, Rundu, April 1965, L. Jacobs (S.M.N. 116); 6 juveniles, Andara, 19-25 August 1971 (S.M.N. 303); 2 subadult ♂, 2 subadult ♀, 3 juveniles, Andara, 30 June 1969, P. Olivier, A. Isaacs (S.M.N. 136); 1 subadult ♂, 1 juvenile ♂, Andara, 2 July 1969, P. Olivier, A. Isaacs (S.M.N. 136); 3♀, Elandshoek, 8 March 1969, B. Lamoral, R. Day (N.M. 10054); 3♂, 1♀, 2 juvenile ♂, 1 juvenile ♀, Waltersdorf, 11-12 March 1969, B. Lamoral, R. Day (N.M. 10049); 3 juvenile ♂, Gautsche Pan, 27 April 1973, P.J. Buys (S.M.N. 443); 1♀, 1 juvenile ♂, 2 juveniles, Andara, 1 July 1969, P. Olivier, A. Isaacs (S.M.N. 136); 1♀, 1 subadult ♀, 1 juvenile ♀, 1♂, 1 subadult ♂, 5 juvenile ♂, Ghaub, 19-30 November 1972, H.C. Strauss (S.M.N. 424); 1♀, Gautsche Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 299); 1 subadult ♂, 1 juvenile ♂, 1 juvenile ♀, Namutoni, P.J. Buys (S.M.N. 109); 5♀, 1♂, 2 juvenile ♂, 1 juvenile ♀, 2 juveniles, Ghaub, 19-30 Novmeber 1972, H.C. Strauss (S.M.N. 423); 1♀, Andara, 19-24 August 1971, E. Mokgoabone (S.M.N. 348); 16 juveniles, Otjikoto, 20-23 November 1972, J. Batista (S.M.N. 428); 1♂, 5♀, 2 juvenile ♀, Otjikoto, 20-23 November 1972, J. Batista (S.M.N. 427); 2 subadult ♀, 1 juvenile ♀, Ghaub, 19-30 November 1972, H.C. Strauss

(S.M.N. 422); 1 subadult ♀ , Andara, 2 July 1969, P.G. Olivier, A. Isaacs (S.M.N. 233); 1♀ , Gautsche Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 294); 1♀ , Uithoek, 28 April 1974, W.D. Haacke (T.M. 10932); 1 subadult ♂, Gautsche Pan, 19-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 295); 1 juvenile , Bayip Pan, South Africa, 3 April 1970, B. Lamoral (N.M. 10460); 1 juvenile ♀ , Gautsche Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 293); (juvenile ♂, Gautsche Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 283); 1 juvenile ♂, Onguma, 7-18 February 1972, M-L. Penrith (S.M.N. 340); 1 subadult ♂, Gautsche Pan, 9-13 June 1971, J. Batista, E. Motsebona (S.M.N. 281); 1 juvenile ♂ , 1 juvenile ♀ , Andara, 2 July 1969, P. Olivier (S.M.N. 214-S.M.N. 215); 1 juvenile ♀ , Gautsche Pan, 19-13 June 1971, J. Batista, E. Motsebona (S.M.N. 281); 1 juvenile ♀ , Aha Mts, D. Krynauw (S.M.N. 85); 1 subadult ♂, Gautsche Pan, 9-13 June 1971, J. Batista, E. Motgoabone (S.M.N. 287); 1♂, 1♀ , Grootfontein, August 1962, F. Gaerdes (N.M. 8374).

E

1♂ , 2♀ , Rietfontein, W.D.H. (N.M. 10664); 1♂ , 1♀ , De Hoek, 10 September 1970, P.J. Buys (S.M.N. 204); 1♂, Eava, 27 April 1966, R. Pack (S.M.N. 70); Many ♂ , many ♀ , many juveniles, De Waal, 17 March 1969, B. Lamoral (N.M. 10055);

SE

1♀ , 2♂, Auob River, South Africa, 1968-1970, E. Leriche (N.M. 10693-N.M. 10694); 1 juvenile ♀ , Jansdraai, South Africa, 19 April 1970, B. Lamoral (N.M. 10621); 1♂, 1 subadult ♀ , Auob River, South Africa, April 1970, B. Lamoral (N.M. 10651); 2 subadult ♂, Xendang, 22 September 1970, Mr N. Swart (S.M.N. 194); 2♀ , Twee Rivieren, South Africa, 10 April 1970, B. Lamoral (N.M. 11089); 4 juvenile ♀ , 3 juvenile ♂ Auob River, South Africa, 18 April 1970, B. Lamoral (N.M. 10649); 1 juvenile ♀ , Upington, South Africa, 27 January 1969, B. Lamoral, R. Day (N.M. 10681); 2 juvenile ♂, 2 juvenile ♀ , Kalahari Gemsbok National Park, South Africa, 10 January 1972, Eastwood (N.M. 10640); 1♂, Jansdraai, South Africa, 19 April 1970 (N.M. 10658); 1♂, Rooibrak, South Africa, April 1970, B. Lamoral (N.M. 10647); 1♀ , Nossob R., South Africa, February 1961, D. Brown (N.M. 8290);

Distribution

The whole of South West Africa excepting the shifting sand dune systems of the Namib and Kalahari.

Bionomics

The burrowing activities and soil predilections of *O. carinatus* are treated fully under the section on soils in chapter 2. Burrow entrances are usually situated at the side of large stones or rocks and occasionally in open ground. In the Kalahari, specimens have sometimes been found in shallow scrapes under large calcrete stones or dead vegetation on consolidated sand and occasionally under the loose bark of dead trees lying on the ground. *O. carinatus* is hemiedaphic and nocturnal. Specimens have on occasion been found wandering about in daytime but this is a rare occurrence.

Opisthophthalmus cavimanus Lawrence, 1928
Figs 4.51, 4.48.c and 4.78.a
Plates 4.52 and 4.53

Opisthophthalmus cavimanus Lawrence, 1928: 274-275

Synonym

Male syntype of *Opisthophthalmus undulatus ugabensis* Hewitt, 1934: 408-410; from Ugab river (A.M. 6574). Seen. NEW SYNONYM. Also see remark under *O. ugabensis*.

Diagnosis

No sister species has yet been found for *O. cavimanus*, which is most closely related to species within the *carinatus* group. *O. cavimanus* can be separated from this group and other species of the genus on the following combination of characters. Carapace fig. 4.78.a: anterior median furrow with a distinct longitudinal suture and somewhat less distinct anterior bifurcating suture: median ocular furrow with a moderately distinct longitudinal suture; interocular surface granular. Ventral surface of telson vesicle smooth and agranular. Cauda II-IV, ventral and ventro-lateral keels absent, ventral surfaces transversely lightly corrugated in ♂, smooth in ♀.

Description

The following account supplements Lawrence's (1928: 274_275) original description, the present diagnosis and pertinent plates and figures. The ♀ of this species was unknown and a description of relevant character states is included herein.

Sexual dimorphism:
In adults, males differ from females in the following characters: while there is little difference in the overall length in specimens of the available material, ♂ trunk is proportionally smaller and more slender with width sternite V/carapace length ratios 0,87 (0,83-0,91) for ♂ and 1,00-1,04 for ♀ (only two adult ♀ available); ♂ cauda is as long or slightly longer than trunk length while in ♀ it is 20% shorter; pedipalp handback of ♂ narrower and fingers longer than in ♀ with width handback/ carapace length ratios 0,51 (0,47-0,54) in ♂ and 0,63-0,69 in 2♀ and length movable finger/handback length ratios 1,50 (1,45-1,55) in ♂ and 1,12-1,20 in 2♀ ; first proximal middle lamella of each pecten with mesial margin angular while pectinal teeth are present along entire posterior margin of pecten in ♂, very shallowly curved while proximal one third of posterior margin of pecten devoid of teeth in ♀ ; ♂ genital operculum suboval in outline, subcordate in ♀; tergites I-VII finely shagreened and matt in ♂, smooth and shiny in ♀ . ♂ with sternites IV-VII and ventral surface of cauda I-III transversely shallowly corrugated and in ♀ these surfaces are smooth; ♂ with 21-27 and ♀ 16-18 teeth per pecten.

Males and females (See also table 4.2):

Granulation: Pedipalp: handback very shallowly reticulated in ♀ , smooth, occasionally with a few scattered, shallow punctations and matt in ♂; dorsal surface of femur and outer intercarinal surface of tibia granular in ♀ , almost agranular in ♂. Carapace, entire surface, including interocular, moderately to distinctly granular. Ventral surface of cauda V granular.

Colour: In ♀ : pedipalps, carapace strong brown No. 55 to deep brown No. 56; tergites deep brown No. 56 to dark brown No. 59; cauda I-V brown orange No. 54 to strong brown No. 55; telson and legs I-IV dark orange yellow No. 72 to strong yellow brown No. 74; sternites III-VII moderate orange yellow No. 71 to dark orange yellow No. 72; pectines light orange yellow No. 70; handback of chelicerae dark orange yellow No. 72; chelicerae fingers very lightly infuscated. Males have the same colour distribution but tend to be slightly more lightly coloured.

Carapace: l.c./x ratio 1,88 (1,86-1,90) for ♀ and ♂.

Pedipalps: tibia and femora lengths distinctly greater in ♂ than ♀.

Legs: Posterior margins of protarsi I and II with many scattered setae as well as a longitudinal row of 2-3 spine-like setae.

Setation: Legs and cauda of ♀ and ♂ moderately pilose. Pedipalps of ♀ moderately pilose while those of ♂ are much more pilose than in ♀.

Trichobothria: As in figs 4.51.a-f. (+1) neobothriotaxic for group C with 14 external ό on tibia.

Hemispermatophore: As in fig. 4.48.c. Differing distinctly from those of O. carinatus and litoralis as following: basal portion and distal lamina narrower; subapical lateral margin of hook strongly curved. In addition the following percentages are different from those of the above species.

(1) ha-w distance X100/dcr-w distance = 32.3 (31,5-33,2)
(2) ha-bsh distance X100/ha-w distance = 44,0 (43,5-44,5)
(3) ha-bsh distance X100/dcr - bsh distance = 17,8 (17,4-18,2)

Variation

Little except in overall colour which tends to be darker in specimens from the eastern region of the distribution range.

Measurements

See plates and figures. Maximum recorded adult body lengths of ♂ 7,5 cm (carapace 1,2 cm) of ♀ 7,0 cm (carapace 1,1 cm).

Type material

According to Lawrence (1928: 274) the type series consists of 3♂ (S.A.M. B 6094, 6095). Only 2♂ syntypes were received on loan. No holotype was designated by Lawrence. One ♂ (S.A.M. B 6094), is hereby selected as the LECTOTYPE of Opisthophthalmus cavimanus and the other ♂ (S.A.M. B 6095) as the PARALECTOTYPE. This material has been labelled accordingly and it is deposited in the collection of the South African Museum.

Material examined

♂ Lectotype, Sesfontein, 1926, Museum Expedition (S.A.M. B 6094);
♂ Paralectotype, Camaeis 1926, Museum Expedition (S.A.M. B 6095);

1♂, Central Kaokoveld, May 1961, F. Gaerdes (N.M. 8304); 1♂, 2 subadult ♂, 2 subadult ♀, 2 juvenile ♀, Sesfontein 3 April 1976, B. Lamoral, L. Ferguson (N.M. 10834); 1 subadult ♀, Fonteine (N.M. 10646); 3♂, 1 subadult ♀, 2 subadult ♂, 1 juvenile ♂, Sesfontein, 4 April 1976, B. Lamoral, L. Ferguson (N.M. 10830); 1♂, Vrede, 31 March 1976, B. Lamoral, L. Ferguson (N.M. 10832); 1 subadult ♂, Okonjambo, 21 May 1970, P.J. Buys (S.M.N. 247); 1♂, Sanitatas, 26 November 1970 , E. Motgoabone (S.M.N. 214); 1♂, Torrabaai, September 1961, A. van Koenen (S.M.N. 124); 1♂, Hoab River, 7 June 1964, W. Steyn (S.M.N. 133).

Distribution

Within zones of vegetation types 1, 5 and northern one third of 2.

Bionomics

O. cavimanus is nocturnal, hemiedaphic and digs 15-20 cm deep burrows in moderately hard soils with surface hardness ranging from categories IX-X (table 2.2). Burrow entrances are usually situated at the side of stones or rocks and occasionally in open ground. O. cavimanus was found to be sympatric with carinatus and O. wahlbergi near the Erongo mountains. See distribution above for vegetation types within species range.

Opisthophthalmus chrysites Lawrence, 1967

Figs 4.52 and 4.48.d

Plates 4.54 and 4.55

Opisthophthalmus chrysites Lawrence, 1967:, 13-16

Diagnosis

O. chrysites is most closely related to *O. wahlbergi* but can be separated from it and other species of the genus on the following combination of characters: carapace anterior and median ocular furrows without sutures; l.c./x ratio falling between 1,85-1,95. Upper surface of pedipalp handback granular. Pedipalp tibia with 20-23 e ó and 7-9 v ó.

Description

The following account supplements Lawrence's (1967: 13-16) comprehensive original description, the present diagnosis and pertinent plates and figures.

Sexual dimorphism:

Only four adult specimens of this species (2 ♂, 2 ♀) have been collected to date. Of these, 2 ♂ and 1 ♀ were examined. The males differ from the female in the following characters: ♂ trunk is more slender with width sternite V/carapace length ratios 0,88-0,90 for ♂ and 1,00 for ♀ ; ♂ tergites finely shagreened, ♀ smooth and shiny; median one third of sternites VI and VII and ventral surface of cauda I transversely wrinkled in ♂ , smooth and shiny in ♀ ; ♂ pedipalp chela fingers longer than ♀ with length movable finger/handback length ratios 1,29-1,32 in ♂ and 1,18 in ♀ ; first proximal middle lamella of each pecten with mesial margin obtusely angular and bearing teeth along entire length of posterior margin of pecten in ♂ , in ♀ shallowly convex and with proximal half of pectinal posterior margin devoid of teeth; ♂ with 20-23 and ♀ 12 teeth per pecten.

Males and females (See also table 4.2):

Trichobothria: As in fig. 4.52. Neobothriotaxic for group C with external ó of tibia varying from 20-23 and ventral ó from 7 to 9. ó d_2 of tibia distinctly closer to i than d_1.

Hemispermatophore: As in fig. 4.48.d. Differing diagnostically from that of O. wahlbergi (fig. 4.67.c-d)) in shapes and sizes of hook notch, distal lamina, basal portion and foot. In addition the following percentages are diagnostic for O. chrysites (N.M. 11092):

(1) ha-w distance X100/dcr-w distance = 28,1%
(2) ha-bsh distance X100/ha-w distance = 46,4%
(3) ha-bsh distance X100/dcr-bsh distnce = 15,1%

Variation

No variation in the material studied.

Measurements

See plates and figures. Maximum recorded body lengths in adult ♂ 8,1 cm (carapace 10,8 mm) of adult ♀ 7,1 cm (carapace 10,5 mm).

Type material

The type series consists of 1 ♂ and 1 ♀ syntypes, no holotype having been designated by Lawrence in his original description. The ♂ (T.M. 9437) is hereby selected as the LECTOTYPE of Opisthophthalmus chrysites and the ♀ (T.M. 9438) as PARALECTOTYPE. These types have been labelled accordingly and are deposited in the collection of the Transvaal Museum, Pretoria.

Material examined

♂ lectotype and ♀ paralectotype, 30 miles N.W. of Ouhandjo, Kaokoveld, South West Africa, May 1966, W.D. Haacke (T.M. 9437 and 9438); 1 ♂ , 6 km from Hoanib River mouth, 28 March 1976, B. Lamoral (N.M. 11092).

Distribution

Kaokoveld and Skeleton Coast Park in north-western South West Africa.

Bionomics

The only specimen personally collected was dug out of a burrow at the side of a small sand dune with surface hardness ranging from categories III-IV (table 2.2). The known localities fall within areas of vegetation types 1 and 5 (fig. 2.4). O. chrysites is hemiedaphic and presumably nocturnal. Its habitat and habitus indicate that it is a psammophilous species.

Opisthophthalmus new species A

Figs 4.53, 4.55 and 4.77.b.
Plates 4.56

Diagnosis

New species A can be separated from other species of the genus on the following combination of characters: Carapace fig.4.77.b: anterior median furrow with longitudinal and anterior bifurcating sutures present but poorly discernible; median ocular furrow with longitudinal suture present but visible only on ventral side of dissected carapace. Pedipalp chela as in *O. opinatus*. Pedipalp tibia: δ d_2 distinctly closer to i than d_1. Telson vesicle: as in *O. opinatus* but with posterior upper lateral surfaces with spiniform granules including numerous minute spicules. *O. new species A* is much smaller than *O. opinatus*, its most closely related species.

Description

The type series consists of several males and two females. The following description is based on the holotype ♂, unless otherwise indicated, and supplements the above diagnosis, table 4.2 and pertinent figures and plates.

Sexual dimorphism

Holotype and paratypes. Adult males differ from females in the following characters: ♂ trunk proportionately smaller and more slender with width sternite V/carapace length ratios 0,89 (0,86-0,92) for ♂ and 1,11-1,12 for the two ♀ paratypes; ♂ cauda approximately 35% longer than trunk length, in ♀ approximately equal while total body length is usually only slightly greater in ♀ ; pedipalp handback of ♂ narrower and fingers longer than ♀ with width handback/carapace length ratios 0,66 (0,63-0,68) in ♂ and 0,77--0,78 in ♀ and length movable finger/handback length ratios 1,32 (1,30-1,35) in ♂ and 1,17-1,19 in ♀ ; first proximal middle lamella of each pecten with mesial margin strongly curved to angular and with pectinal teeth along entire posterior margin of pecten in ♂, very shallowly curved and with proximal one quarter of posterior margin of pecten devoid of teeth in ♀ ; ♂ genital operculum suboval in outline, ♀ subcordate; ♂ with 17-21 and ♀ 12-14 teeth per pecten; overall colour of ♂ lighter than ♀ .

Male holotype:

Granulation: Following surfaces distinctly granular: upper and outer pedipalp handback; tibia, externally; femur, anteriorly and dorsally; entire carapace (in ♀ paratypes, interocular surface only lightly to obsoletely granular); telson vesicle, ventrally and laterally. The following surfaces are sparsely granular: inner pedipalp handback; cauda I-V, dorsal and upper lateral intercarinal surfaces (in ♀ these virtually smooth); cauda IV and V, ventrally. Tergites I-VI entirely finely shagreened (in ♀ smooth and shiny); tergite VII, finely shagreened medially, granular laterally (in ♀ smooth medially, lightly granular laterally). Sternites III-VII and all other body surfaces smooth.

Colour: Tergites dark yellowish brown No. 78, with a moderate orange yellow No. 71 border on posterior and lateral margins. Telson vesicle and legs I-IV moderate orange yellow No. 71. Genital operculum and pectines pale orange yellow No. 73. Cheliceral fingers and distal dorsal portion of each handback melanous, remaining dorsal surface of handback with melanous reticulations. Movable and fixed fingers of pedipalp chela and telson aculeus dark yellowish brown No. 78. All other surfaces dark orange yellow No. 72.

Pedipalps: Handback: finger keel strongly costate granular throughout; upper surface with two longitudinal granular accessory keels; outer surface with one longitudinal granular accessory keel; outer ventral keel predominantly granular; inner ventral keel broadly costate (these accessory keels almost obsolete in ♀).

Carapace: Median eyes nearly medial, with l.c./x ratio 1,90 in holotype and a range of 1,86-1,94 in ♂ and ♀ paratypes.

Legs: Tarsi I & II with 3 short spine-like setae on posterior margin. Tarsi III & IV with a ventral anterior row of 2 spine-like setae and a ventral posterior row of 5 spine-like setae. Post-tarsal lateral claws short, distinctly curved and of equal length. Tarsal median dorsal lobes much shorter than lateral lobes.

Cauda: See table 4.2. Dorsal keels obsolete to shallowly granular with distal spine only slightly larger than penultimate ones. Telson aculeus short and only slightly curved.

Pectines: 18-19 teeth. In paratypes ♂ with 17-21 and ♀ 12-14 teeth per pecten.

Setation: Pedipalps, legs, lateral and posterior margins of sternites III-VII and caudal segments moderately pilose. Pedipalp chela and telson more distinctly pilose than above surfaces.

Trichobothria: As in figs 4.53.a-f. (+1) neobothriotaxic for group C with 14 external ό on tibia. Chela: ό est proximal to dst; distance est-esb approximately equal to esb-eb; V_3 situated in proximal half of ventral surface; ό Et_4 small, nearly in line with Et series and closer to Et_3 than Et_5. Tibia: ό d_2 closer to i than d_1; v_2 nearly equidistant from v_1 and v_3. These character states apply also to ♀ and ♂ paratypes.

Hemispermatophore: As in fig. 4.55.a. The following percentages apply to hemispermatophores of paratype ♂;

(1) ha-w distance x 100/dcr-w distance = 25,5%
(2) ha-bsh distance x 100/ha-w distance = 34,5%
(3) ha-bsh distance x 100/dcr-bsh distance = 10,5%

These percentages vary quite considerably from those of sympatric populations of *O. opinatus*.

Variation

Males and females from the central Namib gravel plains are lighter in overall colour than those from further inland.

Measurements

See plates and figures.

Type material

Holotype ♂ in Natal Museum collection. Paratypes: in Natal Museum; Transvaal Museum, Pretoria and State Museum, Windhoek as indicated in the list of material examined.

Material examined

♂ holotype, Bloedkoppie, Namib Desert Park, 8 February 1972, B. Lamoral (N.M. 10627). Paratypes: 1♂, Ganab, Namib Desert Park, 3 February 1972, W. Goussard and Dr Roer, (N.M. 10690); Paratype ♂, Narib, 9 March 1976, B. Lamoral (N.M. 10796); Paratypes ♀, 2 subadult ♂, Narib, 10 March 1976, B. Lamoral (N.M. 10795); Paratype juvenile ♀, Klein Aub, 11 March 1976, B. Lamoral (N.M. 10797); Paratype ♂, Valencia (T.M. 9652); Paratype ♀, Gorob mine, 29 May 1965, W.D. Haacke (T.M. 9305); Paratype ♂, Gobabeb, 28 February 1975, S. Endrödy Younga (T.M. 11102).

Distribution

Western central and central regions of South West Africa.

Bionomics

O. new species A digs shallow burrows to depths of 10-15 cm in soils with hardness ranging from categories V-VI (table 2.2). Burrow entrances are situated at the side of large stones on rocks. See bionomics of *O. opinatus* for one exception to this at farm Klein Aub 350 and for sympatry with this species. In the central Namib gravel plains a few specimens were found in shallow scrapes under rocks on soils with hardness ranges well above category VII.

The distribution range of *O. new species A* includes vegetation types 2,4 and western parts of 8 (see fig. 2.4) *O. new species A* is nocturnal and hemiedaphic.

Remark

There are only a few morphological criteria separating *O. new species A* from *opinatus*, but the occurrence of these differences in sympatric populations of the two species serves to confirm their non-conspecificity.

Opisthophthalmus concinnus Newlands, 1972

Figs 4.54 and 4.55.b

Plates 4.57 and 4.58

Opisthophthalmus concinnus Newlands, 1972: 241-243

Diagnosis

O. concinnus is most closely related to *O. new species E* but can be separated from it and other species of the genus on the following combination of characters: Carapace: anterior and median ocular furrows without sutures; l.c./x ratio falling between 2,05-2,15. Pedipalp chela with 4 V ó. Pedipalp tibia with 21-24 e ó and 10-13 v ó. Leg tarsi with median dorsal lobe length at least equal to that of lateral lobes.

Description

The following account supplements Newland's (1972: 241-243) comprehensive original description, the present diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ trunk is more slender with width sternite V/carapace length ratios 0,85-0,87 for ♂ and 0,98-1,00 for ♀ ; ♂ tergites finely shagreened, ♀ smooth and shiny; ♂ pedipalp chela handback longer than ♀ with length movable finger/handback length ratios 0,88-0,92 in ♂ and 1,20 in ♀ while movable finger length is propo tionally 7 to 9% longer in ♂ ; ♂ pedipalp femur and tibia 33-35% and 28-30% longer respectively in specimens with identical carapace lengths; pectines of ♂ very long, projecting beyond trochanter IV, with 24-28 teeth per pecten; pectines of ♀ very short, not projecting beyond two thirds of coxa IV, with 4-7 teeth per pecten; first proximal middle lamella of each pecten with mesial margin sharply angular and bearing teeth along entire length of posterior margin of pecten in ♂, in ♀ sublinear and with proximal half of pectinal posterior margin devoid of teeth.

Males and females (See also table 4.2)

Trichobothria: As in fig. 4.54. Neobothriotaxic for group C with external ó of tibia varying from 24 to 28 and ventral ó from 9 to 13. ó d_2 of tibia approximately equidistant from d_1 and i, and distinctly dorsal in position

Hemispermatophore: As in fig. 4.55.b. Differing diagnostically from that of O. new species E (fig. 4.70.g) in shape and size of distal lamina, hook notch and distal crest of distal lobe. In addition the following percentages are diagnostic for O. concinnus (N.M. 11108):

(1) ha-w distance X100/dcr-w distance = 22,8%
(2) ha-bsh distance X100/ha-w distance = 38,6%
(3) ha-bsh distance X100/dcr-bsh distance = 10,3%

Variation

No distinctive variation in the material studied.

Measurements

See plates and figures. Maximum recorded body lengths in adult ♂ 5,0 cm (carapace 7,2 mm) in adult ♀ 4,9 cm (carapace 7,2 mm).

Type material

The type series consists of 1 ♂ holotype (T.M. 9580), 2 ♂ and 3 ♀ paratypes (T.M. 8796, 9581, 9582, 9506 & 9908) all deposited in the collection of the Transvaal Museum in Pretoria.

Material examined

♂ holotype, Groot Aarpan farm, Gordonia District, Cape Province, South Africa, 12 February 1970, L.W. Coons. The following paratypes: 1 ♀, Kwang Pan, Nossob River, Botswana, 19 May 1956, V. FitzSimons (T.M. 8796); 1 subadult ♂ Leeudril, Botswana, 3 February 1970, W.D. Haacke (T.M. 9582); 1 subadult ♂, Leeudril, Botswana, 4 February 1970, H.D. Brown (T.M. 9581); 1 subadult ♀, Kameelsleep, Kalahari Gemsbok National Park, South Africa, 6 June 1970, R.B. Huey (T.M. 9908); 1 subadult ♀ (not ♂ as stated by Newlands, 1972: 242), Leeudril, 28 November 1969, L.W. Coons and R.B. Huey (T.M. 9506). The following non-types: 1♂, Union's End, Kalahari Gemsbok Park, South Africa, no date, Park Staff (N.M. 11108); 3 ♀, Mata Mata, Kalahari Gemsbok Park, no dates, Park Staff (S.A.I.M.R. 912, 913, 915); 1 ♀, Swartmodder farm, Cape Province, South Africa, 15 April 1970, B. Lamoral (N.M. 10360); 2 juvenile ♂, id., 26 February 1973, B. Lamoral (N.M. 10363); 1 juvenile ♀, 5 km North of Mata Mata, Kalahari Gemsbok Park, 25 April 1970, B. Lamoral (N.M. 10362); 1 juvenile ♂, Moravet, Kalahari Gemsbok Park, 24 April 1970, B. Lamoral (N.M. 10361).

Distribution

South-western Botswana and Kalahari Gemsbok Park. Although no specimens have as yet been recorded from South West Africa its association with the Kalahari sand system in the above regions strongly indicates that it is only a matter of time before specimens are collected from the Kalahari sands in the south-eastern region of South West Africa.

Bionomics

Specimens personally collected were found either resting on sandy surfaces at night, or under small rocks and small logs on sand with surface hardness ranging from categories III-IV (table 2.2). It is not known yet whether this species also digs burrows. The known localities fall within an area of vegetation type 13 (fig. 2.4). *O. concinnus* is hemiedaphic and nocturnal. Its habitat and habitus indicate that it is a psammophilous species.

Opisthophthalmus fitzsimonsi Hewitt, 1935, NEW STATUS

Figs 4.55.c, 4.63 and 4.77.d

Plate. 4.59

Opisthophthalmus intercedens fitzsimonsi Hewitt, 1935: 47.

Diagnosis

O. fitzsimonsi is most closely related to *O. intercedens* but can be separated from it and other species of the genus on the following combination of character
Carapace fig. 4.77.d: anterior median furrow with longitudinal suture distinct, anterior bifurcating suture obsolete; median ocular furrow with longitudinal suture obsolete. Pedipalp chela, outer ventro-lateral keel predominantly costate. Cauda V: ventral surface with unevenly distributed granules; ventral keel distinct and granular. Sternites III-VII and ventral surfaces of cauda I-III smooth in ♀ & ♂.

Description

The following description supplements Hewitt's (1935: 47) original description, the present diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: while there is little size difference, ♂ trunk is more slender with width sternite V/carapac length ratios 0,96 (0,91-1,00) for ♂ and 1,20 (1,15-1,26) for ♀ ; ♂ tergites finely shagreened, ♀ smooth and shiny; first proximal middle lamella of each pecten with mesial margin shallowly curved (occasionally shallowly angular in some ♂) and with proximal one quarter of posterior margin of pecten devoid of teeth in ♂ and ♀ . ♂ with 11-14 and ♀ 8-12 teeth per pecten. In all other characters ♂ differ little from ♀ .

Males and females (See also table 4.2):

Granulation: As for O. intercedens, with granulations in ♂ slightly more pronounced. This applies particularly to the interocular suface of ♂ which is lightly to moderately granular in anterior half and smooth in posterior half, just anterior to the median eyes.

Colour: Pedipalps and carapace varying from deep brown No. 56 to strong brown No. 55; anterior three quarters of tergites brown black No. 65 to dark grayish brown No. 62; cauda strong brown No. 55; caudal keels or their normal emplacement if keels are absent, infuscated; legs and pectines strong yellowish brown No. 74; pedipalp chela fingers dark reddish brown No. 44 to brown black No. 65; chelicerae handback, anterior margin of dorsal surface blackened, remaining portion with light infuscated reticulations. Carapace: see table 4.2.

Pedipalps: As for intercedens but with outer ventral keel of handback distinctly costate. Length movable finger/length handback ratios 1,34 (1,30-1,37) for ♂ and ♀ . Width handback/carapace length ratios 0,69 (0,66-0,70) for ♂ and ♀ .

Cauda: As in table 4.2 and diagnosis.

Pectines: ♂ with 11-14 and ♀ 9-12 teeth per pecten.

Setation: As for O. new species C.

Trichobothria: In ♂ as illustrated for O. new species C in fig. 4.66.a-g and in ♀ as illustrated for O. intercedens in fig. 4.62.a-e, with the exception of the tibia dorsal series in which ꝺ d_2 is approximately equidistant from i and d_1 in fitzsimonsi. (+1) neobothriotaxic for group C with 14 external ꝺ on tibia.

Hemispermatophore: As in fig. 4.55.c. Distal lamina long and sub-apical lateral margin of hook (salmh) very short. Percentages of distances of hook apex (ha) to other structures in relation to various sets of distances as follows:

(1) ha-w distance X100/dcr - w distance = 25,0%
(2) ha-bsh distance X100/ha-w distance = 8,8%
(3) ha-bsh distance X100/dcr-bsh distance = 10,4%

Percentage (2) differs quite considerably from that obtained for *O. new species C* while (1) and (3) are fairly similar.

Variation

Specimens in the northern regions of the known species range are darker in overall colour and the keels of cauda I-V on their normal emplacements are more strongly infuscated.

Measurements

See plates and figures. Maximum recorded adult body lengths of ♂ 6,3 cm (carapace 9,8 mm) of ♀ 6,8 cm (carapace 10 mm).

Type material

The type series consists of a ♂ holotype (T.M. 5478), and ♂ paratype (T.M. 5558) and a subadult ♀ paratype (T.M. 5482) which are in good condition and are deposited in the Transvaal Museum collection.

Material examined

Holotype ♂, Gemsbok Pan, Botswana, Vernay Lang Kalahari Expedition (T.M. 5478); Paratype subadult ♀, Gemsbok Pan, Botswana, Vernay Lang Kalahari Expedition (T.M. 5482); Paratype ♂, Gemsbok Pan, Botswana, Vernay Lang Kalahari Expedition (T.M. 5558); 1 ♀, Okahandja, 13-14 March 1969, B. Lamoral, R. Day (N.M. 10073); 2♂, Hoasas 12 March 1969, B. Lamoral, R. Day (N.M. 11083); 3 ♀, 2 juvenile ♀, Portsmut, 7 February 1969, B. Lamoral, R. Day (N.M. 10077); 1 ♂, Richthofen, 23-26 January 1975 (S.M.N. 553); 2♂, Richthofen, 4-31 January 1975 (S.M.N. 551); 5♂, 1 subadult ♂, 9 ♀, 2 subadult ♀, Kuke Pan, Botswana, (T.M. 5459-T.M. 5475); 1 subadult ♂, Gaberones, Botswana (T.M. 5476); 1♂, Kuke Pan, Botswana (T.M. 5477); 1 subadult ♀, Kuke Pan, Botswana (T.M. 5479); 1 subadult ♀, Kaotwe Pan, Botswana (T.M. 5480); 1♂ Kuke Pan, (T.M. 5481) 1♂, Kuke Pan, Botswana (T.M. 5780); 5♀, 1 subadult ♀, 1 subadult ♂, Kuke Pan, Botswana (T.M. 5788-T.M. 5794).

Distribution

Central and eastern regions of South West Africa (fig. 4.63) with vegetation types 7, 8 and 12 (fig. 2.4) and Botswana.

Bionomics

Specimens collected in South West Africa were dug out of burrows 10-15 cm deep in fairly hard soils with surface hardness ranging from categories VIII-X (table 2.2). Burrow entrances are usually situated in open ground, near the base of grass tufts and occasionally at the side of stones or rocks. *O. fitzsimonsi* was found to be sympatric with *carinatus* in the Hakos mountains. The distribution range of *fitzsimonsi* falls within vegetation types 7, 8 and 12 (see fig. 2.4). *O. fitzsimonsi* is nocturnal and hemiedaphic.

Opisthophthalmus flavescens Purcell, 1898

Figs 4.56, 4.55.d and 4.78.e

Plate 4.60

Opisthophthalmus flavescens Purcell, 1898, 7-9

Diagnosis

O. flavescens is most closely related to *O. new species D*, but can be separated from it and other species of the genus on the following combination of characters Carapace: anterior and median ocular furrows without sutures; l.c./x ratio fallin between 1,50 to 1,60 (see fig. 4.78.e). Upper surface of pedipalp handback reticularly granular. Pedipalp tibia with 14 e ó and 3 v ó. Chelicerae chelae distinctly infuscated.

Description

The following account supplements Purcell's (1898: 7-9) comprehensive original description, Kraepelin's (1908: 267) supplement, the present diagnosis and pertinent plates and figures.

Sexual dimorpism:

In adults, males differ from females in the following characters: ♂ trunk more slender with width sternite V/carapace length ratios 0,90 (0,87-0,93) for ♂ and 1,00 (0,98-1,03) for ♀ ; ♂ tergites finely shagreened, ♀ smooth and shiny ♂ pedipalp chela fingers longer than ♀ with length movable finger/handback length ratios 1,75 (1,72-1,78) in ♂ and 1,55 (1,52-1,58) in ♀;

♂ pedipalp handback narrower than ♀ with width handback/carapace length ratio 0,52 (0,50-0,54) in ♂ and 0,67 (0,64-0,70) in ♀ ; first proximal middle lamella of each pecten with mesial margin sharply angular and bearing teeth along entire length of posterior margin of pecten in ♂ , in ♀ shallowly convex and with proximal one fifth of pectinal posterior margin devoid of teeth; ♂ with 33-39 and ♀ 21-25 teeth per pecten.

Males and females (See also table 4.2):

Trichobothria: As in fig. 4.56. (+ 1) neobothriotaxic for group C with 14 external ó on tibia. Pedipalp tibia fig. 4.56.d, with ó d_2 distinctly closer to i than d_1.

Hemispermatophore: As in fig. 4.55.d. Differing diagnostically from that of *new species D* (figs. 4.67.b-d) in shapes and sizes of hooks notch, distal lamina, basal portion and foot. In addition the following percentages are diagnostic for *O. flavescens*:

(1) ha-w distance X100/dcr - w distance = 33,5% (33,0 - 34,0%)
(2) ha-bsh distance X100/ha-w distance = 43,5% (43,0 - 44,0%)
(3) ha-bsh distance X100/dcr-bsh distance = 18,0% (17,5 - 18,5%)

Variation

No important variation in the material studied.

Measurements

See plates and figures. Maximum recorded body lengths of adult ♂ 9,6 cm (carapace 14 mm) of ♀ 9,3 cm (carapace 16 mm).

Type material

Purcell's ♀ holotype was deposited in the collection of the South African Museum in Cape Town. A thorough search of the collection failed to yield the type and a letter from Mr E. Eastwood who was in charge of the collection has confirmed that the type is to be considered as lost. The loss of Purcell's type has therefore been established beyond reasonable doubt and the following specimen is hereby selected and designated as the NEOTYPE of *Opisthophthalmus flavescens*: 1 ♀ , Koichab River banks (26°13'S, 16°05'E), Luderitz District, 10 February 1973, B.H. Lamoral (N.M. 11111). It has been labelled accordingly and is deposited in the type collection of the Natal Museum.

Material examined

1 ♂, 1 ♀, Sesriem 137, 5-8 April 1972, M-L. P., B.H. (S.M.N. 352); 1 ♀, Zuidrivier, February 1971, B. Lamoral (N.M. 10606); 2 ♀, Koichab River bed, 9-12 February 1973, B. Lamoral, K. Porter (N.M. 10641); 1 ♂, Meob Bay Camp, March 1973, C.J. Coetzee (N.M. 10623); 1 juvenile ♂, Gobabeb, December 1963, C. Koch (N.M. 9059); 1 ♂, Aandster farm, 16 February 1974, M.E. Irwin (N.M. 10594); 1 juvenile ♂, Bushman's Paradise, June-July 1969, C.G. Coetzee (S.M.N. 238); 1 juvenile ♀, Namib, 5 March 1960, P.J. Buys (S.M.N. 147); 1 ♀, Gobabeb, November 1969, Mathews (T.M. 9999); 1 ♂, Rooikop, 25 April 1969, H.S. Swanepoel (T.M. 9358); 1 subadult ♂, Zuidrivier, Namib Desert Park, 29 February 1972, B. Lamoral (N.M. 10818); 1 subadult ♀, Aandster 147, 6 March 1976, B. Lamoral (N.M. 10793). ♀ neotype designated above.

Distribution

Namib sand dune system within region with vegetation type 3 as shown in fig. 2.4.

Bionomics

O. flavescens is nocturnal, hemiedaphic and digs 30 to 50 cm deep burrows at the side of small to large consolidated sand dunes with surface hardness ranging from categories IV-V (table 2.2). Its habitat and habitus indicate that it is a psammophilous species. The known localities fall within areas of vegetation type 3. O. flavescens is sympatric with O. holmi within this distribution range.

Opisthophthalmus new species B

Fig. 4.57. and 4.78.c

Plate 4.61

Diagnosis

No sister species being available to O. new species B, it has been found to be most closely related to the opinatus-new species A sister group. O. new species B can be separated from this group and other species of the genus on the following combination of characters. Carapace, fig. 4.78.c: anterior median furrow with a short longitudinal suture and anterior bifurcating suture indistinct; longitudinal suture of median ocular furrow indistinct. **Cauda IV:**

ventral and ventro-lateral keels absent; lateral profile of ventral surface arcuate, entire segment unusually globose.

Description

See also table 4.2. The type series is composed of 7 ♂ and 1 subadult ♀. The following description is based on the adult ♂ holotype, unless otherwise indicated, and supplements the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

Holotype and paratypes. Adult males differ from the subadult female in the following characters: ♂ trunk proportionally more slender with width sternite V/carapace length ratios 0,93 (0,91-0,95) for ♂ and 1,05 for the ♀; pedipalp chela fingers of ♂ longer than in ♀ with length movable finger/handback length ratios 1,25 (1,22-1,28) in ♂ and 1,04 in the ♀; ♂ tergites finely shagreened, ♀ smooth and shiny; ♂ with 6-11 and ♀ 7-8 teeth per pecten.

Male holotype:

Granulation: Upper and outer surfaces of pedipalp handback, upper and outer surfaces of pedipalp tibia and upper surface of femur distinctly and evenly granular; handback finger keel granular throughout and moderately prominent; upper inner marginal keel of handback composed of subspiniform granules; inner surface of handback with scattered large and small granules. Carapace, entire surface granular. Cauda: dorsal surface of I granular; dorsal surfaces of II-III lightly granular, of IV-V very lightly and unevenly granular; lateral and ventral surfaces of cauda V lightly and unevenly granular; proximal ventral half of telson vesicle surface moderately granular.

Colour: Pedipalp and carapace strong yellowish brown No. 74; pedipalp chela fingers strongly infuscated, anterior upper surface with reticulated infuscations, finger keel lightly infuscated. Carapace: lateral eyes and median eyes and ocular tubercle strongly infuscated; median surface around ocular tubercle lightly infuscated. Tergites: anterior three quarters of I-VI and anterior half of VII with partially reticulated infuscations, remaining surfaces strong yellowish brown No. 74. Cauda: I-III dark orange yellow No. 72, IV-V and telson moderate orange yellow No. 71. Sternites III-VII dark orange yellow No. 72. Legs moderate orange yellow No. 71. Pectines light orange yellow No. 70. Cauda II-IV with ventral and ventro-lateral keel emplacements and ventro-lateral keel of V lightly infuscated. Chelicerae: fingers partially strongly infuscated; anterior half of handback reticularly infuscated, remaining non-infuscated surfaces moderate orange yellow No. 71.

Pedipalps: Outer ventro-lateral keel of handback predominantly costate, inner ventro-lateral keel slightly costate.

Carapace: l.c./x ratio 1,93 with median eyes nearly halfway between anterior and posterior margins.

Legs: Legs I and II: protarsi posterior margin with 2 short spine-like setae, tibia posterior margin with a row of 3 very short spine-like setae. Also see table 4.2.

Cauda: Entire cauda 15% longer than trunk. Cauda I ventral and ventro-lateral keels absent, dorsal keel obsolete, dorso-lateral poorly developed; II-IV, ventral and ventro-lateral keels absent, their emplacements indicated by a row of shallow punctations, dorsal and dorso-lateral keels poorly developed, distal granule of dorso-lateral keels moderately enlarged; cauda V, dorso-lateral keel indistinct, ventro-lateral keels composed of short spiniform granules, posteriorly convergent; ventral keel obsolete; anterior ventral surface of telson vesicle granular. Cauda IV unusually globose, with lateral profile of ventral surface arcuate.

Pectines: 7-8 teeth per pecten. First proximal middle lamina of each pecten with mesial margin obtusely angular and with proximal one third of posterior margin of pecten devoid of teeth.

Sternum: Subpentagonal in outline, width subequal to length.

Setation: A moderately pilose species, with setation as for ♀ of O. opinatus.

Trichobothria: As in fig. 4.57.a-e. (+1) neobothriotaxic for group C with 14 external б on tibia.

Hemispermatophore: As in fig. 4.57.f. Differing diagnostically from that of new species A in the shape, length and size of the hook notch, distal lamina, basal portion and foot. Width of middle lamina unusually constricted in proximal median region. Percentages of distances of hook apex to other structures in relation to various sets of distances as follows for paratype (T.M. 10032):

(1) ha-w distance X100/dcr-w distance = 24,0%
(2) ha-bsh distance X100/ha-w distance = 37,5%
(3) ha-bsh distance X100/dcr-bsh distance = 10,9%

Variation

Little variation in paratypes except for the lighter overall colour of specimens from southern Angola.

Measurements

See plates and figures. Maximum recorded body length of adult paratype ♂ 6,0 cm (carapace 9,8 mm). Measurements for holotype as follows (in mm). Carapace: length 8,8; posterior width 8,8; anterior width 6. Pedipalp chela: handback width 6,4; handback length 5,6; movable finger 6,2. Pedipalp tibia: length 6,6, width 3,6. Pedipalp femur: length 5,6; width 2,6. Cauda III: width 3,6; length 4,0; height 3,0. Cauda IV: width 3,6; length 5,0; height 3,4. Cauda V: width 3,6; length 8,0; height 2,6. Telson: width 2,8; length 8,0; height 2,4. Total body length of holotype 5,7 cm.

Type material

Holotype in Natal Museum. Paratypes in Natal Museum, Transvaal Museum and State Museum in Windhoek.

Material examined

Holotype ♂, Cunene River, December-February 1972, Y. Menge (N.M. 11068);
Paratype subadult ♂ , Onguati, 24 February 1962, E. von Koenen (N.M. 11066);
Paratype ♂, Sa Da Bandeira, Angola, 24 December 1970, E.A. Voigt (N.M. 11067);
Paratype subadult ♂, Onguati, 24 February 1962, E. von Koenen (S.M.N. 110);
Paratype ♂, Sa Da Bandeira, Angola, 24 December 1970, E.A. Voigt (T.M. 9984);
Paratype ♂, Sa Da Bandeira, Angola, 24 December 1970, E.A. Voigt (T.M. 9985);
Paratype ♂, Coroca River, Angola, 28 October 1970, I.D. Connell (T.M. 10032);
Paratype ♀, Orumana, 10 February 1975 (S.M.N. 592).

Distribution

Kaokoland and south-western regions of Angola.

Bionomics

No specimens were personally collected and the only information available indicates that some of the specimens collected in Angola were found on fairly hard ground at night.

Opisthophthalmus gigas Purcell, 1898

Figs 4.58, 4.61.a, 4.76.c and 4.80.b

Plate 4.62

Opisthophthalmus gigas Purcel, 1898: 5-7.

Diagnosis

O. gigas is most closely related to O. haackei but can be separated from it and other species of the genus on the following combination of characters. Carapace, fig. 4.76.c: anterior median furrow with longitudinal suture only distinct medially and anterior bifurcating suture absent; median ocular furrow without a longitudinal suture; l.c./x ratio falling between 1,30 to 1,45. Pedipalp chela: outer ventro-lateral keel of handback predominantly costate; ventral surface of handback with 4 V ბ. Pedipalp tibia with 14 e ბ and 3 v ბ. The largest known species of Opisthophthalmus.

Description

The following account supplements Purcell's (1898: 5-7) comprehensive original description, the present diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ quite distinctly from females in the following characters: ♂ trunk more slender with width sternite V/carapace length ratios 0,86 (0,82-0,90) for ♂ and 1,02 (0,98-1,06) for ♀; ♂ tergites finely shagreened, ♀ smooth and shiny; ♂ pedipalp chela finger much longer than ♀ with length movable finger/handback length ratios 2,00 (1,95-2,05) in ♂ and 1,50 (1,45-1,55) in ♀ ; ♂ pedipalp handback narrower than ♀ with width handback/carapace length ratio 0,45 (0,42-0,48) in ♂ and 0,60 (0,57-0,62) in ♀ ; ♂ with 24-29 and ♀ 20-24 teeth per pecten.

Males and females (See also table 4.2):

Trichobothria: As in fig. 4.58. (+ 1) neobothriotaxic for group C with 14 external ბ on tibia.

Hemispermatophore: As in fig. 4.61.a. Percentages of distances of hook apex to other structures in relation to various sets of distances are as follows:

(1) ha-w distance X100/dcr-w distance = 35,0% (34,5-35,5%)
(2) ha-bsh distance X100/ha-w distance = 50,0% (49,5-50,5%)
(3) ha-bsh distance X100/dcr-bsh distance = 20,5% (20,0-21,0%)

Haemolymph electrophoresis

The graphic record obtained on scanning the phoregram of O. gigas with a spectrophotometer is shown in fig. 4.80.b. See fig. 3.9 and relevant section on methods of interpretation of such records in chapter 3.

Variation

No marked variation observed in the material studied.

Measurements

See plates and figures. Maximum recorded body lengths of adults, 16,0 cm (carapace 24,0 mm) for ♂ and 15,5 cm (carapace 23,2 mm) for ♀.

Type material

Purcell's ♀ holotype (S.A.M. B2231) is deposited in the collection of the South African Museum. The type locality and collector are unknown. The holotype was examined and found to be in good condition.

Material examined

♀ holotype, locality, date and collector unknown (S.A.M. B2231); 1 ♂, 3 ♀, Ortmansbaum farm, 26-28 January 1973, B. Lamoral, L. Raw (N.M. 10599); 1 juvenile ♀, Noachabeb farm, 6 February 1973, Lamoral, Porter (N.M. 10691); 1 ♂, Hondeklipbaai, December 1971, J. Wiese (N.M. 10653); 1 subadult ♀, Richtersveld, Blackies' Prospect (N.M. 10618); 1 ♀ Plateau/Aar, 5-18 January 1972 (S.M.N. 331); 1 ♀, Namuskluft 88, 22 September 1973, J. Tebje (S.M.N. 488); 1 subadult ♀, Aus, 16 January 1972, E. Eastwood (N.M. 10613); 3 juvenile ♀, Namuskluft 88, 9 October 1970, P.G. Olivier (S.M.N. 197); 2♂, 2 ♀, Namuskluft 88, 12 October 1970, I. Mokgoabone, P.G. Olivier, J.A. Burger (S.M.N. 196); 1 ♂, Farm Plateau, October 1973, H. Erni (N.M. 10586); 1 ♀, Louwshoop farm 330, 3 February 1973, B. Lamoral (N.M. 10426); 1 ♂, 1 ♀, Jackalswater, 27 November 1897, M. Schlechter (S.A.M. B2198).

Distribution

Southern parts of South West Africa and northern Cape Province of South Africa.

Bionomics

O. gigas is nocturnal hemiedaphic and digs shallow burrows or scrapes under rocks on soils with surface hardness ranging from categories XV to XVIII (table 2.2). The known localities in South West Africa fall within areas of vegetation types 3A and 9. *O. gigas* is sympatric with *O. haackei* within this distribution range.

Opisthophthalmus haackei Lawrence, 1966, NEW STATUS

Figs 4.59 and 4.76.d

Plate 4.63

Opisthophthalmus gigas haackei Lawrence, 1966: 4-5.

Diagnosis

O. haackei is most closely related to *O. gigas* but can be separated from it and other species of the genus on the following combination of characters. Carapace, fig. 4.76.d: anterior median furrow with longitudinal suture only distinct medially and anterior bifurcating suture absent; median ocular furrow with longitudinal suture absent to obsolete; l.c./x ratio falling between 1,35 to 1,45. Pedipalp chela: outer ventro-lateral keel of handback predominantly granular; ventral surface of handback with 5 V ό. Pedipalp tibia with 20-23 e ό and 9-12 v ό.

Description

The following account supplements Lawrence's (1966: 4-5) comprehensive original description, the present diagnosis and pertinent plates and figures.

Sexual dimorphism:

As for *O. gigas*.

Males and females (See also table 4.2):

Trichobothria: As in fig. 4.59. Neobothriotaxic for group C with 5 V ό on pedipalp chela, 20-24 external and 7-8 ventral ό on pedipalp tibia. ό d_2 of tibia distinctly closer to i than d_1.

Hemispermatophore: No adult males available.

Variation

No variation in the material studied.

Measurements

See plates and figures. Maximum recorded body length of adult ♀ 9,3 cm (carapace 17,6 mm). No adult ♂ available.

Type material

Lawrence's ♀ holotype is in the collection of the Natal Museum (N.M. 9105) and is in good condition.

Material examined

♀ holotype, Fish River Canyon, October 1965, W.D. Haacke (N.M. 9105); 1 ♂, Farm Plateau, October 1973, H. Erni (N.M. 10595); 1 ♀, Springbokvlakte, 20 March 1973, B. Lamoral, K. Porter (N.M. 10543); 1 ♂, Ai-Ais, 20 April 1966 (S.M.N. 178); 1 ♀, Fish River Canyon, October 1965, South African Museum (N.M. 9105).

Distributuion

Southern part of South West Africa and northern Cape Province of South Africa.

Bionomics

The only specimen personally collected was found resting on a rock at night and no additional ecological information is available.

Opisthophthalmus holmi (Lawrence, 1969)

Figs 4.60, 4.78.f and 4.81.a

Plates 4.64 and 4.65

Protophthalmus holmi Lawrence, 1969: 105-112; Lamoral and Reynders, 1975: 569.
Opisthophthalmus holmi (Lawrence, 1969); Newlands, 1972: 241.

Diagnosis

O. holmi is most closely related to *O. jenseni* but can be separated from it and other species of the genus on the following combination of characters. Carapace, fig. 4.78.f.: anterior and median ocular furrows without sutures; l.c./x ratio falling between 2,35 to 2,50. Pedipalp chela with 12-16 V δ; handback of ♂ and ♀ moderately wide, with width handback/carapace length ratio 0,53 (0,48-0,58); upper marginal keel of handback granular. Cauda V, lateral profile of ventral surface shallowly convex.

Remark: Lawrence, 1969 described *Protophthalmus* as a new genus with *holmi* as type species. Newlands (1972:241) synonymised *Protophthalmus* with *Opisthophthalmus* while Lamoral (1972: 118-119) described *jenseni* as a new species of *Protophthalmus*. Lamoral and Reynders (1975: 569) reinstated the genus *Protophthalmus* basing this decision on evidence available at the time. Additional comparative evidence obtained in this study has confirmed that *Protophthalmus* is congeneric with *Opisthophthalmus* and that *holmi* and *jenseni* represent an extreme sister group separated from other species by a series of derived character states. Also see chapter 5.

Description

The following account supplements Lawrence's (1969: 105-112) comprehensive original description, Lamoral's (1972: 117-118) supplement, the present diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults males differ little from females except in the following characters: ♂ genital operculum is elliptical in outline, that of ♀ nearly cordate; cauda I to V are proportionally wider and longer in ♂ than in ♀ ; ♂ are generally more heavily granular than ♀ ; see also table 4.2..

Males and females (See also table 4.2):

Trichobothria: As in fig. 4.60.a-f. Neobothriotaxic for group C with 16-18 V δ on pedipalp chela, 26-30 external and 11-13 ventral δ on pedipalp tibia. The distribution of the external δ of the pedipalp tibia is so variable that it has been found impossible to allocate territories to the various groups. δ d_2 of tibia is distinctly closer to i than d_1. Vachon (1973: 943) correctly reported on information which I supplied to him (*in lit.*) that in *O. holmi* δ esb_2 of the tibia is also smaller than other external δ; this observation was based on the few specimens available at the time. Examination of large quantities of additional material has revealed that δ esb_2 is variable in size and that it cannot always be isolated and thus detected.

Hemispermatophore: As in fig. 4.60.g. Differing quite strikingly from any other species of *Opisthopthalmus*, excepting *O. jenseni*, in having the distal end of the distal lamina tapering to a point and not truncated. In addition differing from that of *O. jenseni* (fig. 4.67.a) in shape and size of distal lamina, hook notch, distal end of distal lamina, basal portion and foot. The following percentages are diagnostic for *O. holmi*:

(1) ha-w distance X100/dcr-w distance = 19,3% (19,0-19,7%)
(2) ha-bsh distance X100/ha-w distance = 40,8% (40,4-41,2%)
(3) ha-bsh distance X100/dcr-bsh distance = 8,8% (8,5-9,0%)

Haemolymph electrophoresis

The graphic record obtained on scanning the phoregram of O. holmi with a spectrophotometer is shown in fig. 4.81.a. See fig. 3.9 and relevant section on methods of interpretation of such records in chapter 3.

Variation

Adult specimens from the northern regions of the species range tend to be smaller and more lightly granular than those from the South. Specimens from the central regions of the species range have a vestiture of long stiff setae on the ventral surface of tarsi III and IV while those from localities in the North and South have a ventral posterior row of 2, occasionally 3, spine-like setae.

Measurements

See plates and figures. Maximum recorded body lengths in adult ♂ 7,5 cm (carapace 10,0 mm) in adult ♀ 7,5 cm (carapace 10,5 mm).

Type material

The type series consists of a subadult ♀ holotype and a subadult ♀ paratype deposited in the collection of the Albany Museum (no accession number) in Grahamstown.

Material examined

♀ holotype and ♀ paratype, Gobabeb, June 1968, E. Holm (A.M. no number); 1 ♂, Messum Crater, 26 March 1976, B. Lamoral (N.M. 10845); 1 ♂, Koichab River, February 1973, B. Lamoral (N.M. 10758); 6 ♂, 3 juveniles, Koichab River, 9-12 February 1973, B. Lamoral, K. Porter (N.M. 10677); 1♀, 2 ♂, Gobabeb, February 1972, B. Lamoral (N.M. 10675); 4 ♀, 6 ♂, Koichab River, 9-12 February 1973, B. Lamoral, K. Porter (N.M. 10678); 4 ♀, 19 ♂, Koichab River, 9-12 February 1973, B. Lamoral, K. Porter (N.M. 10676); 2 ♀, Zuid Rivier, February 1972, B. Lamoral (N.M. 10679); 1 ♀, Rosh Pinah, 16-19 February 1973, B. Lamoral (N.M. 10674); 1 ♀, Koichab River, February 1973, B. Lamoral (N.M. 10759); 1 ♀, Gobabeb, 26 April 1969, E. Holm (N.M. 9965); 1 ♂, Gobabeb, 14 December 1968, K. Schaer (N.M. 9964): 8 ♂, Gobabeb, February 1972, B. Lamoral (N.M. 10673).

Distribution

Central and southern Namib Desert within regions with vegetation types 2, 3 and 3A shown in fig. 2.4.

Bionomics

See discussions on psammophilous habits of *O. holmi* in Lawrence (1969: 109-112), Lamoral (1972: 120) and Newlands (1972: 245-249). *O. holmi* is nocturnal, hemiedaphic and its burrows are dug in sand dunes with surface hardness ranging from categories I-III (table 2.2).

Opisthophthalmus intercedens Kraepelin, 1908

Fig. 4.62.a-f, 4.63 and 4.77.c

Plate 4.66

Opisthophthalmus intercedens Kraepelin, 1908: 265.

Synonym

Opisthophthalmus setiventer Lawrence, 1969: 115-116; holotype ♀ (Albany Museum) from 8 miles west of Aus (Luderitz district), South West Africa. Seen. NEW SYNONYM.

Diagnosis

O. intercedens is most closely related to *O. fitzsimonsi* but can be separated from it and other species of the genus on the following combination of characters. Carapace, fig. 4.77.c: anterior median furrow with longitudinal suture distinct, anterior bifurcating suture obsolete; median ocular furrow with longitudinal suture indistinct. Pedipalp chela, outer ventro-lateral keel granular along entire length. Cauda V: ventral surface with unevenly distributed granules; ventral keel distinct and granular. Sternites III-VII and ventral surfaces of cauda I-II smooth in ♀, transversely lightly corrugated in ♂.

Description

The following description supplements Kraepelin's (1908: 265) original descriptio Lawrence's (1969: 115-116) original description of *setiventer*, now a new synonym of *intercedens*, the present diagnosis and pertinent plates and figures. Comparison of Lawrence's ♀ holotype with Kraepelin's ♀ types leaves no doubt that *setiventer* is a synonym of *intercedens*. Lawrence quite erroneously listed wahlbergi and adustus as the most closely related species of setiventer. The ♂ of O. intercedens was unknown and a description of relevant character states is included herein.

Sexual dimorphism:

In adults, males differ from available subadult females in the following characters: ♂ trunk more slender than ♀, with width sternite V/carapace length ratios 0,84 (0,80-0,88) for ♂ and 1,00 (0,96-1,04) for ♀; ♂ tergites finely shagreened, ♀ smooth and shiny; sternites III-VII and ventral surface cauda I-II transversely shallowly corrugated in ♂, smooth and shiny in ♀; ♂ pedipalp chela fingers longer than ♀ with length movable finger/handback length ratios 1,34 (1,30-1,38) in ♂ and 1,20 (1,17-1,24) in ♀; first proximal middle lamella of each pecten with mesial margin obtusely angular and with proximal one sixth of posterior margin of pecten devoid of teeth in ♂, in ♀ almost sublinear and with proximal half of pectinal posterior margin devoid of teeth; ♂ with 17-21 and ♀ 11-13 teeth per pecten.

Males and females (See also table 4.2):

Granulation: Upper and outer surfaces of pedipalp handback evenly granular in ♂, but more shallowly so in ♀; finger keel costate granular in ♂, in ♀ costate to granular in anterior half, posterior half granular and almost obsolete; accessory keel of outer surface obsolete. Outer surface of pedipalp tibia and upper surface of femur lightly granular. Carapace: interocular area virtually agranular and remaining surfaces granular in ♂; in ♀, interocular area and posterior median surface smooth and shiny, lateral surfaces very lightly granular and shiny. Caudal segments: ventral surface of cauda III granular; ventral intercarinal surface of IV and V lightly unevenly granular; proximal ventral surface of telson vesicle lightly granular.

Colour: As for O. new species C.

Chelicerae: As for O. new species C.

Carapace: l.c./x ratio 1,84 (1,80-1,88). See also table 4.2.

Pedipalps: Handback: inner ventral keel almost obsolete in ♀, lightly costate in ♂; outer ventro-lateral keel granular along entire length.

Cauda: As in table 4.2 and diagnosis.

Pectines: ♂ with 17-21 and ♀ 11-13 teeth per pecten.

Setation: as for O. new species C.

Trichobothria: As in fig. 4.62.a-e. (+ 1) neobothriotaxic for group C with 14 external ბ on tibia. Distribution not differing diagnostically from that in O. new species C and O. fitzsimonsi.

Hemispermatophore: As in fig. 4.62.f. Differing diagnostically from those of O. fitzsimonsi (fig. 4.55.c) and O. new species C (fig. 4.66.h) in shapes and sizes of hook notch, distal lamina, basal portion and foot. In addition the following percentages are diagnostic for O. intercedens (N.M. 10726):

(1)	ha-w distance X100/dcr-w distance	= 28,9%
(2)	ha-bsh distance X100/ha-w distance	= 32,4%
(3)	ha-bsh distance X100/dcr-bsh distance	= 11,8%

Variation

No variation in the available material except for the darker overall colour and dark patterns described by Lawrence for setiventer, namely: interocular surface, anterior two thirds of tergites I-VI, pedipalps, ventral surfaces of cauda I-V and telson dark yellowish brown No. 78.

Measurements

See plates and figures. Maximum recorded body lengths of adult ♂ 7,5 cm (carapace 11,4 mm), of subadult ♀ 6,5 cm (carapace 10,6 mm).

Type material

The type series examined consists of 2 ♀ syntypes, no holotype having been designated (Z.M.B. 14973). The largest of these 2 ♀ is hereby selected as the LECTOTYPE of Opisthophthalmus intercedens and the other ♀ together with any other outstanding syntypes as PARALECTOTYPES. The material examined has been labelled accordingly. It is deposited in the collection of the Zoologisches Museum, Berlin.

Homotype

I have selected a ♀ homotype which is deposited in the Natal Museum collection (N.M. 11072).

Material examined

♀ subadult lectotype, 1 juvenile ♀ paralectotype, Kubub, no date, L. Schultze (Z.M.B. 14973); 1 ♀ (homotype), farm Plateau 38, 29 February 1976, B. Lamoral (N.M. 11072); 1 ♂, farm Plateau 38, 29 February 1976, B. Lamoral (N.M. 10726); 2 ♂, Aus, no date, W.F. Purcell (N.M. 9121 and 9122).

Distribution

All available localities are within a radius of 20 km from Aus in the Luderitz district.

Bionomics

The only specimen personally collected was found resting on the surface of consolidated sandy ground with surface hardness ranging from categories VI-VII (table 2.2). The known localities fall within an area of vegetation type 3A. *O. intercedens* is nocturnal and hemiedaphic.

Opisthophthalmus jenseni (Lamoral, 1972) NEW COMBINATION

Figs 4.64 and 4.67.a

Plate 4.67

Protophthalmus jenseni Lamoral, 1972: 118-119.

Diagnosis

O. jenseni is most closely related to *O. holmi* but can be separated from it and other species of the genus on the following combination of characters. Carapace: anterior and median ocular furrows without sutures; l.c./x ratio falling between 2,10 to 2,15. Pedipalp chela with 18-20 V ȯ; handback of ♂ (♀ unknown) distinctly wide, with width handback/carapace length ratio 0,70; upper marginal keel of handback composed of blunt spiniform tubercules, much longer and larger than those of handback upper surface. Cauda V, lateral profile of ventral surface shallowly concave.

Remark

See remark under *O. holmi*.

Description

The following account supplements Lamoral's (1972: 118-119) comprehensive original description, the present diagnosis and pertinent plates and figures. No further specimens have been collected since the original description of this species based on 1 adult ♂ holotype.

Trichobothria: As in fig. 4.64. Neobothriotaxic for group C with 18-20 V ȯ on pedipalp chela, 30-31 external and 9-10 ventral ȯ on pedipalp tibia. Otherwise as for *O. holmi*.

Hemispermatophore: As in fig. 4.67.a. Distal end of distal lamina tapering to a curved point and not truncated. Also see comments under O. holmi. The following percentages are diagnostic for O. jenseni:

(1) ha-w distance X100/dcr-w distance = 16,05%
(2) ha-bsh distance X100/ha-w distance = 38,5%
(3) ha-bsh distance X100/dcr-bsh distance = 6,8%

Measurements

See plates and figures. Total body length 4,5 cm, carapace length 6,9 mm. Width sternite V/carapace length ratio 0,90.

Type material

The ♂ holotype is deposited in the collection of the Transvaal Museum, Pretoria (T.M. 9504). It is in fair condition.

Material examined

♂ holotype. Bethanis farm, 65 km West of Welwitschia (now called Khorixas) in Damaraland, 20 December 1968, R.A.C. and M.K. Jensen (T.M. 9504)

Distribution

As above

Bionomics

See Lamoral (1972: 118). No additional information available since original description.

Opisthophthalmus litoralis Lawrence, 1955

Figs 4.65.a-g, 4.76.f and 4.81.b

Plate 4.68

Opitsthophthalmus wahlbergi litoralis Lawrence, 1955: 216-217.

Diagnosis

O. litoralis is most closely related to O. carinatus but can be separated from it and other species of the genus on the following combination of characters: Carapace, fig. 4.76.f: anterior median furrow with a poorly visible longitudinal suture, anterior bifurcation obsolete to indistinct; median ocular furrow with an obsolete longitudinal suture and no posterior bifurcation. Pedipalp chela: upper surface of handback agranular, smooth and shiny in ♀, smooth and matt in ♂, never with shallow reticulations; finger keel shallowly costate in ♀, strongly costate in ♂; outer ventrolateral keel of handback predominently granular. Cauda IV ventral and ventrolateral keels costate granular.

Description

The following description supplements Lawrence's (1955: 216-217) original description, his (1969: 115) supplement, the present diagnosis and pertinent plates and figures.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ trunk proportionately smaller and more slender with width sternite V/carapace length ratios 0,90 (0,86-0,93) for ♂ and 1,04 (1,0-1,08) for ♀; ♂ cauda approximately 20% longer than trunk length, in ♀ approximately equal while total body length is approximately only 5% greater in ♀; pedipalp handback of ♂ narrower and fingers longer than ♀ with width handback/carapace length ratios 0,59 (0,57-0,61) in ♂ and 0,68 (0,66-0,70) in ♀ and length movable finger/handback length ratios 1,45 (1,41-1,51) in ♂ and 1,38 (1,35-1,40) in ♀; first proximal middle lamella of each pecten with mesial margin sharply angular while pectinal teeth are present along entire posterior margin of pecten in ♂, very shallowly curved while proximal one eighth of posterior margin of pecten devoid of teeth in ♀; ♂ genital operculum suboval in outline, subcordate in ♀; ♂ distinctly more pilose than ♀; ♂ with 28-32 and ♀ 18-22 teeth per pecten.

Males and females (See also table 4.2):

Granulation: Differing little from <u>O. carinatus</u> except as listed in table 4.2.

Colour: As described for <u>O. carinatus</u> from near Windhoek but with interocular surface distinctly lighter than rest of carapace.

Carapace: l.c./x ratio 1,74 (1,72-1,76)

Legs: Protarsi I and II with many scattered setae and a longitudinal row of 2-3 long stiff setae on posterior surface but no spine-like setae as in <u>O. carinatus</u>. Lateral claws of legs I-IV long, distally slightly curved and of unequal length, with posterior claw shorter than anterior. Median dorsal lobe of tarsi I-IV subequal in length to lateral lobes.

Trichobothria: As in fig. 4.65.a-f. (+ 1) neobothriotaxic for group C with 14 external o̍ on tibia. Chela: o̍ est slightly distal to or level with dst; distance between o̍ est and esb approximately equal to that between esb and eb. Pedipalp tibia: o̍ d_2 distinctly closer to i than d_1; o̍ v_2 approximately equidistant to v_1 and v_3.

Hemispermatophore: As in fig. 4.65.g. Differing distinctly from that of *O. carinatus* in the following character states. distal lamina very broad, hook broad, hook notch deeply excavated, hook apex obtuse, subapical lateral margin of hook short. The following percentages are diagnostic:

(1) ha-w distance X100/dcr-w distance = 31,5% (31,0-32,0)
(2) ha-bsh distance X100/ha-w distance = 34,5% (34,0-35,0)
(3) ha-bsh distance X100/dcr-bsh distance = 13,5% (13,0-14,0)

Haemolymph electrophoresis

The graphic record obtained on scanning the phoregram of *O. litoralis* with a spectrophotometer is shown in fig. 4.81.b. See fig. 3.9 and relevant section on methods of interpretation of such records in chapter 3.

Variation

Little except in overall colour which tends to be darker in specimens south of the Cunene River and in southern Angola.

Measurements

See plates and figures. Maximum recorded adult body lengths of ♂ 8,5 cm (carapace 12,8 mm) of ♀ 8,8 cm (carapace 13,6 mm).

Type material

Lawrence's ♂ holotype was examined and found to be a subadult. It is deposited in the collection of the Lund University Zoology Museum (L.U.Z.M. 1540) and is in good condition.

Homotype

A male homotype has been selected and deposited in the Natal Museum collection (N.M. 10824).

Material examined

♂ holotype, Rocky Point, Skeleton Coast, 10 June 1951, Lund University expedition (L.U.Z.M. 1540); 3 ♂, Unjabmond, 2 October 1965, W. Steyn, P. Swart (S.M.N. 132); 1 subadult ♀, Hoanib R., 5 December 1972, C.G. Coetzee (S.M.N 416); 1 ♂, Ugabmond, 29 June 1964, F. Brown (S.M.N. 131); 2 ♂, 3 ♀, many juveniles, Möwebaai, 11 August 1973, J.B., E.M., (S.M.N. 453); 1 ♂, Huabmond, 10 January 1965, P. Buys (S.M.N. 122); 12 ♂, 4 nymph ♀, Cunene, Angola, 23 September 1969, C. Coetzee (S.M.N. 164); 1 juvenile ♂, Möwebaai, 16 August 1973, B.F. Kensley (S.M.N. 457); 1 juvenile ♂, Khumibrivier, 12 June 1969, C.G.C. (S.M.N. 220); 1 ♂, 2 juveniles, Cunene, Angola, 27 September 1969 C. Coetzee (S.M.N. 163); 1 ♀, Möwebaai, 1 June 1969, B.F. Kensley (S.M.N. 234); 1 ♂, Unjabriv., September 1966, W.D. Haacke (T.M. 9308); 1 ♀, Unjab river mouth, 30 September 1965, W.D. Haacke (T.M. 9788); 1 ♂, Torra Bay, 20 March 1972, H.D. Brown (T.M. 10652); 1 ♂, Möwebaai, 29 March 1976, B. Lamoral, L. Ferguson (N.M. 10748); 1 ♂ Homotype, Unjab riv., 27 March 1976, B. Lamoral, L. Ferguson (N.M. 10824); 2 juvenile ♂, Möwebaai, 29 March 1976, B. Lamoral, L. Ferguson (N.M. 10808); 1 ♂, Brandberg Wes, 29 April 1964, W. Steyn (N.M. 10711); 1 ♀, Torra Bay, 30 March 1976, B. Lamoral, L. Ferguson (N.M. 10820); 1 ♂, Möwebaai, 28 March 1976, B. Lamoral, L. Ferguson (N.M. 10821); 1 ♀, Unjab river mouth, 28 March 1976, B. Lamoral, L. Ferguson (N.M. 10825); 1 ♂, 1 ♀, Möwebaai, August 1973, J.B.,E.M. (N.M. 11070).

Distribution

Skeleton Coast Park with the southernmost recorded locality at Ugab River mouth. This species has also been recorded north of the Cunene River mouth in south-western Angola.

Bionomics

A large proportion of the material collected was found under driftwood and decaying carcasses of large marine mammals cast up by the sea on the littoral zone of the Skeleton Coast. Further inland, specimens were found in very shallow burrows or scrapes under large stones on ground with soil hardness ranging between categories VII-IX (see table 2.2). The distribution range of *O. litoralis* falls within zones of vegetation types 1 and 2 (fig. 2.4). *O. litoralis* is nocturnal and hemiedaphic.

Remark

Lawrence (1955: 244 and 1969: 115) indicated that *O. litoralis* is most closely related to the *wahlbergi* group of species. New evidence presented in this study indicates a direct affiliation with *O. carinatus*.

Opisthophthalmus new species C

Fig. 4.66. a-h, 4.63 and 4.78.b.
Plate 4.69

Diagnosis

No sister species being available to O. new species C, it has been found to be most closely related to the intercedens-fitzsimonsi sister group. O. new species C can be separated from this group and other species of the genus on the following combination of characters. Carapace, fig. 4.78.b: anterior median furrow with longitudinal and anterior bifurcating sutures present but poorly developed; median ocular furrow with an obsolete longitudianl suture. Pedipalp chela, outer ventro-lateral keel predominantly costate. Cauda V: ventral surface evenly granular; ventral keel absent or indistinct from adjacent granules. Sternites III-VII and ventral surfaces of cauda I-III evenly granular in ♂ . Habitus of ♀ unknown.

Description

The type series is composed of males and no females have been collected yet. The following description is based on the adult holotype ♂ , and supplements the above diagnosis, and pertinent figures and plates. Also see table 4.2.

Male holotype :

Granulation: The following surfaces distinctly and evenly granular: upper and outer handback; dorsal and outer pedipalp tibia; dorsal pedipalp femur; dorsal cauda I; lateral and ventral cauda V. Ventral surface of telson lightly granular. Upper lateral margin of cauda V granular but without a distinct dorsal keel.
Carapace: interocular surface almost smooth to very lightly granular; lateral surfaces lightly granular. Tergites: I-VI finely shagreened throughout; VII finely shagreened medially, lightly granular laterally.

Colour: Overall colour orange yellow to yellowish brown. Pedipalps: all segments strong yellowish brown No. 74 with movable and fixed fingers strong brown No. 55. Chelicerae strong yellowish brown No. 74, with fingers and anterior margin of handback lightly infuscated. Carapace, tergites, sternites and cauda I-V deep yellowish brown No. 75. Anterior margin of tergites with light reticulated infuscations. Legs and telson moderate orange yellow

No. 71. Pectines light orange yellow No. 70.

Chelicerae: Ventral surface of handback punctate; fingers distinctly longer than handback length.

Pedipalps: Handback: finger keel granular, composed of granules slightly larger than adjacent granules of either upper or outer surfaces; outer surface with a median longitudinal granular accessory keel; upper surface without traces of any accessory keels; outer ventral keel predominently costate, with 3-4 notches along its length; inner ventral keel almost obsolete. Width handback/carapace length ratio 0,52. Length movable finger /handback length ratio 1,13.

Carapace: Median eyes posterior of medial with l.c./x ratio 1,77 in holotype and a range of 1,74-1,80 in paratypes.

Median eyes: large, 2,5 times the diameter of lateral eyes and less than one diameter apart from each other.

Legs: Tarsi I & II with 2-3 spine-like setae on posterior margin. Tarsi III with 1 ventral anterior and 4 ventral posterior spine-like setae. Tarsi IV without any ventral anterior but 4 ventral posterior spine-like setae. Posttarsal lateral claws moderately long, distally curved and of equal length. Tarsal median dorsal lobes distinctly shorter than lateral lobes.
Cauda: As in table 4.4 and diagnosis. Telson aculeus, long and only slightly curved.

Pectines: 9-9 teeth. In paratype ♂ 5-9 per pecten. First proximal middle lamella of each pecten subtriangular in outline.

Sternum: Subpentagonal, slightly longer than wide.

Setation: Pedipalps, legs, lateral and posterior margins of sternites III-VII and caudal segments moderately pilose.

Trichobothria: As in fig. 4.66.a-g. (+ 1) neobothriotaxic for group C with 14 external ó on tibia. Chela: ó est distal to dst; distance est-esb approximately half of esb-eb; V_3 situated in proximal half of ventral surface; Et_4 small, nearly in line with Et series and closer to Et_4 that Et_5. Tibia: ó d_2 closer to i than d_1 with distance i-d_2 equal to two thirds of distance d_2 - d_1; ó v_2 distinctly closer to v_1 than v_3. These character states also apply to ♂ paratypes.
Hemispermatophore: As in fig. 4.66. h. The following percentages apply to hemispermatophores of paratype ♂ :

(1) ha-w distance X100/dcr-w distance = 25%
(2) ha-bsh distance X100/ha-w distance = 28%
(3) ha-bsh distance X100/dcr-bsh distance = 8,6%

Variation

Paratypes from the same locality as the holotype exhibit little variation worth mentioning except in the number of pectinal teeth which range from 5-9. Paratypes from Schwarzkuppen farm, which is further north and west of the Karasberge, are darker in overall colour and some specimens have light reticulated infuscations on the carapace, tergites, outer surfaces of prefemora and femora of legs I-IV. In some specimens cauda IV & V are lightly infuscated.

Measurements

See plates and figures. Maximum recorded body length of adult ♂ 4,9 cm (carapace 7 mm).

Type material

Holotype ♂ in Natal Museum collection. Paratypes: in Natal Museum; 1 ♂, Transvaal Museum, Pretoria; 1 ♂, State Museum, Windhoek.

Material examined

Holotype ♂, Ortmansbaum, 26-28, January 1973, B. Lamoral (N.M. 11106). Paratypes: 6 ♂, Ortmansbaum, 26-28 January 1973, B. Lamoral (N.M. 10683); 14 ♂, Swarzkuppen, 8 February 1973, B. Lamoral & K. Porter (N.M. 10688).

Distribution

Known from only two localities south of 27^{0} of latitude, in South West Africa. See material examined.

Bionomics

All the specimens obtained were collected at night with the aid of an ultra-violet lamp and were found resting on sand dunes or sandy river banks with surface hardness ranging from categories IV-V (table 2.2). No specimens were dug out of burrows and it is therefore impossible to verify whether these surfaces are the sites of this species' burrows. The two type localities fall within areas of vegetation type 9 (see fig. 2.4).

Opisthophthalmus opinatus (E.Simon, 1887)

Figs 4.68, 4.61.b and 4.77.a

Plates 4.70,4.71

Table 4.4

Mossamedes opinatus E. Simon, 1887: 382-383.

Synonyms

Opisthophthalmus scabrifrons Hewitt, 1918: 129-130; 2 ♂ syntypes (T.M. 411 & 412) from Narudas Süd and Quibis, South West Africa. All seen. NEW SYNONYM.

Opisthophthalmus opinatus bradfieldi Hewitt, 1931: 97-99; 1 ♀ 1 ♂ syntypes (A.M. 6359), 1 ♀ (A.M. 6359), 1 ♂ (A.M. 6311) from Krantzberg, Namib Desert, South West Africa. All seen. NEW SYNONYM.

Diagnosis

Adult ♂ and ♀ are subject to clinal variation in overall size and other character states shown in table 4.4. Notwithstanding this, the following combination of characters separates O. opinatus from other species of the genus. Carapace, fig. 4.77.a: anterior median furrow with a distinct longitudinal suture but poorly developed to obsolete anterior bifurcating suture; median ocular furrow with a distinct longitudinal suture. Pedipalp chela: upper surface of handback with numerous rounded, occasionally anastomosing granules. Pedipalp tibia: ♂ d_2 approximately equidistant from d_1 and i.

Telson vesicle: ventral and lateral surfaces always lightly to heavily granular; posterior upper lateral surfaces with spiniform granules but never including numerous minute spicules. O. opinatus is most closely related to new species A.

Description

The following description supplements E. Simon's (1887: 382-383) original description, Hewitt's original descriptions of the new synonyms listed above, the present diagnosis and pertinent plates and figures. Material available for this revision and examination of the types of scabrifrons and bradfieldi have led to the conclusion that the diagnostic characters selected by Hewitt are so variable as to bridge the character sets proposed by him to separate these species. This variability is the result of hitherto unsuspected clinal differences in what were thought to be diagnostic ones. Habitus extremes are illustrated in plates 4.70.a & b and 4.71.a & b.

Sexual dimorphism:

In adults males differ from females in the following character: ♂ smaller but not proportionally more slender; ♂ cauda 1,5 times as long as trunk length, ♀ cauda 1,2 times as long while total body length is only slightly greater in ♂; upper surface of pedipalp handback nearly flat in ♂, shallowly convex in ♀; ♂ telson and pedipalp chela more pilose than ♀ see also differences in table 4.4; ♂ with 19-23 and ♀ 13-19 teeth per pecten.

Males and females (See also table 4.2):

Colour: Females, overall dark brown No. 59 to deep brown No. 56; telson, chelicerae and legs strong yellowish brown No. 74. Males are usually more lightly coloured than females.

Pedipalps: Finger keels usually predominantly granular, anterior half occasionally costate in some specimens, particularly in populations from the northern regions of the species range.

Cauda: Lateral and ventral intercarinal surfaces of I-III smooth and agranular.
Setation: A sparsely to moderately pilose species.
Trichobothria: As in figs 4.68.a-e (+ 1) neobothriotaxic for group C with 14 external o̍ on tibia. Chela: o̍ est proximal to or level with dst; distance est-esb approximately equal to esb-eb; V_3 situated in proximal half of ventral surface; o̍ Et_4 small and in line with Et series. Tibia: o̍ d_2 approximately equidistant from d_1 and i.
Hemispermatophore: As in fig. 4.61.b. See also table 4.4.

Variation

In addition to characters listed in table 4.4 the following are subject to clinal variation (character states of northern regions populations of the species range are given first, followed by those in the southern regions or opposite extremes of the clines): overall colour of ♀ and ♂ as dark as described above to much lighter; first proximal middle lamella of each pecten mesially rounded to angular in ♂.

Measurements

See plates, figures and table 4.4.

Type material

Simon's adult ♀ holotype was examined. It is deposited in the collection of the Museum national d'Histoire naturelle, Paris (R.S. 0235) and was found to be in good condition, see plate 4.70.

Material examined

♀ holotype, Kalahari, no date (Schinz, R.S. 0235, collection E. Simon 9621); 1 ♂ Kabiras, 2 January 1916, R.W. Tucker (S.A.M. B1704); 1 ♀ Garries, 20 December 1915, R.W. Tucker (S.A.M. B1720); 1 ♂, Kabiras, 2 January 1916, R.W. Tucker (S.A.M. B1705); 1 juvenile ♀, Nauchas, 3 January 1916, R.W. Tucker (S.A.M. B1717); 1 ♀ Namsem, 22 December 1915, R.W. Tucker (S.A.M. B1709); 1 ♂, Nomtsas, 23 December 1915, R.W. Tucker (S.A.M. B1708); 1 juvenile ♂, 1 juvenile ♀, Areb, 4 January 1916, R.W. Tucker (S.A.M.) B1711); 1 ♂, Nauchas, 3 January 1916, R.W. Tucker (S.A.M. B1700) 1 ♂, Nauchas, 3 January 1916 (S.A.M. B1716); 1♂ Kabiras, 2 January 1916 (S.A.M. B1703); 1 subadult ♀, Nauchas, 3 January 1916, R.W. Tucker (S.A.M. B1701); 1 ♀, Aus, December 1926 (S.A.M. B7002); 1 juvenile ♀; Swakopmund (A.M. 6421); 1 ♂, Kiries West (S.A.M. B6987); 1 juvenile ♀, Erongo West, 5 September 1975, REG (S.M.N. 566) 1 ♀, Hohenheim, 26 March 1961 (S.M.N. 141); 1 ♂, Noachabeb, 7-12 January 1972 (S.M.N. 327); 1 ♂, Nauzerus, December-January 1973-1974, Chris Kingsley (N.M. 10553); 1 juvenile ♂, Aar, 29 February 1976, B. Lamoral (N.M. 10789); 1 ♀, Plateau, 4 February 1973, B. Lamoral (N.M. 10590); 1 juvenile ♂, 1 juvenile ♀, Kamkas, 8 March 1976, B. Lamoral (N.M. 10794); 1 ♀, 4 subadult ♀, Saffier, 5 March 1976, B. Lamoral (N.M. 10724); 1 ♂, 1 ♀, Vredenhof, 21 February 1976, B. Lamoral (N.M. 10727); 1 ♀, Nauzerus, December-January 1973-1974, Chris Kingsley (N.M. 10551); 1 ♀, Nauzerus, December-January 1973-1974, Chris Kingsley (N.M. 10554); 1 ♀, Saffier, 5 March 1976, B. Lamoral (N.M. 10801); 5 juvenile ♀, 2 juvenile ♂, Plateau, 29 February 1976, B. Lamoral (N.M. 10788); 4 juvenile ♀, 3 juvenile ♂, 2 juveniles, Rehoboth, 13 March 1976, B. Lamoral (N.M. 10814); 2 ♂, 1 ♀, Kubub, 2 March 1976, B. Lamoral (N.M. 10790); 2 ♀, Kam River, December 1937, H.W. Bell-Marley (N.M. 8329); 2 ♀, 1 ♂, 3 juvenile ♀, 4 juveniles, Klein Aub, 11 March 1976, B. Lamoral (N.M. 10806); 1 ♂, 1 juvenile ♀, Narib, 10 March 1976, B. Lamoral (N.M. 10802); 1 ♂, 1 ♀, Noachabeb, 6 February 1973, B. Lamoral (N.M. 10711); 4 ♀, 2 subadult ♂, 1 juvenile ♀, 1 juvenile ♂, Us, 6 February 1973, Lamoral, Porter (N.M. 10609); 1 ♀, Nauzerus, December-January 1973-1974, Chris Kingsley (N.M. 10552); 2 ♂, 2 juveniles, Maltahoe, 12-14 December 1934, Dr K. Jordaan (B.M. 1934 4.25 21-23).

Distribution

South of 21° of latitude in South West Africa with the exclusion of the Namib and Kalahari sand systems.

Bionomics

O. opinatus digs burrows to depths of 15-25 cm in soils with surface hardness ranging from categories VIII to XIII (table 2.2). Burrow entrances are usually situated in open ground in the northern regions of the species range and at the side of large stones or rocks in the southern regions while in intermediate regions both situations are encountered. *O. opinatus* was found to be sympatric with *new species A*, its most closely related species, at two localities in western central South West Africa, namely farms Narib 4 and Klein Aus 350. At Narib 4, the entrances of burrows of *opinatus* were all in open ground and those of *new species A* at the side of rocks while at Klein Aub 350 this situation was reversed. This observation possibly indicates an ecological difference of burrow location in sympatric conditions but the low number of records available (see material examined) precludes a definite statement on the matter.

The distribution range of *opinatus* encompasses vegetation types 4, 7, 8 and 9 (see fig. 2.4). *O. opinatus* is nocturnal and hemiedaphic.

Opisthophthalmus new species D

Figs 4.69 and 4.67.b
Plates 4.72 and 4.73

Diagnosis

O. new species D is most closely related to O. flavescens but can be separated from it and other species of the genus by the following combination of characters. Carapace: anterior median and median ocular furrows without sutures; l.c./x ratio 1,75-1,80. Cauda: cauda V, ventro-lateral keels posteriorly divergent; cauda III and IV with ventral and ventro-lateral keels absent to obsolete; ventral surface of telson vesicle agranular.

Description

See also table 4.2. The type series consists of an adult ♀ holotype, 2 subadult ♀ paratypes, 4 adult ♂, 2 subadult ♂ paratypes. The following description is based on the ♀ holotype unless otherwise indicated, and supplements the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

Holotype and paratypes. Adult males differ from the only adult ♀ available in the following characters: ♂ trunk proportionally more slender with width sternite V/carapace length ratios 0,95 (0,93-0,98) for ♂ and 1,09 for ♀; ♂ cauda proportionally 25% longer than trunk length, ♀ cauda subequal to trunk in length; ♂ tergites and carapace finely granular, ♀ smooth and shiny; first proximal middle lamella of each pecten with mesial margin obtusely angular and bearing teeth along entire length of posterior margin of pecten in ♂, in ♀ shallowly convex and with proximal one third of pectinal posterior margin devoid of teeth; ♂ pedipalps are more pilose than ♀; ♂ with 18-22 and ♀ 12-16 teeth per pecten.

Female holotype:

Granulation: upper and outer surfaces of pedipalp handback and tibia and outer femur shiny and smooth to very shallowly reticulated in texture and occasionally with a few scattered granules; inner surfaces of handback, tibia and femur and dorsal femur with few scattered granules; carapace, interocular surface smooth and shiny, lateral and posterior surfaces lightly granular; tergite VII lateral surfaces lightly granular; ventral surface of cauda V lightly granular, ventral keel not very distinct, ventro-lateral keels granular to sub-spiniform, dorsal keels obsolete (partially present in ♂ paratypes); all other cuticular surfaces smooth and shiny.

Colour: Pedipalps, caudal segments and cheliceral fingers dark yellowish brown No. 78; cheliceral handback, carapace and tergites deep yellowish brown No. 75; legs I-IV dark orange yellow No. 72; sternite VII strong yellowish brown No. 74 and I-VI light orange yellow No. 70; pectines and genital operculum light yellow No. 86.

Pedipalps, fig. 4.69: handback finger keel shallowly costate, outer ventrolateral keel shallowly granular; dentate margin of fixed and movable fingers of chelae with respectively 5 and 6 enlarged and prominent teeth in addition to the terminal ones; fingers of ♂ and ♀ long, with length movable finger/handback length 1,58 (1,55-1,62); handback of ♂ and ♀ narrow with width handback/carapace length ratio 0,50 (0,48-0,52).

Legs: See table 4.2.

Cauda: See table 4.2.
Sternum: Subpentagonal in outline, width equal to length.

Setation: A moderately pilose species, see plates 4.72 and 4.73.

Trichobothria: As in fig. 4.69. (+ 1) neobothriotaxic for group C with 14 external ɓ on tibia. Also see couplet 23 in key to species of <u>Opisthophthalmus</u>.

Hemispermatophore: As in fig. 4.67.b. Differing diagnostically from that of <u>flavescens</u> in the shape, length and size of the hook notch, distal lamina, distal crest of distal lamina, basal portion and foot. Percentages of distances of hook apex to other structures in relation to various sets of distances are as follows for paratype N.M. 10601:

(1) ha-w distance X100/dcr-w distance = 30,4%
(2) ha-bsh distance X100/ha-w distance = 40,9%
(3) ha-bsh distance X100/dcr-bsh distance = 15%

Variation

Only in colour. The ♀ holotype is darker in overall colour than any of the paratypes. ♂ are in addition lighter than ♀ in overall colour as described for <u>O. new species A</u>, a sympatric species.

Measurements

See plates and figures. Greatest recorded body length of adult paratype ♂ 6,5 cm (carapace 9,2 mm) of adult ♀ holotype 6,5 cm (carapace 9,2 mm).

Type material

Holotype in Natal Museum (N.M. 9123). Paratypes in: Natal Museum; Transvaal Museum, Pretoria; State Museum, Windhoek.

Material examined

♀ holotype, Ururas near Rooibank, Namib Desert Park, August 1966, F. Gaerdes (N.M. 9123). Paratypes: 1 subadult ♀, Swartbank, Namib Desert Park, 19 February 1972, B. Lamoral (N.M. 10593); 1 subadult ♀, Ganab, Namib Desert Park, 16 September 1971, P.G. Olivier (S.M.N. 356); 1 subadult ♂, Swartbank, 2 February 1972, B. Lamoral (N.M. 10537); 1 subadult ♂, Rössing Mountains, Swakopmund district, 1 March 1974, M.J. and M.L. Penrith (S.M.N. 514); 1 ♂, no data (T.M. 8923); 1 ♂, 32 km North of Swakopmund, 11 May 1972, O. Prozesky (T.M. 10493); 1 ♂, Swartbank weather station, Namib Desert Park, 14 February 1972, W. Goussard (N.M. 10602); 1♂, Rooibank, Namib Desert Park, 2 February 1972, Dr Roer (N.M. 10601).

Distribution

Central Namib gravel plains.

Bionomics

All specimens collected were found in shallow scrapes under large stones on soils with surface hardness ranging from categories VII-X. *O. new species D* is hemiedaphic and presumably nocturnal. No additional ecological data are available.

Opisthophthalmus new species E

Fig. 4.70

Plates 4.74 and 4.75

Diagnosis

O. new species E is most closely related to *O. concinnus* but can be separated from it and other species of the genus on the following combination of characters. Carapace: anterior and median ocular furrows without sutures; l.c./x ratio 2,10-2,25. Pedipalp chela with 4 V ɓ. Pedipalp tibia with 14 e ɓ and 3 v ɓ. Leg tarsi with median dorsal lobe distinctly shorter than lateral lobes. It is the smallest species of *Opisthophthalmus* so far described, with a maximum total body length of 4,2 cm.

Description

See also table 4.2. The type series consists of a ♀ holotype, 2 ♀ paratypes and 160 ♂ paratypes. The following description is based on the ♀ holotype , unless otherwise indicated, and supplements the above diagnosis and pertinent plates and figures.

Sexual dimorphism:

Holotype and paratypes. Adult males differ from the two females that are adults out of the three available, in the following characters: ♂ smaller than ♀ (see plates 4.74 and 4.75); ♂ trunk proportionately more slender with width sternite V/carapace length ratios 0,80 (0,77-0,83) for ♂ and 0,93-0.95 for ♀ ; ♂ tergites and carapace finely granular, ♀ smooth and shiny; ♂ sternites III-VII and ventral surfaces cauda I-III densely and uniformly shallowly punctate, in ♀ these surfaces very sparsely and shallowly punctate and smooth; ♂ with 9-13 and ♀ 1-3 teeth per pecten.

Female holotype:

Granulation: Upper and outer surfaces of pedipalp handback, tibia and femur smooth and shiny while sparsely and lightly reticulated in texture; ventral surface of cauda V densely and finely granular, ventral keels absent, ventro-lateral keels obsolete; proximal ventral surface of telson vesicle lightly granular; ventral surface of Cauda IV sparsely and shallowly punctate; all other cuticular surfaces smooth and shiny except those described under sexual dimorphism.

Colour: Pedipalps, carapace and cauda I-V strong brown No. 55; telson and legs I-IV brownish orange No. 54; tergites and sternites deep yellowish brown No. 75; posterior margins of carapace, tergites I-VI and sternites III-VI dark orange yellow No. 72; pectines light orange yellow No. 70.

Chelicerae: Large with length of chela equal to 60% of carapace length; chela fingers longer than handback and with movable fingers distally strongly curved.

Pedipalps: Finger keel almost obsolete while in ♂ paratypes the finger keel is strongly costate. Outer ventro-lateral keel of handback shallowly costate but distinctly costate in ♂ paratypes. Length movable finger/length handback ratio 1,06 and width handback/carapace length ratio 0,39; these ratios are approximately the same in ♂ paratypes.

Carapace: l.c./x ratio 2,21 with median eyes distinctly antero-median in position.

Legs: Legs I and II: tarsi, protarsi and tibia posterior and anterior margins with a single row of long sweep-like setae.

Cauda: All caudal segments devoid of any keels except ventro-lateral of V which are obsolete; in ♂ paratypes a few small granules are present distally in the region of the dorsal keels in cauda I-IV, otherwise as for ♀ holotype.

Pectines: 2 teeth per pecten. Also see plate 4.74.b.

Sternum: Subpentagonal in outline, width subequal to length.

Setation: A lightly pilose species with setation as for O. concinnus.

Trichobothria: As in fig. 4.70.a-f for paratype ♀ (N.M. 11105). (+ 1) neobothriotaxic for group C with 14 external δ on tibia. Pedipalp femur, fig. 4.70.f, with δ d distinctly distal to i.

Hemispermatophore: As in fig. 4.70.g. Differing diagnostically from that of O. concinnus in the shape, length and size of the hook notch, distal lamina and distal crest of distal lobe. Percentages of distances of hook apex to other structures in relation to various sets of distances are as follows for paratype N.M. 10684.

(1) ha-w distance X100/dcr-w distance = 20,1%
(2) ha-bsh distance X100/ha-w distance = 34,8%
(3) ha-bsh distance X100/dcr-bsh distance = 7,8%

Variation

Only in colour. Specimens from Belda farm 361, with the following surfaces having light to dark reticulated infuscations: dorsal and posterior pedipalp tibia and femur; carapace and tergites; distal half of prefemur and anterior and posterior femur of legs I-IV.

Measurements

See plates and figures. Maximum recorded body lengths of adult paratype ♂ 3,8 cm (carapace 5 mm) of holotype ♀ 4,2 cm (carapace 6,2 mm).

Type material

Holotype in Natal Museum. Paratypes in : Natal Museum; Transvaal Museum, Pretoria; State Museum, Windhoek; Museum National d'Histoire naturelle, Paris, France; British Museum (Natural History), London, England; American Museum of Natural History, New York and California Academy of Sciences, San Francisco, United States of America.

Material examined

Holotype ♀, Louwshoop, 3 February 1973, B. Lamoral, K. Porter (N.M. 11104). Paratypes: 1 ♀, Belda, 1 February 1973, B. Lamoral (N.M. 11105); 55 ♂, Belda, 1 February 1973, B. Lamoral (N.M. 10687); 4 ♂, Belda, 28 February 1973, B. Lamoral (N.M. 10684); 102 ♂, Louwshoop, 3 February 1973, B. Lamoral, K. Porter (N.M. 10684); 1 ♀, Ortmansbaum, 18-21 October 1971, no collector's name (S.M.N. 308).

Distribution

South central region of South West Africa.

Bionomics

As for *O. new species C* with which *O. new species E* is sympatric. At this stage no definite ecological differences between the two species are available.

Opisthophthalmus schultzei Kraepelin, 1908

Figs 4.71, 4.72 and 4.77.f

Plates 4.76 and 4.77

Opisthophthalmus schultzei Kraepelin, 1902: 262-263

Synonyms

Opisthophthalmus laevicauda Roewer, 1943: 230-232, pl. 5, fig. 9a-d; ♀ holotype (not ♂) (M.M.S. 6741/148), Luderitzbucht, South West Africa. Seen. NEW SYNONYM.

Opisthophthalmus undulatus Kraepelin, 1908: 263-264; 2 ♂ syntypes (Z.M.B 14993), Kubub, gr. Namaland, South West Africa. Seen. NEW SYNONYM.

Diagnosis

O. schultzei is most closely related to *O. adustus* but can be separated from it and other species of the genus by the following combination of characters. Carapace fig. 4.77.f: anterior median furrow with distinct longitudinal and anterior bifurcating sutures; median ocular furrow with longitudinal suture indistinct. Caudal segments II-IV with distal spines; dorsal keels only slightly larger than preceding ones. Ventral surface of telson vesicle lightly granular, telson not infuscated. Protarsi I and II with a row of 3 spine-like setae on posterior surface. Lateral claws of equal length within each pair, short and strongly curved.

Description

The following account supplements Kraepelin's (1908: 262-263) original description, his original description (1908: 263-264) of *O. undulatus* a new synonym of *O. schultzei*, Roewer's (1943: 230-232) original description of *O. laevicauda* also a new synonym, the present diagnosis, pertinent plates and figures and table 4.2.

Kraepelin's description of *schultzei* was based on a subadult ♀ and a juvenile ♂ and that of *undulatus* on adult males. The character states listed in table 4.2 for *schultzei* were compared with those found in the ♂ types of *undulatus* and no diagnostic differences, besides ones normally associated with sexual dimorphism, could be established. Roewer's holotype of *laevicauda* was found to be a ♀ and not a ♂ and, similarly, to be conspecific with *schultzei*.

Sexual dimorphism:

No adult ♀ is available but the following differences between adult ♂ and subadult ♀ are distinct. ♂ trunk proportionally more slender with width sternite V/carapace length ratios 0,88 (0,85-0,91) for ♂ and 1,05 for the largest ♀ ; pedipalp handback of ♂ narrower and fingers longer than in ♀ with width handback/carapace length ratios 0,70 (0,69-0,71) in ♂ and 0,83 in the largest ♀ and length movable finger/handback length ratios 1,52 (1,50-1,54) in ♂ and 1,30 in the largest ♀ ; ♂ tergites finely shagreened, ♀ smooth and shiny; sternites IV-VII and ventral surfaces of cauda I-III and, to a variable extent, of cauda IV finely, transversely rippled in ♂ these smooth and shiny in ♀ ; first proximal middle lamella of each pecten with mesial margin obtusely angular and with proximal one sixth of posterior margin of pecten devoid of teeth in ♂ , in ♀ almost sublinear and with proximal one third of pectinal posterior margin devoid of teeth; ♂ with 16-20 and ♀ 12-13 teeth per pecten.

Males and females (See also table 4.2):

Granulation: Upper and outer surfaces of handback evenly granular in ♀ , but more shallowly so in ♂ ; finger keel costate granular anteriorly, granular posteriorly in ♀ , in ♂ costate anteriorly costate granular posteriorly; accessory keel of outer surface obsolete. Outer, dorsal and inner surfaces of pedipalp tibia and upper surface of femur lightly granular. Carapace: interocular surface smooth, lateral surfaces lightly granular, posterior median surface agranular in ♀ , very lightly granular in ♂ . Proximal ventral surface of telson vesicle lightly granular in both sexes.

Colour: Pedipalps and carapace, strong brown No. 55; cauda I-V, deep yellowish brown No. 75; sternites, dark orange yellow No. 72; legs I-IV, moderate orange yellow No. 71, pectines, light orange yellow No. 70; tergites, anterior three quarters brown black No. 65, lateral margins and posterior one quarter with a light orange yellow No. 70 border. Chelicerae: fixed and movable fingers brown black No. 65; anterior one third of handback brown black No. 65 to darkly reticular, posterior two thirds strong yellowish brown No. 74.

Pedipalps: Outer ventro-lateral keel of handback granular, inner ventro-lateral keel moderately costate.

Carapace: l.c./x ratio 1,73 (1,71-1,75). (See also table 4.2)

Legs: As in table 4.2.

Cauda: As in table 4.2 and diagnosis.
Pectines: ♂ with 16-20 and ♀ 12-13 teeth per pecten.

Setation: Pedipalps, legs, lateral and posterior margins of sternites III-VII and caudal segments, moderately pilose in ♀, these distinctly more pilose in ♂.

Trichobothria: As in figs 4.71.a-e and 4.72.a-e for ♀ and ♂ respectively (+ 1) neobothriotaxic for group C with 14 external ♂ on tibia. Differing diagnostically from O. adustus in the following distribution: pedipalp chela, distance between ♂ est and esb approximately equal to half that between esb and eb.

Hemispermatophore: As in fig. 4.72.f. Differing diagnostically from that of O. adustus (fig. 4.57.f) in the shape and length or size of the hook notch, distal lamina, basal portion and foot. Percentages of distances of hook apex to other structures in relation to various sets of distances as following:

(1) ha-w distance X100/dcr-w distance = 24,4%
(2) ha-bsh distance X100/ha-w distance = 30,6%
(3) ha-bsh distance X100/dcr-bsh distance = 9,1%

Variation

No variations in the available material except for the lighter overall colour of the 2 ♂ from the Erongo mountains (N.M. 11071 and S.M.N. 174).

Measurements

See plates and figures. Maximum recorded body lengths of adult ♂ 9,3 cm (carapace 13 mm) of largest subadult ♀ 7,7 cm (carapace 10,6 mm).

Type material

The type series examined consists of a subadult ♀ and a juvenile ♂ syntypes, no holotype having been designated (Z.M.B. 14988). The ♀ is hereby selected as the LECTOTYPE of *Opisthophthalmus schultzei* and the ♂ as PARALECTOTYPE. These have been labelled accordingly and are deposited in the collection of the Zoologisches Museum Berlin.

Homotypes

I have selected a ♀ and ♂ homotype which are deposited in the Natal Museum collection (N.M. 10720).

Material examined

♀ lectotype and ♂ paralectotype, Kubub, gr. Namaland, no date, L. Schultze (Z.M.B. 14993); 1 ♀ and 1 ♂ subadults (homotypes) farm Kubub 15, 1 March 1976, B. Lamoral (N.M. 10720); 1 ♂, Erongo mountains, 3 August 1961, P.J. Buys (N.M. 11071); 1 ♂, Erongo mountains, 3 August 1961, P.J. Buys (S.M.N. 174); 1 juvenile ♂, Aus, 29 November 1912, G.S.M.A. (T.M. 406).

Distribution

All available localities are within a radius of 15 km of Aus in the Luderitz district, with the exception of the 2 ♂ from the Erongo mountains in the Omaruru district. The Erongo mountains are situated approximately 525 km north of Aus and provided there has not been an error in the locality recording for these 2 ♂, this considerably extends the species range of *O. schultzei*.

Bionomics

The only specimens personally collected (♀ and ♂ homotypes) were dug out of burrows 15-20 cm deep in very hard, stony ground with surface hardness falling within categories XX-XXI. Burrow entrances were situated at the side of large stones. The distribution range of *O. schultzei* falls within a region of vegetation type 3A in the south and 7 in the northern limit (Erongo Mountains). *O. schultzei* is nocturnal and hemiedaphic.

Opisthophthalmus setifrons Lawrence, 1961

Fig. 4.73, 4.61.c and 4.78.d
Plate 4.78

Opisthophthalmus setifrons Lawrence, 1961: 151-152.

Synonyms

Opisthophthalmus vivianus Lawrence, 1969: 112-113; ♂ holotype (not ♀ as stated by Lawrence) (T.M. 8225), Rehoboth area, South West Africa. Seen. NEW SYNONYM.

Opisthophthalmus pictus nigrocarinatus Lawrence, 1969: 113-115; ♂ holotype (not ♀ as stated by Lawrence) (Albany Museum collection), 30 mls South of Ohopoho, Kaokoveld, South West Africa. Seen. NEW SYNONYM;

Remark

It is probable that O. setifrons is a synonym of O. pictus Kraepelin, 1894 of which the type locality is Reddersburg in the Orange Free State, South Africa. This potential synonymy could not be verified by examining Kraeplin's types. It is based on the conclusion that all the material identified as O. setifrons in this revision was found to be conspecific with specimens of O. pictus from many localities (as far South-East as Graaf Reinet) in the Cape Province of South Africa.

Diagnosis

Because of the uncertainty surrounding the validity of the present status of O. setifrons no direct affinity to a sister species can be allocated at this stage. The following combination of characters is however diagnostic of the species. Carapace, fig 4.78.d: anterior median furrow with distinct longitudinal and anterior bifurcating sutures, the latter long and occupying almost one quarter of the total carapace length. Sternite VII and ventral surface of cauda I rasp-like, covered with large, non anastomosing crescent-shaped granules which are usually individually infuscated.

Description

The following account supplements Lawrence's (1961: 151-152) original description, his original descriptions (1969: 112-115) of O. vivianus and O. pictus nigrocarinatus both new synonyms of setifrons, the present diagnosis, pertinent plates and figures and table 4.2.

Sexual dimorphism:

In adults, males differ from females in the following characters: ♂ trunk proportionally more slender with width sternite V/carapace length ratios 0,90 (0,86-0,93) for ♂ and 1,06 (1,04-1,09); ♂ cauda approximately 15% longer than trunk length, in ♀ approximately equal while total body length is approximately the same in both sexes; pedipalp handback of ♂ narrower and fingers longer than ♀ with width handback/carapace length ratios 0,70 (0,67-0,73) in ♂ and 0,86 (0,82-0,90) in ♀ and length movable finger/handback length ratios 1,71 (1,66-1,76) in ♂ and 1,42 (1,38-1,43) in ♀ ; ♂ pedipalps and cauda more pilose than ♀ . Tergites of ♂ lightly shagreened of ♀ smooth and shiny.

Males and females (See also table 4.2).
Granulation: As for O. pictus. See also this diagnosis and Lawrence's description of O. vivianus and O. pictus nigrocarinatus (1969: 112-115) and plate 4.78.
Pedipalps: Upper and outer surfaces of handback evenly and distinctly granulated with flattened granules; finger keels granular, upper accessory and outer accessory keels granular and distinct in ♂ and ♀.
Colour: As described by Lawrence for O. vivianus and O. pictus nigrocarinatus (1969: 112-115).
Carapace: l.c. x ratios 1,63 (1,61-1,65) for ♀ and ♂. Interocular surfaces of ♀ and ♂ smooth excepting lateral margins of anterior median furrow and anterior bifurcation which are lined with a single row of small granules.

Pectines: First proximal middle lamella of each pecten with mesial margin shallowly curved while proximal one third of posterior margin of pecten is devoid of teeth in ♀ and ♂ . ♂ with 11-15 and ♀ 10-13 teeth per pecten.

Trichobothria: As in fig. 4.73.a-f (+ 1) neobothriotaxic for group C with 14 external ₀ on tibia.
Hemispermatophore: As in fig. 4.61.c. Percentages of distances of hook apex to other structures in relation to various sets of distances, as following for one hemispermatophore dissected.

(1) ha-w distance X100/dcr-w distance = 24,4%
(2) ha-bsh distance X100/ha-w distance = 30,6%
(3) ha-bsh distance X100/dcr-bsh distance = 9,1%

Variation
Little except in overall colour and amount of infuscation of the crescent-shaped granules on the sternites and ventral surfaces of caudal segments, within samples of the same population.
Measurements
See plates and figures. Maximum recorded body lengths of adult ♂ 8,5 cm (carapace 13,6 mm) of ♀ 8,2 cm (carapace 13,3 mm).

Type material
Lawrence's ♂ holotype is in good condition and is deposited in the Natal Museum (N.M. 8330).
Material examined
Holotype ♂, Kam River, October-December 1937, H.W. Bell-Marley (N.M. 8330); 1♀, Isabis, December 1974 (S.M.N. 596); 4♀, Keilberg, 10 March 1969, B. Lamoral, R. Day (N.M. 10072); 2 ♂ Swartbooisdrif, no date, Kaokoveld

Expedition (S.M.N. 115); 7♀, 10 subadult ♂, De Waal, 16 March 1969, B. Lamoral (N.M. 10544); 1♂, Swartbooisdrift, Kaokoveld Expedition, no date (N.M. 11107).

Distribution

Available material comes from the following regions: Kaokoland, Otavi Highlands and Rehoboth, Windhoek and Gobabis districts.

Bionomics

The only specimens personally collected were dug out of burrows with entrances in open ground (no entrances were found at the side of large stones). The burrows extended to a depth of 15-20 cm below surface in soils with surface hardness falling within categories XV-XVII. Available distributions fall within regions with vegetation types 5, 6, 8 and 12. *O. setifrons* is nocturnal and hemiedaphic.

Opisthophthalmus ugabensis Hewitt, 1934, NEW STATUS

Figs 4.74, 4.49.e-j and 4.76.b
Plate 4.79

Opisthophthalmus undulatus ugabensis Hewitt, 1934: 408-410.

Synonym

Opisthophthalmus luciranus Lawrence, 1959: 384-385; subadult ♀ holotype (T.M. 8939) and 2 juvenile ♂ paratype (T.M. 8940 & 8942) from Lucira, southern Angola. All seen. NEW SYNONYM.

Remark

Hewitt described *O. ugabensis* on 1♀ and 1 ♂ syntypes. The ♂ syntype is conspecific with *O. cavimanus* Lawrence, 1928.

Diagnosis

O. ugabensis is a sibling species of *O. brevicauda* but can be separated from the latter by the following combination of morphological characters. Pedipalp tibia figs 4.74.d-f & 4.49.e-j: ∂ esb$_2$ without an accessory ∂; ∂ V$_1$ without an outer accessory ∂: distance between ∂ i and d$_1$ two and a half times that between i and d$_2$.

Description

The following account supplements Hewitt's (1934: 408-410) original description, Lawrence's (1959: 384-385) description of *O. luciranus*, the present diagnosis and pertinent plates and figures.

Sexual dimorphism:

As for *O. brevicauda*.

Males and females (See also table 4.2):

Colour: As for *O. brevicauda* but with melanous surfaces of caudal segments, telson, tergites I-VII, sternite VII and dorsal and lateral surfaces of pedipalp trochanter femur and tibia, much lighter to absent in specimens from southern Angola.

Carapace: with sutures as in fig. 4.76.b.

Trichobothria: As in figs 4.74.a-f and 4.49. e-j; external ό of tibia varying from 14 (fig. 4.49.f) to 20 (fig. 4.49.i); no accessory ό to esb series or V_1 of tibia as in specimens of *O. brevicauda*.

Setation: As in *O. brevicauda*.

Hemispermatophore: As in fig. 4.74.g. Hook notch deeply excavated; percentage ha-bsh distance of ha-w distance 41% (40-42%); position of hook apex distinctly proximal on total distal lamina length, percentage ha-w distance of dcr-w distance 35% (33-37%).

Variation

Colour as reported above. Specimens from Angola and south of the Cunene in northern Kaokoland have 14 external ό on tibia as in fig. 4.49.f, 2 ♂ from Khumib river mouth (S.M.N. 216 and 217) have 20 external ό distributed as in fig. 4.49.i and all specimens from the Brandberg mountains and the lectotype ♀ from Ugab have 16 external ό distributed as in fig. 4.74.e. In all these, V ό of tibia number 7-13.

Type material

Hewitt's ♀ and ♂ syntypes (A.M. 6574) are deposited in the collection of the Albany Museum. The ♂, however, is conspecific with *O cavimanus* Lawrence (see remark above). The ♀ is hereby selected as the LECTOTYPE of *Opisthophthalmus ugabensis*, it has been labelled accordingly and is deposited in the Albany Museum collection.

Material examined

♀ lectotype, Ugab river, no date, R.D. Bradfield (A.M. 6574); 2 juvenile ♂, Brandberg mts, 20 February 1969, B. Lamoral, R. Day (N.M. 10038); 3 juvenile ♂, 1 juvenile ♀, Numaskloof, 5 August 1969, P. Buys (S.M.N.100); 2 juvenile ♀, Numasplato, 9 August 1969, P. Buys (S.M.N. 95); 1 ♀, 2 subadult ♂, Brandberg, 16 August 1969, P. Buys (S.M.N. 101); 1 ♀, Brandberg Wes Myn, 20 April 1966, Bestuurder van myn (S.M.N. 91); 1 subadult ♂, Khumibriver Mouth, 12 June 1969, C.G.C. (S.M.N. 217); 1 ♂, Khumibriver Mouth, 12 June 1969, C.G.C. (S.M.N. 216); 1 juvenile ♂, New Catengue, South West Angola, 20 October 1970, I.D. Connell (T.M. 10033); 3 ♀, 3 ♂, 2 juvenile ♀, Moçamedes 22 October 1949, Angola, (Ang. 4038); 1 ♂, 1 ♀, Kaokoveld (N.M. 11073); 2 subadult ♀, Kunene River, 16 August 1956, G. Rudebeck Brincus material (N.M. 11074); 1 subadult ♀, 2 juvenile ♀, Curocua Road and Iona junction, Angola, 19-21 October 1969, C. Coetzee (S.M.N. 162).

Distribution

Western Damaraland, western and northern Kaokoland in South West Africa and Southern Angola.

Bionomics

No data available.

Opisthophthalmus wahlbergi (Thorell, 1876)

Figs. 4.75, 4,67c & 4.79
Plates 4.80 to 4.82

Miaephonus wahlbergi Thorell, 1876: 13.

Synonyms

Opisthophthalmus wahlbergi gariepensis Purcell, 1901: 194-195; many syntypes (S.A.M. 2178 and 2184) from Naroep, northern Cape Province, South Africa. All seen. NEW SYNONYM.

Opisthophthalmus wahlbergi nigrovescicalis Purcell, 1901: 195; many syntypes (S.A.M. 2202, 2232, 2235 and 2971) from Naroep, northern Cape Province, South Africa. All seen. NEW SYNONYM.

Diagnosis

Adult ♂ and ♀ are subject to extensive colour pattern variations as well as a few other less extensive character state variations which are listed in the section on variation. Notwithstanding these, the following combination of characters separates O. wahlbergi from its most closely related species, O. chrysites and other species of the genus. Carapace: anterior median and median ocular furrows without any sutures; l.c./x ratio 1,70 (1,65-1,75). Cauda: cauda V, ventro-lateral keels posteriorly subparallel to each other; cauda III, ventral and ventro-lateral keels costate; cauda IV, ventral keels granular, ventro-laterals costate granular; ventral surface of telson vesicle granular.

Description

The following account supplements Thorell's (1876: 13) very brief original description, Thorell's (1877: 222-225) extensive supplement, Purcell's (1899: 139-141 and 1901: 194-195) supplements, the original descriptions of the species synonymised above, the above diagnosis and pertinent plates and figures.

Material available for this revision and examination of the types of *O. wahlbergi gariepensis* and *O. wahlbergi nigrovescicalis* have led to the conclusion that the diagnostic morphological characters selected by Purcell are so variable as to bridge the character sets proposed by him to separate these species. These variabilities are the result of hitherto unsuspected clinal differences in what were thought to be diagnostic ones, particularly in the presence or absence of infuscated patterns. In addition Purcell (1901: 195) described the above two subspecies from the same locality, namely Naroep while recording (1899: 139) *O. wahlbergi wahlbergi* from Zandhoogte, a nearby locality ! Habitus extremes are illustrated in plate 4.80 and 4.82.

Sexual dimorphism:

Adult males differ from adult females in the following characters: ♂ trunk is more slender with width sternite V/carapace length ratios 0,80 (0,76-0,84) for ♂ and 1,00 (0,95-1,05) for ♀ ; ♂ cauda is proportionally 20% longer than trunk length, ♀ cauda is equal or subequal to trunk in length; ♂ tergites and carapace finely granular, ♀ smooth and shiny; in some populations sternite VII and ventral surface of cauda I are transversely shallowly wrinkled while these surfaces are smooth in ♀ ; first proximal middle lamella of each pecten with mesial margin obtusely angular and bearing teeth along entire length of posterior margin of pecten in ♂ , in ♀ shallowly convex and with proximal one third of pectinal posterior margin devoid of teeth; ♂ pedipalps are more pilose than ♀ ; ♂ with 23-30 and ♀ with 16-23 teeth per pecten.

Males and females (See also table 4.2):

Colour: As for population samples from regions within the Kalahari sand system south of the 20^{0} of latitude (see figs 2.8) in South West Africa. Females: pedipalps, carapace, cauda I-VI and sternites varying from brownish orange No. 54 to deep brown No. 56; cauda IV and V is quite often lightly to moderately infuscated in some populations; telson varying from dark orange yellow No. 72 to strong yellowish brown No. 74; legs varying from brownish orange No. 54 to strong yellowish brown No. 74; tergites I-VII deeply infuscated but with a broad strong yellowish brown No. 74 band along lateral and posterior margins; chelicerae, posterior half of handback varying from deep brown No. 56 to strong brown No. 55 while anterior half and fingers vary from moderately to deeply infuscated; pectines and genital operculum light orange yellow No. 70. Males: as for ♀ but generally lighter in overall colour. Samples from other regions exhibit colour pattern variations which are listed under the section on variation.

Pedipalps: Handback finger keel shallowly costate to obsolete in ♀ , costate and distinct in ♂; upper surface of handback smooth to very shallowly reticulate in texture in ♀ and ♂ occasionally with a few scattered small granules in ♂ .

Carapace: Interocular surface smooth and shiny, lateral and posterior surfaces lightly granular.

Trichobothria: As in fig. 4.75 (+ 1) neobothriotaxic for group C with 14 external ó on tibia. Also see couplet 23 in key to species of Opisthophthalmus

Hemispermatophore: As in fig. 4.67. c-d, the distal transverse undulation of the distal lamina shown in this figure is not present in most of the other hemispermatophores dissected. The hemispermatophore of O. wahlbergi differs diagnostically from that of its most closely related species, O. chrysites, in the shape, length and size of the hook notch, distal lamina, distal crest of distal lamina, basal portion and foot. Percentages of distances of hook apex to other structures in relation to various sets of distances are as following:

(1) ha-w distance X100/dcr-w distance = 25,5% (24,0%-27,0%)
(2) ha-bsh distance X100/ha-w distance = 39,0% (37,0%-41,0%)
(3) ha-bsh distance X100/dcr-bsh distance = 11,0% (10,0%-12,0%)

Variation

Fig. 4.79 shows the distribution range of O. wahlbergi. Population samples from the ensuing sub-regions of this range exhibt the following variations.

(i) West of Warmbad and South of the 27^{0} of latitude: as in plate 4.82; ventral surface of cauda III, entire cauda IV, V and telson, deeply infuscated; anterior portion of and occasionally entire carapace deeply infuscated; tergites I-VI occasionally entirely deeply infuscated and without a yellowish band along posterior and lateral margins of each tergite; anterior upper, outer and inner surface of chelicerae handback and fingers deeply infuscated;in some specimens from the same locality the telson (eg. N.M. 10624 from Louwshoop farm) is yellowish and not or only faintly infuscated.

(ii) North and North-East, namely populations from north of the 20° of latitude in the East and from Ovamboland and Etosha Game Park: much lighter in overall colour and with the infuscation patterns described for typical Kalahari populations distinctly attenuated or absent; in typical samples from this subregion only the following surfaces are lightly to moderately infuscated, ventral and lateral surfaces of cauda III-V, anterior one quarter of chelicerae handback and fingers, and pedipalp chela fingers.

(iii) Western namely populations from Damaraland down to the Namib Desert Park: overall colour as for typical Kalahari populations but without any infuscations (including the chelicerae) except occasionally on ventral surface of cauda V; carapace anterior margin with a broad U-shaped notch instead of a shallow V-shaped one; ventral surfaces of cauda V and telson more lightly granular.

(iv) South of the Orange River in the Northern Cape Province of South Africa: ranging in infuscation patterns from those found in typical Kalahari populations to those described by Purcell for nigrovescicalis.

Measurements

See plates and figures. Greatest recorded body length of adult ♂ 11,0 cm (carapace 16,3 mm) of adult ♀ 11,6 cm (carapace 19,0 mm).

Type material

Thorell's ♀ holotype is deposited in the Entomological section of the Naturhistoriska Riksmuseet in Stockholm (N.R.S., collection T. Thorell no. 48). It was examined and found to be in fairly good condition though very darkened.

Material examined

♀ holotype, Caffraria 1840-1845, J.A. Wahlberg (N.R.S. no. 48).
The roman numerals used for the subheadings of the different subregions listed here often refer to populations with variations of colour patterns listed in the section on variation.

Material from (i) and (iv)

3♀, 2 ♂, 1 subadult ♀, Augrabies falls, 7 April 1970, B. Lamoral (N.M. 10607); 1 subadult ♂, Fish River Canyon, 11 March 1969. W.D. Haacke (N.M. 10617); 2♀, 1 ♂, Louwshoop farm, 4 February 1973, B. Lamoral (N.M. 10624); 1♀, Ai-Ais, 5 February 1973, B. Lamoral (N.M. 10645); 3 juvenile ♀, 3 February 1973, B. Lamoral, K. Porter (N.M. 10643); 1♂, Namies, W.F. Purcell (N.M. 9119); 1♀, Namies, W.F. Purcell (N.M. 9120); 1 juvenile ♂, Goodhouse 29-31 January 1973, B. Lamoral (N.M. 10591); 2♂, 3♀, Pella Mission, 5-6 April 1970, B. Lamoral (N.M. 10622); 1♀, Pella Mission, 6 April 1970, B. Lamoral (N.M. 10632).

Material from (ii) East and North of (i) and
south of (ii)

2♀, 3 juvenile ♀, 1 juvenile ♂, Okawao, 5 March 1969, B. Lamoral, R. Day (N.M. 10078); 1 ♀, 2 ♂, 2 juvenile ♀, 2 juvenile ♂, Wattersdorf farm, 11-12 March 1969, B. Lamoral, R. Day (N.M. 10037); 4♀, 1 ♂, 3 juvenile ♀, 2 subadult ♂, 3 juvenile ♂, Sukses Dam, 2 March 1969, B. Lamorl, R. Day (N.M. 10034); 6♀, 6♂, De Waal farm, 17 March 1969, B. Lamoral (N.M. 10040); 1♂, Aus, Etosha, 2-6 March 1969, B. Lamoral, R. Day (N.M. 10036); 3♀ Sterkstroom farm, 19-20 March 1969, B. Lamoral (N.M. 10944); 2♂, 3♀, 5 juveniles, 1 subadult, Mata Mata, 27 April 1970, B. Lamoral (N.M. 10657); 2♂, 2♀, 1 juvenile, Twee Rivieren, 16 April 1970, B. Lamoral (N.M. 10648); 1♂, 5 ♀, 2 juveniles, Jansdraai, 19 April 1970, B. Lamoral (N.M. 10616); 2♀, 1♂ 1 juvenile, Moravet, 24 April 1970, B. Lamoral (N.M. 10642); 3♂, 1♀, Klein Skrypan, 17 April 1970, B. Lamoral (N.M. 10635); 4♀, 1 ♂, 3 juveniles, confluence of Auob and Nossob rivers, 18 April 1970, B. Lamoral (N.M. 10610); 3♀, 1♂, Bayip Pan, 23 April 1970, B. Lamoral (N.M. 10608); 2 juveniles, Ghaub 47, 19-30 November 1972, H.C. Strauss (S.M.N. 414); 1 juvenile ♂, 1 juvenile ♀, Noachabeb 97, 7-12 January 1972 (S.M.N. 326); 1♂, Noachabeb farm, 6 February 1973, B. Lamoral (N.M. 10541), 1♂, 2 ♀, Seven Pan, 29 April 1970, B. Lamoral (N.M. 10615); 2 subadult ♂, Kameelsleep, 3 May 1970, B. Lamoral (N.M. 10612); 1♀ Mata Mata, 21 March 1969, B. Lamoral (N.M. 10033); 1♀, Twee Rivieren, 18 November 1970 (N.M. 10605); 3♀, Nossob kamp, 29 April 1970, B. Lamoral (N.M. 10626); 1♂, Noachabeb 97, 7-12 January 1972 (S.M.N. 328); 1 ♂, Twee Rivieren, 1960-1970, Leriche family and staff (N.M. 10630); 3♀ Katima Molilo, October 1970, W.D. Haacke (T.M. 9973-T.M. 9975); 1 subadult, 2 juveniles

Twee Rivieren, 20 April 1970, B. Lamoral (N.M. 10633); 1♀ , Mata Mata, 27 April 1970, B. Lamoral (N.M. 10620); 3♂, 2 ♀, De Waal farm, 17-18 March 1969, B. Lamoral (N.M. 10041); 1♀ , 3♂, Mata Mata, 10 January 1972, Eastwood (N.M. 10356); 5♂, 1 subadult ♂, 4 ♀ , 4 subadult ♀ , 1 juvenile, Swartmodder farm, 25-26 February 1973, B. Lamoral (N.M. 10540); 1♂, 1♀ , Auob River, 5 April 1970, B. Lamoral (N.M. 10663); 2♀ , 2♂, Pollentswa River, 2 May 1970, B. Lamoral (N.M. 10634); 2♂, Kapako, 27 June 1969, P. Olivier (S.M.N. 210-S.M.N. 211); 1 juvenile ♂, 3 juvenile ♀ , Kapako, June 1969, P. van Niekerk (S.M.N. 151); 1♀ Epukiro Reserve, 28 September 1964, F.W. Botes (S.M.N. 84; 1♂, 1 subadult ♀, Katima Molilo, 24 Ocrober 1970, H.D. Brown (T.M. 10195-T.M. 10196).

Material from (iii)

1♂ Ganab, 27 January 1972, B. Lamoral (N.M. 10413); 3 subadult ♀ , 3 subadult ♂, 1♀ , Amihab Mountain, 27 January 1972, B. Lamoral (N.M. 10662); 1♀ , Bloedkoppie, 9 February 1972, B. Lamoral (N.M. 10539); 2♀ , 2 subadult ♀ . 2 subadult ♂, Vrede, 31 March 1976, B. Lamoral, L. Ferguson (N.M. 10829); 1♀, Ganab, 27 January 1972, B. Lamoral (N.M. 10638); 2 subadult ♀, 1 subadult ♂ , 1 juvenile ♂, Ombu, 6 April 1976, B. Lamoral, L. Ferguson (N.M. 10838); 1♂, 1♀ , Tinkas mountains. February 1972, B. Lamoral (N.M. 10682): 1 ♀, Erongo mountains, 6 April 1976, B.Lamoral, L. Ferguson (N.M. 10753); 1♀ , Brandberg, 5 August 1969, P. Buys (S.M.N. 97); 2 ♀, Bloedkoppie, 1-10 July 1970, P. Olivier (S.M.N. 211); 1 juvenile ♂, Bloedkoppie, 9 January 1972, B. Lamoral (N.M. 10665); 3♀ , 1 subadult ♀ , 2 subadult ♂ Makalani, 27 February 1969, B. Lamoral, R. Day (N.M. 1112).

Distribution

As in fig. 4.79, for South West Africa. *O. wahlbergi* has also been recorded from southern Angola, western and northern Botswana, western Rhodesia, south western Zambia and the northern regions of the Cape Province in South Africa.

Bionomics

The burrowing activities and soil predilections of *O. wahlbergi* are treated extensively under the section on soils in chapter 2. Burrow entrances are usually situated in open ground and only very rarely at the sides of rocks or dead vegetation on consolidated sand. *O. wahlbergi* is nocturnal and hemiedaphic.

Opisthophthalmus werneri Lamoral, 1975. DUBIOUS SPECIES

Opisthophthalmus pilosus Werner, 1936: 187-189
Opisthophthalmus werneri Lamoral, 1975: 563.

Werner's type material of this species was in the Zoologische Museum Hamburg but was destroyed in an air disaster while on its way on loan to the Natal Museum for study. The type series consisted of either 2 ♀ syntypes or 1 ♀ and 1♂ syntypes. The uncertainty regarding the sexes of the types stems from Werner's ambiguous original description in which he listed 2 ♀ for material examined but proceeded to describe a ♀ and ♂.

The following aspects are difficult to reconcile with Werner's original description of this species:

- Werner states that his species does not have a forked suture anteriorly but cites O. peringueyi, which has a distinct fork anteriorly, as the most closely related species.
- None of the species treated in this study fit Werner's description. This could indicate that O. werneri is in fact a valid species which may turn out to be related to either O. adustus or O. flavescens, depending on the presence or absence of a medial suture on the carapace.

For the above reasons, it is advisable at this stage to maintain the present status of this species on the assumption that material conspecific with Werner's species may yet be collected.
Werner's original description was in German. A complete translation thereof follows.

O. pilosus n. sp. (Fig. 5, page 188).

♀ South West Africa, Ludertiz Bay, 30-40 km in surrounding dunes, Eberlans leg. ded. Eing. No. 44, 1929.

♀ German South West Africa. Prof. Dr Griess leg. Eing. No. 18, 1926.
Among the numerous specimens of O. carinatus which Prof. Griess had collected, was also a single not fully-grown ♀ of a species which appears closely related to O. peringueyi. Thereto belongs in all probability the abovementioned fully-grown ♂, which I initially regarded as a separate species, but had to regard as belonging together after comparing descriptions and finally the animals themselves.
Pectinal teeth 23-21 (♂) 21-21 (♀). ♂ colour red-brown. Hand yellow-brown, finger, outer and inner rim and finger keel black, legs and telson vesicle

yellow. Carapace: in front deeply incised, without an actual fork; interocular area in the front portion clearly falling off obliquely downwards, very finely and sparsely granular, coarsely granular on the sides, anterior margin coarsely granular, similarly also inwards from the side eyes. Middle eye closer to posterior margin of carapace than the anterior one. Median furrow deeply encompassed by indistinct granules. Supraciliar ridge smooth - abdominal tergites matt with median keel, last tergal plate distinctly granular; all sternites completely smooth. Dorsal keel of the cauda all granular, 2nd to 4th segment with a very distinct distal spine, while all upper lateral keels are granular. Lower lateral keel smooth, blunt in 1st-3rd segment, with the 1st hardly distinguishable; on the 4th and 5th segments of the keels are distinctly serrated, on the 5th there is an irregular row of grains between the lower median and lateral keels. Dorsal surface of the cauda with scattered granules.

Dimension of 1st caudal segment ♂ 7 x 6, ♀ 4 x 4 mm
Dimension of 5th caudal segment ♂ 15 x 5, ♀ 9 x 3 mm

Pedipalp hand with very flat tubercules on the inner area, coarsely granular on the outer; finger keel proximally granular, distally costate. Outer secondary keel granular, outer marginal keel granular, inner marginal keel fairly sharp-edged, set with sharp granules, inner secondary keel indistinct. Both pedipalp fingers with strong teeth on the inner edge. Surface of femur and posterior surface of tibia coarsely granular as well as all its keels - Telson vesicle with rows of granules. Pedipalps, telson vesicle as well as other limbs covered with long fairly dense hairs.

The ♀ is distinguishable from the ♂ by the uniform red-brown colouring, the smooth finely pitted, abdominal tergite, a hand with a completely coarsely granular upper surface, the shorter pedipalp chela fingers with weaker inner teeth and entirely granular fingerkeel - The spines on the outer ventral and inner ventral surface of tarsi of the 4th legs in both sexes, protarsi without spines but with long bristles.

Dimensions:

	♂	♀
Total length	100 mm	84 mm
Trunk	40 mm	50 mm
Hand length	24 mm	18 mm
Movable fingers	15 mm	10 mm
Hand width	11 mm	9 mm

CHAPTER 5

DISCUSSION AND CONCLUSIONS

1. PHYLOGENY

TERMINOLOGY, METHOD AND LIMITATION

Terminology.

Since the publication of Hennig's "Phylogenetic Systematics" in 1966, much has been written on this new contribution to systematic theory, which has become more widely known as cladistics. The number of papers discussing cladistic theory in the journal Systematic Zoology alone, since 1967, attests to the increasing number of elaborations contributed to the field and illustrate a concomitant expansion in terminology. The terminology used here broadly follows either that used by Brothers (1975 and 1978) and Ashlock & Brothers (Ms.) or that of Platnick (1976 to 1977).

Methods.

Cladistic analyses leading to cladistic dendrograms or cladograms, can be constructed either by electronic computers or by hand. Ideally one should use both methods and compare the results.

Owing to limitations inherent in the present study, which are discussed further on, it was judged unnecessary and impractical, at this stage, to attempt the construction of computer cladograms and instead, to limit myself to the hand method. While the principles involved in hand methods of cladistic analysis have been published (Hennig, 1966 and Brundin, 1966 and 1968 etc.), details of the process have been only cursorily treated. Ashlock & Brothers (Ms. and pers. com.) have expounded a detailed procedure intended as a comprehensive statement for workers wishing to develop a phylogenetic classification. Most of their basic procedures are implemented withing the limitations of the present work.

The initial step in a cladistic analysis consists in the determination of primitive-derived sequences of character states. The derived states proposed will be used to identify synapomorphies. The data are thus arranged into transformation series of homologous character states and as pointed out by Platnick (1977: 380) "the polarity of these transformation series is determined by out-group comparison, and shared innovations are used to construct internested series of three-taxon statements that operate at a level of generality above that of specific ancestor-descendant hypotheses."

Early cladistic literature is deficient in good methods for determining primitive-derived character sequences. It has recently been pointed out by several authors that the most useful method for determining dervied states is that known as outgroup comparison, which is particularly reliable when one is in search of within-group rarity or unique derived character states essential in the recognition of holophyletic (sensu Brothers 1978) or monophyletic (sensu Nelson, 1973) groups.

In addition to the above, the following criteria of directional change in character states were considered in this analysis:

(1) Relative abundance - it is assumed that a character state widely distributed in an ancestral group is primitive for descendant groups and, conversely, any other state of the same character which is rare in the ancestral group is a derived state.

(2) Correlation of derived states - character states occurring in a single taxon are considered derived if their presence is highly positively correlated with derived states of other characters. Such concordance of derived states could, in some cases, possibly be a pleiotropy, a kind of obligatory correlation that should be discarded if it can be recognised.

(3) Structural complexity - this is applied to either qualitative or quantitative characters. It is assumed that the more complex state is derived. One should bear in mind here the possibility of secondary adaptive regression to an apparent "primitive state", which in fact represents a derived state.

(4) Morphological specialisation - it is inferred that a state is derived if it is predominant in some adaptive specialisation. While, in a given large group, several morphological structures may be found performing the same function, it is assumed, however, that within a homogenous group, a specialised function is usually performed with the same structure, and that a state exhibited by such a structure was

selected from more generalised states in the ancestral pool.

(5) Ecological specialisation - this is an extension of adaptive specialisation. This concept can be particularly useful when a structural function is not obvious. Thus a state is considered to be derived when it is relatively more predominant in species with a particular ecological requirement than in other species. The comb-like rows of setae on the posterior and anterior margins of legs I and II in psammophilous scorpions are an example of such a derived state.

(6) Geographic restriction - a character state with a high degree of frequency in a particular geographic area is assumed to be derived.

(7) Closely affiliated taxa - a character state is deemed derived if it predominates only in a limited morphologically homogenous assemblage of taxa.

(8) Correlation of applied criteria - a character state is assumed to be more probably derived or primitive when two or more of the above criteria are congruous in showing phyletic direction. If a state is rare, adaptive and only present in a restrictive geographical region for instance, then it is more probable that this state is derived than if fewer of the criteria were applicable.

Most of the above criteria follow those used by Marx & Raub (1970). A large proportion of the characters studied are qualitative. These characters have states that differ in shape or form, in presence or absence of a feature, in position etc. . Quantitative characters used include proportional and meristic ones. Meristic and proportional characters are treated as continuous variables but are broken into sequential classes. Qualitative and quantitative characters were each allocated character numbers and entered in tables, such as tables 5.1 or 4.2. Each state (or each sequential class) for a particular character was allocated a secondary number. States applicable to each species are then identifiable through these secondary numbers entered in the relevant species columns. Thus each character state is coded by a double number which identifies the character and the state. The coded characters listed in tables are then discussed for each genus in the text, and either primitive or derived status is allocated to each state, wherever possible. The double number codes are also used in the cladograms where they are associated with either shaded blocks to indicate a derived state or an open block for a primitive state.

Limitations.

The following considerations apply to the seven genera revised: two, Karasbergia (one species) and Lisposoma (two species) are endemic to South West Africa; another two, Buthotus (two species in South West Africa) and Hadogenes (three species in South West Africa), are predominantly extralimitrophe; one, Uroplectes, is well represented in South West Africa as well as in the rest of the Afrotropical Region and in most of the Oriental Region; the last two, Parabuthus and Opisthophthalmus, have almost half of their species endemic to the South West Africa region.

Ideally, a cladogram constructed for the species of a genus should incorporate all the species described within that genus. While generic and infra-generic affiliations are analysed and discussed to the best of available data, the conclusions reached and the cladograms constructed for four of the genera (Buthotus, Parabuthus, Uroplectes and Opisthophthalmus) suffer from one or more of the following limitations.

1. The character states for extralimitrophe species could only be obtained from existing literature and no material was available for the investigation of additional character states. These restrictions apply to Buthotus and to a much lesser extent, Uroplectes.
2. Specimens of species occurring outside South West Africa were studied but the taxonomic status of at least one third of these species was found to be either dubious or at least in need of revision. The character states of such species were used for comparative purposes in the determination of primitive-derived sequences of states in South West African species but the extralimitrophe species were not included in cladograms. These limitations affect Parabuthus, Uroplectes and Opisthophthalmus.

As a result of these constraints, the cladograms constructed reflect only degrees of relationship (namely closest relatives) while branching sequences are inferred ones, for the species of four genera of scorpions occurring in the South West Africa region.

The genus Hadogenes is represented by three species in South West Africa and although the genus is endemic to southern Africa, no cladistic analysis was attempted as the taxonomy of the 24 species described from outside South West Africa is chaotic.

A revision of the non-South West Africa components of the above four genera is in preparation. When completed, it will be published with comprehensive cladograms constructed by computer and hand analysis.

PHYLOGENY OF THE TAXA REVISED

Genus BUTHOTUS (Buthidae)

Twenty one species of Buthotus have been described to date (Vachon & Stockmann,1968: 91-92), 10 of which occur outside Africa from Arabia to India and 11 in Africa. Of the 11 African species, aeratus is a synonym of conspersus (present revision), emini is most probably a synonym of trilineatus, and fuscitruncus is a species of uncertain validity according to Vachon & Stockmann (1968: 110). The relationships of the remaining eight species and the inferred phylogeny of the African group are shown on the cladogram in fig. 5.1 , which was prepared using character states listed in table 5.1.

This cladogram was prepared on the assumption that the African species represent a group distinct from that of the other species of the genus distributed in the Oriental Region, as indicated in Vachon & Stockmann (1968).

States of the characters considered:

1. Cauda V, ventro-lateral keels. On the basis of outgroup comparison, distal convergence (1.1) is the primitive state and divergence (1.2) the derived state.

2. Sexual dimorphism. Based on the criteria of outgroup comparison and structural complexity, little or no dimorphism (2.1) represents the primitive state and distinct dimorphism (2.2) the derived state.

3. Cauda V, area bounded by dorso- and ventro - lateral keels. The most common state (using in-group comparison) is a sub-oval outline (3.1) and is therefore considered primitive while a subrectangular outline 3.2 is derived. The presence of the derived state in both arenaceus and polystictus is ascribed to parallelism.

4. Pedipalp femur macrosetae. Few setae (4.1) are considered to be the primitive state by virtue of the structural complexity (in a quantitative direction) and relative abundance criteria and numerous macrosetae (4.2) the derived state.

5. Cauda IV, V and telson colour. Yellow (5.1) is the primitive state and black (5.2) the derived state on the basis of outgroup comparison and relative abundance.

6. Pedipalp femur dorsal surface. Based on the criterion of structural complexity, a smooth surface (6.1) is considered primitive and a granular one (6.2) derived.

7. Cauda IV, median lateral keel. Absence thereof (7.1) is considered primitive and distinct presence (7.2) derived on the basis of structural complexity and in-group comparison.

8. Tergites II-VI, median lateral keels. The unforked state (8.1) is primitive and forked state (8.2) derived on the basis of structural complexity and in-group comparison.

9. Cauda IV, dorso-lateral keel. Based on the criterion of structural complexity, a granular keel (9.1) is considered more primitive than a costate granular (9.2) keel. The presence of the derived state in both conspersus and polystictus is ascribed to parallelism.

10. Cauda V, median lateral keel. Same reasoning as for character 7 above.

11. Carapace, tergites, cauda I-III colour. Same reasoning as for character 5 above.

The following deductions on the phylogeny of the African group of species of Buthotus are propounded.

(1) The species shown in fig. 5.1 represent three main cladistic groups of species, namely (i) the "conspersus" group, composed of arenaceus and conspersus; (ii) the "hottentota" group, composed of polystictus trilineatus, minax and hottentota; (iii) the "scaber" group, composed of scaber and franzwerneri.

(2) The conspersus group is a sister group of the hottentota group while both form a large sister group of the scaber group.

(3) Superimposition of the cladogram shown in fig. 5.1 on the known distribution of the African species of Buthotus in fig. 5.2 indicates a correlation of the inferred branching sequences in the cladogram with the present distribution of the species, as well as with the three groups of species. Such congruence further substantiates the proposed phylogeny. Reservations attached to

the interpretation of this type of congruence are discussed under the biogeography of Buthotus in this chapter.

Genus KARASBERGIA (Buthidae)

Karasbergia is clearly distinguishable from any other genera or groups of genera on the combination of characters listed in its generic diagnosis in chapter 4. Of the characters defined in this diagnosis, a few are shared individually but never in the same combination, by a few of the 43 buthid genera described to date.

These are:

1. a subpentagonal sternum which is found also in the following six small genera: Butheoloides Hirst, 1925 (2 species from Morocco and Mali Republic in North Africa), Orthochirus Karsch, 1891 (4 species from North and North East Africa, Arabian Deserts, Iran and India), Microtityus Kjellesvig-Waering, 1966 (2 species from Trinidad and Venezuela in South America), Charmus Karsh, 1879 (India), Anaplobuthus Caporiacco, 1932 (one species of doubtful status from Morocco), Akentrobuthus Lamoral, 1976 (one humicolous species endemic to the primary forests of eastern Zaire); the presence of a subpentagonal sternum in these genera is a character state they share with taxa of the family Chactidae;
2. absence of ꝺ d_2 on the pedipalp femur which also occurs in the following two small genera: Lissothus Vachon, 1948 (monotypic, from Algeria) and Microbuthus Kraepelin, 1898 (three species from Mauritania Republic, Ethiopia and southern Yemen);
3. predominant presence of only two lateral eyes on either side of the carapace, otherwise found only in the monotypic genus Akentrobuthus Lamoral, 1976.
4. absence of small teeth on the proximal ventral side of the chelicera fixed finger which occurs only in the genus Uroplectes Peters, 1861, (many species in the Afrotropical and Oriental regions) and Lissothu Vachon, 1948 (monotypic from Algeria).

Character states 1 and 4 are primitive for scorpions of the family Buthidae on the basis of outgroup comparison for 1 and structural complexity for 4. Their presence as well as that of other primitive characters in *Karasbergia*, while indicating a primitive origin, contains no phylogenetic information.

While it is possible to propose a sister-group for *Karasbergia* in one instance on the basis of a synapomorphy such as for example the absence of ȯ d_2 on the pedipalp femur as in genera *Lissothus* and *Microbuthus*, possession of other synapomorphies such as punctations on lateral and ventral surfaces of cauda IV-V, as in *Orthochirus* and *Microbuthus* and predominant presence of only two lateral eyes on either side of the carapace found only in *Akentrobuthus*, indicate possible affinities with different sister groups and therefore a different lineage. If anything, the contradictory nature of the similarities between *Karasbergia* and the various genera studied tend to lead one to suspect character convergen at this stage of investigations, and a cladistic reappraisal of all the small genera within the family Buthidae is thus clearly called for.

As contended by Platnick (1976: 198-199) the retention or erection of monotypic genera is incompatible with a cladistic approach since any extant species should have at least one extant or extinct sister species within each genus. It is suggested here that either a new species of *Karasbergia* will be found, as has happened in the case of *Lisposoma*, or that *K. methueni*'s sister species has become extinct.

Genus PARABUTHUS (Buthidae)

Prior to this revision, 10 species of *Parabuthus* had been described from South West Africa, one of these (*granulatus*) was represented by four subspecies and another (*laevifrons*) by five subspecies. The fauna thus comprised 17 described infrageneric taxa and these are treated as follows in chapter 4: seven are synonymised and 10 are retained as valid species with no subspecies, while three new species are described. A new species, *P. kalaharicus* Lamoral 1977, was recently added to the fauna. As a result of this 14 species are now recognised from South West Africa and these are listed in table 5.2.

The relationships and inferred phylogeny of the 14 South West African species are shown on the cladogram in fig. 5.3., which was derived by using character states listed in table 5.2.

States of the characters used.

1. Cauda IV, ventral and lateral keels. Based on the criterion of outgroup comparison, presence of keels (1.1) is considered the primitive state and absence (1.2) derived.

2. Adult general size. Small (2.1) is considered primitive and large (2.2) derived on the basis of outgroup comparison within the family Buthidae.

3. Sexual dimorphism in shape of proximal middle lamella of pectines in adults. Virtually absent (3.1) is the primitive state and present and distinct (3.2) the derived one by virtue of the outgroup comparison and structural complexity criteria.

4. Cauda IV, median lateral keel. Present and well developed (4.3) is considered primitive, while, sequentially, present but poorly developed (4.2) is derived and absent to posteriorly obsolete (4.1) represents an even more derived state than the previous two states by virtue of the outgroup comparison criterion.

5. Telson vesicle. A reduced vesicle (5.1) is considered derived while a non-reduced one (5.2) primitive on the basis of outgroup comparison within the family Buthidae.

6. Cauda V, accessory dorsal crest in adult ♂.
On the criterion of outgroup comparison, absence (6.1) is considered primitive, present but poorly developed (6.2) derived and present but well developed and spiniform (6.3) sequentially even more derived.

7. Cauda II, dorsal stridulatory area. Not reaching posterior margin (7.1) is considered primitive and reaching posterior margin (7.2) derived on the basis of structural complexity as well as outgroup comparison.

8. Caudal segments width. Cauda I wider than IV (8.1) is deemed to be primitive and cauda I narrower than IV (8.2) derived, on the basis of within-group rarity.

9. Cauda I-V and telson. Sparsely pilose (9.1) is considered primitive and densely pilose (9.2) derived on the criteria of within group rarity and structural complexity.

10. Pedipalp tibia ♂ esb$_2$. Level with or slightly distal to esb$_1$ (10.1) surmised derived and distinctly distal to esb$_1$ (10.2) primitive on the basis of ingroup rarity.

11. Cauda IV-V, lateral intercarinal surfaces. On the basis of outgroup comparison and structural complexity, smooth (11.1) is considered primitive and granular (11.2) derived.

12. Sternites. On the basis of within group rarity, smooth (12.1) is considered primitive and punctate (12.2) derived.

13. Pedipalp femur, ♂e$_1$. Almost halfway between ♂d$_4$ and d$_5$ (13.1) is considered derived and level with or distal to ♂ d$_5$ (13.2) primitive on the basis of within group rarity.

14. Cauda V, distal half of ventro-lateral keels. With lobate processes (14.1) is surmised derived and with spinose processes (14.2) primitive on the basis of structural complexity as well as within group rarity.

15. Pedipalp hand movable finger length of ♀. Short (15.1) is considered derived and long (15.2) primitive on the basis outgroup comparison.

16. Tergites I-VI, median keels. On the criteria of outgroup comparison and within group rarity, present (16.1) is surmised to be primitive and absent (16.2) derived.

17. Cauda V, ventro-lateral keels. On the basis of outgroup comparison, ecological specialisation and correlation of applied criteria, keels sub-parallel to each other (17.3) represent the primitive state while distally divergent keels (17.2) and distally convergent ones (17.1) are opposite derived states.

18. Telson vesicle dorso-proximal surface. On the basis of within group rarity, a deep longitudinal excavation (18.1) is considered derived and a very shallow excavation (18.2) primitive.

19. *Legs IV length.* On the criteria of outgroup comparison and ecological specialisation (i.e. sandy habitat), very long (19.1) is considered derived and moderately long (19.2) primitive.

On the basis of available information, the following comments are offered on the phylogeny of the South West African species of *Parabuthus*.

(1) The 14 species shown in fig. 5.3 represent three main cladistic groups of species, namely: (i) the "*brevimanus*" group, composed of *brevimanus*, *kuanyamarum*, *new sp. A* and *new species C*; (ii) the "*granulatus*" group, composed of *granulatus* and *kalaharicus*; (iii the "*villosus*" group composed of the remaining eight species.

(2) The *granulatus* group is a sister group of the *villosus* group while both of these form a large sister group to the *brevimanus* group

(3) The cladogram for the *villosus* group indicates a division into two subgroups namely the *raudus* (*villosus*, *brachystylus*, *raudus* and *schlecteri*) and *laevifrons* (*stridulus*, *laevifrons*, *kraepelini* and *new species B*) subgroups. While synapomorphy 6.3 in fig. 5.3 unite the species within the *raudus* subgroup, no synapomorphy could be found uniting the species within the *laevifrons* subgroup which is indicated with a broken line. One could venture to say that character state 7.2 in table 5.2 represents a synapomorphy uniting the species of the *laevifrons* subgroup and that the occurrence of 7.2. in *brachystylus* as well as in the species of the *brevimanus* group is due to convergence. While this may well be the case, no data are currently available to justify such deduction. A revision of the 25 described extralimitrophe infrageneric taxa of *Parabuthus*, distributed in the rest of the Afrotropical faunal region right up to Saudi Arabia, will almost certainly shed new light on various unresolved aspects of the phylogeny of the genus.

(4) The relatively low number of characters available (19 compared with 70 for *Opisthophthalmus*) for the construction of the cladogram in fig. 5.2 and the inconsistent quality of data available for extralimitrophe species of *Parabuthus* make it impossible at this stage to suggest which group is potentially more advanced than any other one. See phylogenetic deduction (3) under the genus *Opisthophthalmus* for the interpretation of the word "advanced" in the present context

Genus UROPLECTES (Buthidae)

At the beginning of this revision, six species of *Uroplectes* had been described from South West Africa. One of these was represented by four subspecies. The fauna thus comprised nine infrageneric taxa and these are treated as follows in chapter 4: one is synomymised and eight are retained as valid species with no subspecies while one new species is described. One species, *U. vittatus* (Thorell, 1877) known from Botswana, is added to the fauna of South West Africa. As a result of this 10 species are now listed for South West Africa and these are represented in table 5.3

The relationships and inferred phylogeny of the 10 South West African species are shown on the cladogram in fig. 5.4., derived by using character states listed in table 5.3.

States of the characters used.

1. *Pedipalp femur, ♂ d_2*. On the basis of outgroup comparison, on proximo-dorsal side of dorso-internal keel (1.1) is the primitive state and on proximo-internal side of dorso-internal keel (1.2) the derived one.
2. *Pecten, first proximal tooth in ♀*. Wider but not longer than adjacent teeth (2.1) is considered to be the primitive state while falciform and much longer than adjacent teeth (2.2) is derived using the criterion of within group rarity.
3. *Tergites I-VI, lateral keels*. Present (3.1) is deemed primitive while absent (3.2) is derived on the basis of outgroup comparison.
4. *Cauda II-V, ventro-lateral keels*. Present (4.1) is surmised primitive and absent (4.2) derived on the basis of outgroup comparison.
5. *Pedipalp hand, ♂ eb*. Distinctly proximal to inner base of fixed finger (5.1) is viewed as primitive and level with or distal to inner base of fixed finger (5.2) as derived on the criterion of outgroup comparison.
6. *Pedipalp chela fingers*. Long (6.2) represents the primitive state while short (6.1) and extremely long (6.3) are opposite derived states on the basis of outgroup comparison.
7. *Cauda II-IV, dorsal and dorso-lateral keels*. On the basis of outgroup comparison and ecological specialisation well developed and distinct (7.1) is surmised primitive and poorly developed (7.2) derived.

8. *Cauda I-V.* Sparsely pilose (8.1) is viewed as primitive and densely pilose (8.2) derived on the basis of outgroup comparison and within group rarity.
9. *Pedipalp handback inner surface.* On the criteria of outgroup compariso as well as within group rarity, sublinear to slightly procurved (9.1) is considered as primitive and distinctly procurved to bulbous (9.2) derived.
10. *Cauda IV, ventral keels.* Obsolete (10.1) is surmised derived and costate or granular (10.2) primitive on the basis of outgroup comparison and correlation of applied criteria.
11. *Cauda V, ventro-median keel.* Present and distinct (11.1) is considered primitive and absent or indistinct (11.2) derived on the basis of outgroup comparison and correlation of applied criteria.
12. *Pedipalp hand.* On the criterion of outgroup comparison, almost apilose (12.1) is viewed as primitive and distinctly pilose (12.2) derived.
13. *Telson vesicle subaculear tooth.* On the basis of outgroup comparison and within-group rarity, present (13.1) is deemed derived and absent (13.2) primitive.
14. *Cauda II, ventro-lateral keels.* On the basis outgroup comparison, ecological specialisation and correlation of applied criteria, granular (14.1) represents the primitive state while costate granular (14.2) and obsolete (14.3) are opposite derived states.
15. *Cauda length.* Short (15.1) is considered derived and long (15.2) primitive on the basis of outgroup comparison and within-group rarity.

The following comments are possible for the phylogeny of the South West African species of *Uroplectes*.

(1) The 10 species listed in fig. 5.4 represent four main phylogenetic groups of species, namely: (i) the "*planimanus*" group consisting of *teretipes*, *new species A* and *planimanus*; (ii) the "*vittatus*" group composed of *vittatus* and *otjimbinguensis*; (iii) the "*pilosus*" group comprising *pilosus*, *longimanus*, *schlecteri* and *gracilior*; (iv) the "*carinatus*" group represented by only one species in South West Africa, namely *carinatus*, whose sister species *variegatus* (C.L. Koch, 1845) is distributed in the southwestern regions of the

Cape Province in South Africa.

(2) The carinatus group is a sister group of the pilosus group and both are sister groups of the vittatus group of which all three form a large sister group of the planimanus group.

(3) The relatively low number of useful characters available (15 instead of 70 for Opisthophthalmus) for the erection of the cladogram in fig. 5.4 and incomplete sets of data for extralimitrophe species of Uroplectes impair possible advanced or primitive status allocations to any of the four groups of species at this stage. One could tentatively suggest that since the planimanus group is the only completely endemic one in South West Africa, it is the most advanced group on the mootable precept that its geographic restriction is the product of the most recent vicariance in terms of historical biogeography.

Genus HADOGENES (Scorpionidae)

Five species of Hadogenes have so far been described from South West Africa. These are treated as following in this revision: one has been synonymised and another retained as dubious. Consequently three species are now recognised as valid for South West Africa.

No phylogenetic appraisal is possible as this stage as the South West Africa species represent only a minor group in comparison to the 24 species described from outside South West Africa, the taxonomy of which is chaotic.

The genus Hadogenes is endemic to southern Africa and appears to be most closely related to the genus Heteroscorpion Birula, 1903. The genus Iomachus Pocock, 1893, is probably congeneric with Hadogenes.

Genus LISPOSOMA (Scorpionidae)

Formerly a monotypic genus, it now comprises two species following the description of a new species in this revision.

Attempts to derive possible affinities for Lisposoma with extant genera of either the Scorpionidae or other families have yielded similar results to those outlined for the phylogeny of *Karasbergia*. Particular attention was paid to a comparison of character states with various genera of the family Bothriuridae, but the results obtained so far are inconclusive and work on this aspect is still in progress.

Genus OPISTHOPHTHALMUS (Scorpionidae)

At the outset of this revision, 24 species of *Opisthophthalmus* had been described from South West Africa. even of these were represented by two subspecies each and one by three subspecies. Hence, the fauna consisted of 33 described infrageneric taxa and these are treated as follows in chapter 4: 13 are synonymised; one, *O. werneri*, is retained as dubious; 19 are retained as valid species with no subspecies, while five new species are described. Consequently, 24 species are now recognised from South West Africa and these are listed in table 4.2.

The relationships and inferred phylogeny of the 24 South West African species are shown on the cladogram in fig. 5.5, which was constructed by using character states listed in table 4.2.

States of the characters considered.

Of the 70 characters listed in table 4.2, 50 were found to be the most useful in the construction of the cladogram shown in fig. 5.5. The significance of the derived states in these 50 characters was found to vary from one instance to another and all derived states are thus usually not equally useful.

The proposed primitive-derived sequences for the states of the 50 characters used in the cladogram are as follows.

1. *Carapace anterior median suture*. On the basis of outgroup comparison, presence thereof (1.1) is the derived state and absence (1.2) the primitive one. An anterior median suture is absent in all genera of the family Buthidae and in virtually all other families, except for most genera of the Afrotropical Scorpionidae.
2. *Median eye position*. Based on the criteria of outgroup and ingroup comparison and closely affiliated taxa, medial to postero-medial (2.2)

eyes represent the primitive state while distinctly anterior or anterior-medial (2.1) and distinctly posterior (2.3) are opposites of differently derived states.

3. Carapace interocular surface. A granular (3.1) surface is considered to be the derived state and a smooth (3.2) the primitive state by outgroup comparison within the family Scorpionidae.

6. Carapace superciliary crests. A well developed crest (6.2) is considered to be the derived state and a shallow one (6.1) the primitive state by virtue of the relative abundance criterion.

7. Median eyes size. Large eyes (7.2) are the derived state and small ones (7.1) the primitive state when applying the relative abundance criterion.

8. Median eyes, distance apart. Equal to or less than eye diameter (8.2) is the derived state and greater than eye diameter (8.1) the primitive one by virtue of the relative abundance criterion.

9. Pedipalp chela lmf/lhb ♂. A ratio higher than 1,61 (9.3) is considered to be the derived state while one within a range of 1,41-1,60 (9.2) is the primitive one by virtue of outgroup comparison.

10. Pedipalp chela lmf/lhb ♀. A ratio higher than 1,21 (10.3) is deemed to be the derived state while one lower than 1,20 (10.1) is the primitive state when applying the outgroup comparison criterion within the family Scorpionidae.

11. Pedipalp chela, upper surface handback. Based on the criteria of outgroup comparison and structural complexity a smooth surface (11.1) is considered primitive and a granular one (11.2) derived.

12. Pedipalp chela, finger keel. An indistinct keel (12.3) or absence thereof is considered the primitive state, while sequentially, a predominantly granular one (12.2) is derived and a predominantly costate state (12.1) represents an even more derived state than the previous two states by virtue of the outgroup comparison and structural complexity criteria.

13. Pedipalp chela, outer ventro-lateral keel. Predominantly costate (13.1) is surmised to be the derived state and predominantly granular (13.2) the primitive one on the premises of ingroup comparison and structural complexity.

14. *Pedipalp chela, δ est.* Proximal to or level with dst (14.1) is considered derived and distinctly distal to dst (14.2) primitive on the basis of limited occurrence in ingroup comparison.

15. *Pedipalp chela, distance δ est-esb.* *Circa* equal to esb-eb (15.1) is considered the primitive state and *circa* half of esb-eb (15.2) the derived state on the basis of ingroup comparison.

16. *Pedipalp chela, longitudinal position of δ V_3.* On the criterion of limited occurrence in ingroup comparison, distinctly medial (16.2) is considered derived and in proximal half (16.1) primitive.

17. *Pedipalp chela, ventral δ.* A total number of 14 (18.1) is primitive and more than 14 (18.2) is derived on the criterion of ingroup rarity.

19. *Pedipalp tibia ventral δ* A total of 3 δ (19.1) is primitive and more than 3 (19.2) is derived on the criterion of ingroup rarity.

20. *Pedipalp tibia, if only 3 v δ, δ v_2.* On the criterion of ingroup rarity, distinctly closer to v_1 (20.1) is considered primitive and medial or closer to v_3 than v_1 (20.2) derived.

21. *Pedipalp tibia, δ d_2.* On the basis of ingroup comparison, *circa* equidistant from d_1 and i (21.1) is considered primitive and distinctly closer to i than d_1 (21.2) derived.

22. *Pedipalp tibia, external intercarinal surfaces.* Granular (22.1) is surmised to be derived and virtually agranular (22.2) primitive on the basis of outgroup comparison and structural complexity criteria.

24. *Sternite VII in ♂.* Based on the criteria of outgroup comparison and structural complexity, smooth (24.1) is considered primitive, granular (24.2) derived, and with transverse ridges (24.3) sequentially even more derived.

27. *Cauda I, dorsal surface in ♀.* Smooth (27.1) is surmised primitive and granular (27.2) derived on the basis of outgroup comparison.

28. *Cauda I, dorsal keels.* Present and distinct (28.2) is considered primitive and absent to obsolete (28.1) derived on the basis of outgroup comparison.

36. *Cauda III, dorsal keels.* As for 28.

37. Cauda III, ventral keels. Based on the criteria of outgroup comparison and ecological specialisation, granular keels (37.4) are considered the primitive state and costate granular (37.3) followed by costate (37.2) sequentially derived (with 37.2 more derived than 37.3) while absent to obsolete (37.1) is also considered a derived state in a different direction.

39. Cauda III, lateral profile of ventral surface. Based on the criterion of ingroup rarity, noticeably convex (39.3) is surmised to be derived and sublinear (39.1) to shallowly convex (39.2), sequentially primitive.

40. Cauda III, ventral surface. Granular (40.2) and punctate (40.3) are considered opposite derived states and smooth (40.1) primitive on the basis of ingroup comparison.

43. Cauda IV, ventral keels. As for 37.

44. Cauda IV, ventro-lateral keels. As for 37.

46. Cauda IV, ventral surface in ♀. Smooth (46.1) is considered primitive and granular (46.2) derived on the basis of ingroup relative scarcity of the latter.

47. Cauda IV, lateral profile of ventral surface. Based on the criterion of ingroup rarity, noticeably convex or arcuate (47.3) is surmised to be derived and sublinear (47.1) to shallowly convex (47.2) sequentially primitive.

50. Cauda V, dorsal keels. Using the criteria of outgroup and ingroup comparisons a partially developed keel (50.2) is considered primitive while absent (50.1) and distinct along entire length (50.3) are opposite derived states.

51. Cauda V, ventral keel. On the basis of outgroup comparison and ecological specialisation, a single row of granules (51.2) represents the primitive state and absence (51.1) the derived state.

52. Cauda V, ventro-lateral keels. Granular keels (52.1) represent the primitive state and spiniform or denticulate ones (52.2) the derived state using outgroup comparison and ecological specialisation as criteria.

53. Cauda V, ventro-lateral keels. On the basis of outgroup comparison, ecological specialisation and correlation of applied criteria, keels

sub-parallel to each other (53.3) represent the primitive state while posteriorly convergent keels (53.1) and posteriorly divergent ones (53.2) are opposite derived states.

54. Cauda V, ventral intercarinal surface. A granular surface (54.2) is surmised to be primitive and a sparsely granular one (54.1) derived on the basis of ingroup low frequency for the latter.

56. Telson vesicle ventral surface. Using outgroup comparison, smooth (56.1) is surmised to be primitive and lightly to distinctly granular (56.2) derived.

57. Telson vesicle lateral surface. Based on the criterion of ingroup rarity, lightly to distinctly granular (57.2) is deemed derived and smooth (57.1) primitive.

58. Telson vesicle shape. Owing to a low ingroup frequency a globose vesicle (58.1) is surmised to be derived and an elongated one (5.2) primitive.

59. Leg protarsi I and II, posterior surface setation. On the basis of outgroup comparison and ecological specialisation, a row of 3-4 spine-like setae (59.1) represents the primitive state while a few stiff setae (59.2), many scattered setae (59.3) an a comb-like row of stiff setae (59.4) represent a progression of different derived states with the latter being the most derived one.

60. Leg tarsi III, ventral anterior row of spine-like setae. Absent (60.1) is surmised to be the derived state and present (60.2) the primitive one on the basis of ingroup low frequency for the former.

61. Leg tarsi III, ventral posterior row of spine-like setae. A reduced number of these setae [61.2 (1 to 4)] is considered derived and a large number [61.2 (5 to 7)] primitive using the criteria of ingroup comparison, ecological specialisation and correlation of applied criteria.

62. Leg tarsi IV, ventral anterior row of spine-like setae. As for 60.

64. Leg tarsi III and IV, ventral surface setation. On the basis of outgroup comparison and ecological specialisaton, no setae (64.1) represents the primitive state, while a few setae (64.2) and many setae (64.3) represent a progression of derived states.

65. Leg tarsi lateral claws shape. Short and distinctly curved (65.1) represents the primitive state while long and distally curved (65.2) and long and distally sublinear (65.3) represent a progression of derived states on the basis of outgroup comparison, ecological specialisation and correlation of applied criteria.

66. Leg tarsi I-II, lateral claws length within each pair. Using the criteria of outgroup comparison and ecological specialisation, equal (66.1) represents the primitive state and unequal (66.2) the derived state.

67. Leg tarsi III-IV, lateral claws length within each pair. As for 66.

68. Leg tarsi median dorsal lobe, length in relation to lateral lobes. Based on the criterion of ingroup relative scarcity equal or subequal (68.1) is surmised to be the derived state and distinctly shorte (68.2) primitive.

69. Carapace anterior suture furcation. On the basis of outgroup comparison, total absence thereof (69.3) represents the primitive state while bifurcate, short and obsolete to distinct (69.2) and trifurcate, long and distinct (69.1) represent a progression of derived states.

70. Cauda II, ventral surface ♂. On the basis of outgroup comparison, smooth (70.1) is considered primitive while granular (70.2) and with transverse ridges (70.3) on the one hand and punctate (70.4) on the other hand are considered opposite derived states.

The proposed primitive-derived sequences for the states of the 20 characters not used in the cladograms are as follows.

4. Carapace lateral surfaces and 5. Carapace postero-median surfaces. Granular surfaces (4.1 & 5.1) are considered primitive and smooth ones (4.2 and 5.2) derived, by virtue of the outgroup comparison criterion.

23. Tergites I-VI in ♂. Finely granular (23.2) is considered primitive because it is the most common condition when applying the ingroup comparison criterion while virtually smooth (23.1) and granular (23.3) are relatively rare states and therefore derived.

25. Sternite VII in ♀. As for 24 used in cladogram.

26. Cauda I, dorsal surface in ♂. As for 27 used in the cladogram.

29. Cauda I, ventral keels and 30. Cauda I, ventro-lateral keels. As for 37 used in the cladogram.

31. Cauda I, ventral surface in ♂ and 32. Cauda I, ventral surface in ♀. As for 24 used in the cladogram.

33. Cauda II, dorsal keels. As for 28 used in the cladogram.

34. Cauda II, ventral keels and 35. Cauda II, ventro-lateral keels. As for 37 used in the cladogram.

38. Cauda III, ventro-lateral keels. As for 37 used in the cladogram.

41. Cauda IV, dorsal keels. As for 28 used in the cladogram.

42. Cauda IV, dorsal keels distal spine. A slightly enlarged spine (42.2) is considered primitive on the basis of outgroup comparison while a non-enlarged (42.1) and a very distinctly enlarged and spiniform spine (42.3) are oppositely derived states.

45. Cauda IV, ventral surface in ♂. As for 46 used in the cladogram.

48. and 49. Cauda V, dorsal surface in ♂ and ♀. On the basis of outgroup and ingroup comparisons, smooth (48.1) is considered primitive and granular (48.2) derived.

55. Cauda V, lateral profile of ventral surface. Sublinear (55.3) is considered primitive because it is the most frequent condition when applying the ingroup comparison criterion while shallowly concave (55.1) and shallowly convex (55.2) occur less frequently and are therefore oppositely derived states.

63. Leg tarsi IV, ventral posterio row of spine-like setae. As for 61 used in the cladogram.

Taking into account the cladistic relationships shown in fig. 5.5, the primitive-derived sequences listed above for the states of the 70 characters entered in table 4.2, character states described in chapter 4 and the limited data available for extralimitrophe species, leads me to th following deductions on the phylogeny of the South West African species of Opisthophthalmus:

(1) The species shown in fig. 5.5. represent three main cladistic groups of species, namely: (1) the "*carinatus*" group, composed of *gigas*, *haackei*, *brevicauda*, *carinatus*, *ugabensis*, *litoralis* and *cavimanus*; (ii) the "*opinatus*" group, composed of *opinatus*, *new species A*, *new species B*, *intercedens*, *fitzsimonsi*, *new species C*, *schultzei*, *adustus* and *setifrons*; (iii) the "*wahlbergi*" group composed of *wahlbergi*, *chrysites*, *new species D*, *flavescens*, *new species E*, *concinnus*, *holmi* and *jenseni*.

(2) The *carinatus* group is a sister group of the *opinatus* group while both of these form a large sister group to the *wahlbergi* group.

(3) On the assumption that taxa or groups of taxa with relatively few characters in derived states can be referred to as primitive and conversely those with a high proportion of derived states, as advanced, the *wahlbergi* group is the most advanced of the three groups as the species it is comprised of bear the highest proportion of derived character states. This view is reinforced by geological and biogeographic considerations (see discussion on biogeography) which indicate that the sand systems of South West Africa are less old than other geological formations and that consequently psammophile taxa, such as all the species within the *wahlbergi* group, are almost certainly less primitive than non-psammophile taxa. Application of these criter to species within the *wahlbergi* group suggests that the *new specie D* - *flavescens* and *holmi-jenseni* sister species are more advanced than their respective sister groups on the cladogram in fig. 5.5. In addition the *holmi-jenseni* sister species are the most advanced of all because, in the distinctly tapered and fusiform distal crest of the distal lamina of their hemispermatophores, these species bear a character state uniquely derived in the genus *Opisthophthalmus*. It was felt at some stage that such uniqueness provided sufficient distinctness to retain *holmi* & *jenseni* within Lawrence's (1969: 105) genus *Protophthalmus*. The existence

several synapomorphies between the *holmi-jenseni* sister species and other species within the *wahlbergi* group has prompted me not to reinstate the genus *Protophthalmus* as anticipated previously (Lamoral, 1973: 569). The *wahlbergi* group is endemic to the South West Africa region and there are no extralimitrophe species that fall within this group.

(4) On the criterion of relative occurrence of derived character states outlined in (3), the *carinatus* group is more advanced than the *opinatus* group. As both groups include insufficiently revised extralimitrophe species not represented in the cladogram in fig. 5.5, it is not possible at this stage to comment further than to indicate relationships of species within these two groups. It is, however, possible to infer that species with (more than +1) neobothriotaxy of the external and ventral surfaces of the pedipalp tibia are more advanced than those with the usual number of 6 for the genus. This applies to *haackei*, *brevicauda* and *ugabensis* within the *carinatus* group. None of the species within the *opinatus* group have evolved such neobothriotaxy.

(5) *O. adustus* (*opinatus* group) and *litoralis* (*carinatus* group) are the only species within their respective groups that have adapted to a psammophile way of life.

(6) A marked reduction in the number of pectinal teeth almost certainly represents a derived character state on the basis of the outgroup comparison criterion. While representing useful diagnostic information such reduction does not provide much phylogenetic information as it is subject to parallelism within the *opinatus* and *wahlbergi* groups.

2. PALAEOGEOGRAPHY AND PALAEOCLIMATOLOGY OF SOUTHERN AFRICA

This section briefly outlines the main past environmental factors that might have affected dispersal or vicariance in an assessment of the biogeography of the South West African scorpions. The information supplied was obtained mainly from the following sources of reference: Haughton (1963), Schwartzbach (1963), Cracraft (1973), van Zinderen Bakker (1975 & 1976) and Tankard and Rogers (Ms.).

Although fossil scorpions are comparatively very rare and known only from the northern Hemisphere, representatives of the group are known from most geological systems from the Silurian to Recent. In a major revision in preparation, Erik Kjelleswig-Waering (pers. comm.) has divided fossil scorpions into two suborders, namely the Branchioscorpions and Pulmonates. The Branchioscorpions consisted of two kinds, the Lobosterns with bilobed sternal plates and the Holosterns with undivided sternal plates. The Branchioscorpions had gills and lived in water; they occur in fossil deposits dating from the Silurian to middle Jurassic and it is therefore suspected that they dominated the entire Paleozoic era and died with the end of the Cretaceous period and Mesozoic era. The pulmonates (Neosterns) are known from as far back as Middle Carboniferous and all have small rounded stigmata. These probably left the water in about the Upper Devonian period, concurrently with the Amphibians.

No fossil scorpions have as yet been recorded from the southern Hemisphere. The discovery of such material is probably only a matter of time and as commented on by Kjelleswig-Waering (lit. comm.), "For every pair of eyes looking for fossils in the southern Hemisphere, you will find several thousands in the northern. The depositional environment is important but Brazil, Argentina & South Africa have good carboniferous beds and there they will be found when more people look for them. For example no Silurian or Devonian eurypterids had ever been found in <u>all</u> South America until I made it a point to search for them - in museums, mislabelled !" My own assessment is that it is very unlikely that fossil scorpions will be found in carboniferous beds of southern Africa which at that time was extremely cold, in the grip of an ice age, and with the paleomagnetic south pole situated somewhere in the Transvaal. Instead it is far more likely that the earliest African fossil scorpions will be found in Cretaceous beds when most of Africa was subjected to the Mesozoic era warming phase. This is based on the assumption that most arachnid orders evolved in the northern Hemisphere or Laurasia regions of Pangaea during the Paleozoic era, migrated overland to Gondwanaland and thus ultimately Africa, as the warm tropical belt was shifted southwards with the drifting of the landmasses that resulted in the present configurations of the continents and concurrent climates. The earliest known fossils of southern African winged insects come from Upper Permian beds (Riek, 1973). This would tend to indicate that scorpions, which are much less vagile than flying insects, probably only reached southern Africa well after the formation of the predominantly wet and inhospitable Karoo system which straddled the Palaezoic and Mesozoic eras and extended from the Upper Carboniferous to the Lower Jurassic.

It would further appear that no scorpions were present in southern Africa before the Cretaceous or the end of the Mezozoic era when South America had already begun to drift away from Africa. A lack of any direct affinities (taking possible vicariance into consideration) between extant Afrotropical and Neotropical scorpions tends to confirm this. It would thus seem that the only palaeogeographic and palaeoclimatic events which could potentially have affected the distribution of southern African scorpions are those which have prevailed at any relevant time since the beginning of the Tertiary period.

During the Cretaceous much of northern and western Africa was covered by the Tethys sea which was in contact with the Atlantic Ocean from Nigeria to Libya and Algeria. Post-Eocene Africa had virtually its present shape. Throughout most of the Tertiary a large proportion of the northern part of the continent was more humid and forested than during the Quartenary, although some desert situations have existed apparently since the Eocene. Most of central Africa was tropical to subtropical in the Eocene. It appears that during the Tertiary, much of Africa had climates similar to present ones but that there probably existed a great deal of local variation , this being particularly the case after the Oligocene in southern Africa.

In southern Africa and South West Africa a drop in the relative sea levels from the Miocene onwards resulted in a deepening of the river valleys within the coastal belts while inland greatly dissected planation accompanied by deposition of material on the planed surfaces led to changes of configurations which in intermontane valleys and along mountain peaks gave rise to scalloped terraces and elsewhere formed table-topped hills with sharp margins or pinnacles of an even height. In South West Africa, sediments accumulated in the Etosha and Ovamboland basin to a thickness of up to 240 metres, as well as in the bigger rivers flowing into the Kalahari basin, while aggradation of up to 120 metres occurred in rivers draining westward into the Atlantic. At the end of the Tertiary, uplift coupled with an increase in rainfall early in the Pleistocene led to rapid valley incision of westward flowing rivers while during the Middle Pleistocene gravel terraces were formed along the sides of the valleys, the gravel subsequently becoming calcified.

Since the Miocene southern Africa and, more topically, South West Africa, have been subjected to important variations in climate basically caused by expansions and contractions of the Antarctic ice cap. This caused movements of the climatic zones equatorwise in colder, hypothermal periods and to higher latitudes in warmer, hyperthermal periods Northward shifts of the climatic zones and the cold Benguela Current during glacial times resulted in extensive aridification of the western coastal regions as well as inland regions in Angola, South West Africa and Botswana.

There are very good reasons to believe that the origin and evolution of deposits of the Kalahari and Namib sand systems are linked with phases of aridification during glacial periods from the Miocene to the Quaternary. These two sand systems have played very important roles in the distribution and biogeography of South West African scorpions. The extent of the present distribution of these sand systems is shown in fig. 2.8.

van Zinderen Bakker (1975: 69-70) believes the Kalahari System to be much older than has been formerly supposed. He surmises that the lower member of this sand system is most probably of Oligocene age while the unconsolidated sands of the upper member are of Pliocene-Pleistocene age. van Zinderen Bakker (1975: 72) further believes that the Kalahari sand system "may well be of the same age as the Namib Desert" sand system and he suggests that the Namib Desert could have originated in the Oligocene when cold Antarctic Central Water fist moved northward. Haughton (1963: 331-336) holds similar views on the age of the Kalahari sands, but does not comment on the potential age of the Namib sands.

Tankard and Rogers (Ms.) while agreeing with the principles which led to aridification of the west and hinterland of South West Africa, present strong evidence in favour of comparatively more youthful desert conditions. Tankard and Rogers suggest that "Like the Australian model (Bowler, 1976) development of aridity in southern Africa was progressive and comparatively youthful. Aridity was initiated in the Late Tertiary, but only fully established in the Quaternary". Bornman (1977: 24) suggests that the plant Welwitschia mirabilis, which is restricted to the Namib Desert and fringing areas in the North, may have evolved in a more temperate or tropical environment, and the Namib Desert " in contrast to the popularly held view", is "a comparatively young desert." M-L. Penrith (pers.comm.) holds similar views derived from her work on tenebrionid beetles.

According to Tankard & Rogers, the vertebrate fauna of South West Africa was of a pan-African nature and the environment dry wooded grassland with summer rainfall in the Miocene.

Whatever the correct ages of the Kalahari and Namib sands, it is cetain that significant variations in climate have occurred during the Late Miocene and the Pleistocene glaciations. These changes were of a rhythmic nature and resulted in shifts of the climatic belts and the arid zone to lower or higher latitudes. Such shifts must in turn have caused advancing and retreating dispersals of biota over vast distances.

3. BIOGEOGRAPHY

Current concepts of biogeography represent attempts to explain the distribution of extant taxa in terms of historical factors rather than through the exclusive use of their contemporary ecology.

In the absence of fossil records, biogeographical considerations of African and, more topically, southern African scorpions can be derived only from available, non-palaeontological sources such as those outlined in section 2 of this chapter.

On the subject of biogeographic hypotheses, Platnick and Nelson (1978: 3) have summarised contemporary thinking by stating: "clearly, then, neither dispersal nor vicariance explanations can be discarded *a priori* as irrelevant for any particular group of organisms, and it might seem that the ideal method of biogeographic analysis would be one that allows us to choose objectively between these two types of explanations for particular groups." The existence of a barrier is implied in both explanations of potential modes of speciation but vicariance and dispersal represent distinct models of disjunctions differentiated as following:

- Vicariance implies that the splitting of an ancestral population was caused by the appearance of a barrier.
- Dispersal implies that the splitting took place after dispersal across a pre-existing barrier.

The dispersion of scorpions is confined to terrestrial vagility. Because aquatic and aerial dispersion are highly improbable (barring exceptional or artificial circumstances such as rafting or synanthropy), it is suggested that historical biogeography (*sensu* Rosen, 1978: 159-160) of scorpion faunas separated by significant expanses of such barriers is best explained through a vicariance model. Terrestrial dispersion is in turn controlled at any time by various prevailing ecological requisites, comparable to the current ones described in chapter 2.

It follows that changes in environmental conditions leading to a disruption of essential ecological requirements across the distribution range of any species would represent a new barrier and constitute a vicariance event which, potentially, could lead to speciation.

These and related considerations form the basis of biogeographic interpretations propounded in this section.

Genus BUTHOTUS (Buthidae)

Buthotus arenaceus is endemic to the southern one-third of South West Africa and the northernmost parts of the Cape Province in South Africa while conspersus is restricted to the north-western half of South West Africa, spreading well into Angola (see fig. 4.6). Both species are, however, totally endemic to the south-western regions of Africa and distinctly isolated from eastern African species by the Kalahari sand system.

Figure 5.2. represents an attempt to superimpose the cladogram in fig. 5.1 on the extant distributions of the African species of Buthotus. It must be emphasized that the starting point of the cladogram and the placement of the inferred branching points on the map do not indicate speculations on the actual location in space of ancestral elements. Each branching point between extant sister species could, however, indicate potential zones of vicariance if congruence with historical events can be demonstrated. Bearing these considerations in mind, the following historical biogeography is proposed for the three groups of African species of Buthotus. Ancestral elements of Buthotus probably evolved in northern Gondwanaland (presently northern and eastern parts of Africa as well as Arabia) during the Mid-Mesozoic era, after the breakup of Pangeaea into Laurasia and Gondwanaland. From the Cretaceous to the Eocene periods, ancestral elements of the scaber group and conspersus - hottentota group evolved separately as the result of vicariance in response to disjunctions caused by the Tethys sea and by the formation, later, of the Red Sea in early Miocene.

By the end of the Oligocene the ancestral elements of the conspersus-hottentota group had probably migrated as far South and North-West as their present distributions, aided and abetted by prevailing tropical to subtropical climates and vegetation. The emergence of the Upper members of the vast Kalahari sand system during the Pliocene must have induced the vicariance that separated precursors of the conspersus and hottentota groups as none of the extant African species of Buthotus bear psammophile adaptations.

Westward expansion of the Kalahari sand system (redistributed sands) to its present westerly limit in South West Africa (fig. 2.8) probably forced the ancestral element of the conspersus group to migrate in the same direction. Once the western front of the Kalahari sands had reached the central highlands right up to the 1500 metre contour line (fig. 2.7), presumably in the Pleistocene, the ancestral range had become effectively bisected and a vicariance established that accounts for the current two species, conspersus and arenaceus, and their distribution (fig. 4.6).

It is therefore postulated that conspersus and arenaceus speciated allopatrically during post-Pliocene times.

Genus KARASBERGIA (Buthidae)

A monotypic genus with K. methueni as the type species, Karasbergia is endemic to regions North and South of the Orange River. Because of its uncertain phylogenetic relationship to other taxa within the Buthidae, it is impossible at this stage to suggest any biogeographic history for Karasbergia. One can but suspect that K. methueni is probably a relic of a former forest-dwelling fauna that survived the advent of aridification in peri-Miocene times by adopting a semi-endogean existence prior to its present infralapidicolous one.

Genus PARABUTHUS (Buthidae)

Parabuthus is endemic to the Afrotropical faunal region and all its extant species, with the exception of P. liosoma (H. & E., 1829) and P. granimanus Pocock, 1895 which occur also in Arabia as well as North East Africa, are confined to sub-saharan Africa, with the exclusion of Zaire and all regions west of it and west of Sudan. Extant forms of Parabuthus are broadly confined to regions with vegetation types ranging from Deserts to Woodland Savannas.

This endemicity suggests that the ancestral elements of *Parabuthus* evolved in north-eastern Africa in Eocene or Post Eocene times, when Africa had virtually its present shape, when most of central Africa was tropical to subtropical and the northern parts of the continent were more humid and forested than during the Quaternary and when some semi-desert to woodland savanna situations apparently arose in parts of North East Africa.

Although no complete cladogram is as yet available for the genus, preliminary investigations indicate that the South West African species of *Parabuthus* show greater affinity of character states with species from the northwestern Cape Province of South Africa and the northwest and central Karoo than with east African species. If these preliminary findings are correct, then one can but suggest that the extant species of *Parabuthus* evolved from ancestral elements that migrated to southern Africa after the Kalahari sand system had begun to form and that these elements had to bypass the Kalahari sand system in a southernly direction, to migrate into South West Africa (and ultimately Angola) during Miocene to post Miocene times.

On these premises, it is surmised that *Parabuthus* evolved more recently than, and is a more advanced genus, than *Buthotus*. It follows that the ancestral elements of South West African species of *Parabuthus* are of more recent origin than those of *Buthotus*.

It is propounded that three major events influenced the speciation of ancestral elements of *Parabuthus* to give rise to the existing number of species and concurrent distribution ranges in South West Africa. These are:

(1) The partitioning of ancestral elements into regions north and south of the Central Highlands by the westward expansion of the Kalahari sand system, right up to the eastern 1500 metre contour line of the central highlands, presumably in Pliocene times. This would explain the present distributions of *new species C*, *schlecteri* and *laevifrons* south of the Central Highlands and and *new species A*, *brachystylus* and *kraepelini* north thereof.

(2) Post-Pliocene adaptation in the eastern regions of South West Africa to the sandy substrata of the Kalahari sand system which led to the emergence of semi-psammophilous species such as

kuanyamarus, kalaharicus and raudus.

(3) Post Pliocene adaptation in the western regions to the sandy substrata of the Namib sand system, which led to the emergence of stridulus, a psammophilous species.

Three extant species, namely granulatus, villosus and brevimanus are not affected by the Central Highlands disjunction and have a virtually unrestricted distribution north, within and south thereof. Their distribution is nevertheless restricted by the Namib and Kalahari sand systems.

It is suggested that (1) above is the result of vicariance while (2) and (3) are due to dispersal. It is further suggested that (2) and (3) represent more recent events than (1) and that therefore the taxa involved represent more advanced elements than those that speciated as a result of (1).

Genus UROPLECTES (Buthidae)

Species of Uroplectes are distributed in the Afrotropical and Oriental regions. Extant forms are broadly restricted to regions with vegetation types ranging from Deserts to fairly dense Woodland Savannas.

The present distribution of this genus suggests an early historical biogeography that is very similar to that of Buthotus and both genera probably evolved approximately at the same time and along the same lines, with the exception of speciation patterns in the southern parts of Africa. Even though a complete cladogram has not yet been constructed for the genus Uroplectes, available information and preliminary results indicate that extant species from the south-western regions of South Africa show greater affinity of character states with species from South West Africa than with east African species, while species from the south-eastern regions of South Africa (Natal and north eastern Transvaal) appear to be more closely related to east African species than to species from western southern Africa.

If these preliminary findings are correct then the following historical biogeography is proposed for *Uroplectes* in southern Africa. During the Miocene, ancestral elements of *Uroplectes* had probably migrated as far south as East Africa and Angola. The emergence of the upper members of the vast Kalahari sand system during the Pliocene must have provided the vicariance that separated precursors of extant eastern and western southern African elements.

Once this had taken place, the then endemic South West African precursors of *Uroplectes* speciated under the influence of events similar to those that affected ancestral elements of *Parabuthus*, namely:

(1) The splitting of ancestral elements into regions North and South of the Central Highlands by the westward expansion of the Kalahari sand system, presumably in Pliocene-Pleistocene times. This would account for the present distribution of *new species A*, *longimanus*, *schlecteri* and *gracilior* south of the Central Highlands and *planimanus* and *otjimbinguensis* north thereof.

(2) Post Pliocene adaptation in the eastern regions of South West Africa to the sandy conditions of the Kalahari sand system which gave rise to a species such as *carinatus*. *U. vittatus* is distributed across the Kalahari sand system but its sharing of several character states with those of extant east African species suggests that *vittatus* evolved within the Kalahari sand system from a pre-Kalahari ancestral element that gave rise to *otjimbinguensis* and *vittatus*, as result of vicariance rather than dispersal of the latter from South West Africa into the Kalahari sand system after its formation.

(3) Post Pliocene adaptations in the western regions to Namib Desert conditions which led to the speciation of *teretipes* and *pilosus*.

Some species which are predominantly distributed either north or south of the Central Highlands are found also in regions within the Central Highlands. These are *new species A*, *planimanus*, *otjimbinguensis* and *gracilior*. In each case, however, such occurrences represent either southern or northern limits of their respective distribution ranges.

As in *Parabuthus*, it is inferred that (1) above is the result of vicariance while (2) and (3) are due to dispersal. Also, (2) and (3) represent more recent speciation events than (1) and taxa involved thus represent more advanced elements than those that speciated as a result of (1).

Genus HADOGENES (Scorpionidae)

Like *Opisthophthalmus*, *Hadogenes* is endemic to southern Africa. Although the genus is insufficiently revised, it would seem that the three species of *Hadogenes* present in South West Africa were derived from ancestral elements that occurred in the northern Cape Province of South Africa.

Genus LISPOSOMA (Scorpionidae)

The two species of *Lisposoma* are endemic to the northern half of South West Africa and southern Angola. Of the two, *elegans* is the most widely distributed while *new species A* appears to be restricted to the Otavi Highlands. No specimens of *elegans* have been recorded south of the Central Highlands.

Because of the uncertainty of its phylogenetic relationship with other taxa of the family Scorpionidae, no dependable biogeographic history can be proposed at this stage. One can but suspect that the genus represents a relic of a formerly tropical forest-dwelling ancestral element that survived the onset of aridification in peri-Miocene times by resorting to a semi-endogean existence. The fact that *new species* A still occupies a euedaphic habitat tends to lend support to this. Adaptation to an infralapidicolous habitat by *elegans* must have contributed greatly towards its present fairly wide distribution.

Genus OPISTHOPHTHALMUS (Scorpionidae)

All the described species of *Opisthophthalmus* are endemic to southern Africa with the exception of *O. boehmi* (Kraepelin, 1897) which occurs in Tanzania and *O. glabrifrons* Peters, 1861, a southern African species whose distribution range extends into Mozambique and Tanzania.

All extant forms of *Opisthophthalmus* are fossorial and the distribution of species is controlled mainly by soil hardness. It can be said that soil hardness is affected to a greater or lesser extent by vegetation which is in turn the result of prevailing climatic conditions such as those shown in fig. 2.5.

The present distribution of the genus indicates that the ancestral elements of Opisthopthalmus evolved in southern Africa.

Although no complete cladogram is available for the genus, preliminary findings indicate that the South West African species of Opisthophthal mus are more closely affiliated with species from the northwestern Cape Province of South Africa and the northwest and central Karoo than with species from the eastern regions of southern Africa. The majority of the extant southern African species which belong to the most primitive group of Opisthophthalmus, namely the opinatus group, are distributed mainly in the southern half of South West Africa, as well as the northern Cape, the Karoo and the eastern parts of South Africa, while all the species belonging to the most advanced group, namely the wahlbergi group, are endemic to the South West African species.

Bearing these considerations in mind, the following historical biogeography is proposed for the genus Opisthophthalmus.

Ancestral elements of Opisthophthalmus evolved in the eastern and south-central regions of southern Africa from as yet unknown ancestral east African elements after the beginning of the Kalahari sands formation, presumably in Late Miocene. The extant species of Opisthophthalmus in South West Africa evolved from populations of these ancestral elements tha migrated into the northern Cape Province of South Africa and South West Africa by bypassing the southern limits of the Kalahari sand system, probably during the Pliocene.

Subsequently to the course of events proposed above, the historical biogeography of the South West African species is thought to have broadly developed as a result of the following events:

(1) The disjunction of ancestral elements into regions north and south of the Central Highlands by the westward expansion of the Kalahari sand system, presumably in Pliocene-Pleistocene times. This led to the distribution of species such as brevicauda, ugabensis cavimanus, new species A and new species B within regions north of the Central Higlands and gigas, haackei, opinatus, intercedens,

fitzsimonsi and schultzei within regions south thereof.

(2) Post Pliocene adaptations in the eastern regions of South West Africa to the sandy substrates of the Kalahari sand system which gave rise to psammophilous species such as wahlbergi and concinnus.

(3) Post Pliocene adaptations in the western regions to the sandy substrates of the Namib Desert which led to the evolution of semi-psammophilous (SP), psammophilous (P) or ultra-psammophilous (UP) species such as adustus (SP), flavescens (P), holmi (UP), new species D (SP), jenseni (P) chrysites (P) and littoralis (SP).

(4) Post Pliocene adaptations in the southern regions of South West Africa to fairly large areas covered with sand (presumably of mixed redistributed Kalahari and Namib sand origins) which currently occur both north and south of the Orange River. This led to the speciation of psammophilous species such as new species C and new species E.

It is proposed that (1) above is the result of vicariance while (2), (3) and (4) are due to dispersal. It is further contended that (2), (3) and (4) represent more recent events than (1) and that therefore the taxa involved represent more advanced elements than those that evolved as a result of (1). These premises are in congruence with phylogenetic deductions propounded elsewhere.

Two extant species, namely carinatus and setifrons, are unaffected by the Central Highlands disjunction and have a virtually unrestricted distribution north, within and south thereof while nevertheless being distributed in areas with optimum ranges of intraspecific soil hardness requirements.

Although O. wahlbergi is predominantly distributed over regions covered by the extensive Kalahari sand system (fig. 2.8.) it has also migrated into various eastern fringes of the northern Namib sands and the redistributed sands in the southern parts of South West Africa north and south of the Orange river.

4. CONCLUSIONS

On the basis of phylogenetic, palaeogeographic, palaeoclimatic and biogeographic considerations discussed in this chapter, I have the followin general conclusions to offer.

1. The scorpion fauna of South West Africa is derived from elements that originated in Laurasia during Pangean times. These elements migrated overland to the north African region of Gondwanaland and ultimately to southern Africa in the wake of the warm tropical belt southward shift, resulting from the drifting of landmasses which led to the present configuration of continents and climates.

   Some of those elements gave rise to genera now widespread in the Afrotropical and Oriental regions (Buthotus and Uroplectes), others to genera endemic to the Afrotropical region (Parabuthus) or subregion thereof, such as southern Africa (Opisthophthalmus and Hadogenes) and South West Africa (Karasbergia and Lisposoma).

2. The progressive spatial restriction of groups of taxa, such as an entire genus, distinct groups of species within a genus, or single species, are the result of vicariance, which has led to endemicity and a limited scope for contemporary dispersal. In many instances, the proposed vicariance agents are either still in existence (as in the case of the Kalahari sand system, or the Central Highlands of South West Africa, etc.), or testable evidence is available for their past existence, and these thus provide a high degree of congruence with disjuncted distribution patterns. In other instances however, the inferred agents of vicariance are, at this stage, only speculative ones.

   Psammophilous species, however, most probably evolved as a result of dispersal from within South West Africa into any one of the sand systems rather than as a result of vicariance. As a matter of fact, phylogenetic deductions for the genus Opisthophthalmus indicate that the psammophilous species are the most advanced ones (i.e. the wahlbergi group) and consequently the most recently evolved. It follows that psammophilous species must have evolved after the sand systems had become well established and that the most likely way in which speciation could have taken place was through dispersal into an ecosystem which previously constituted a barrier.

3. Taking possible vicariance and dispersal into consideration, no affinities could be found between the scorpion fauna of either South West Africa or southern Africa and South America. This lack of affinity was found to prevail from generic to subfamily levels for the family Buthidae and to family level for the Scorpionidae. Except for the controversial genus *Opisthacanthus* (see Newlands, 1973 and Francke, 1974) members of the family Scorpionidae are totally absent from the New World and it is concluded that the family evolved in post Cretaceou times after the continents of the New World had drifted away from Laurasia and Gondwanaland respectively.

4. All the genera of the family Scorpionidae occurring in South West Africa and in southern Africa for that matter (excepting the genus *Opisthacanthus* in the latter instance) are endemic to southern Africa and with the probable exception of *Lisposoma*, they represent the more advanced taxa of scorpions in the subcontinent.

5. The nature of the substratum, taken in its broadest possible definition, is probably the most important single factor that has and still determines the distribution of scorpions. The nature of the substratum is affected to a greater or lesser extent by vegetation which is in turn partly the result of prevailing climatic conditions.

6. Since the Pliocene, the Kalahari sand system has operated as an agent of vicariance preventing migration of scorpion species along the north-east to south-west "drought corridor" described by Balinsky (1962).

REFERENCES

ALEXANDER, A.J., 1957. The courtship and mating of the scorpion, *Opisthophthalmus latimanus*. *Proc. Zool. Soc. Lond.*, 128: 529-544.

————————— 1959. Courtship and mating in the buthid scorpions. *Proc. Zool. Soc. London*, 133 (1): 145-169.

ASHLOCK, P.D. and BROTHERS, D.J. Ms. Higher classification for evolutionary Systematics through cladistic and anagenetic analysis.

BALINSKY, B.I., 1962. Patterns of animal distribution on the African Continent. *Ann. Cape Prov. Mus.* 2: 299-309.

BARNARD, W.S., 1965. 'n Kaart van die Klimaatstreke van Suidwes-Afrika. *J. S.W.A. Sc. Soc.*, 18-19: 74-84.

BIRULA, A., 1903. Sur une nouvelle espèce de scorpions provenant de l'isl Madagascar. *Ann. Mus. St. Petersb.* 7 (1): x-xi (Russian, with Latin diagnoses of n.g. and sp.).

BORNMAN, C.H., 1977. *Welwitschia mirabilis*: structural and functional anomalies. *Madoqua*, 10 (1): 21-31.

BROTHERS, D.J., 1978. How pure must a cladistic study be ? - A response to Nelson on Michener. *Syst. Zool.*, 27 (1): 118-122.

CAPORIACCO, L. di, 1932. Arachnidi. *Boll. Zool.*, *Napoli* 3 (5): 233-238.

CARTHY, J.D., 1968. The pectines of scorpions. *Symp. Zool. Soc. Lond.* No. 23: 251-261.

COATON, W.G.H. & SHEASBY, 1972. Preliminary report on a survey of the termites (Isoptera) of South West Africa. *Cimbebasia Memoir* No. 2: 1-129.

CRACRAFT, J., 1972. The relationship of the higher taxa of birds: problems in phylogenetic reasoning. *Condor* 74 (4): 379-392.

CROSSKEY, R.W. and WHITE, G.B., 1977. The Afrotropical Region. A recommended term in zoogeography *J. nat. Hist.*, 1977, 11: 541-544.

DAVIDSON, D.T., 1965. Penetrometer measurements. *In* C.A. Black (ed.-in-chief). *Methods of soil analysis* Part 1: 472-484. No. 9, Agronomy Series, American Soc. of Agronomy. Inc. Madison, Wisconsin

DAVIS, B.J., 1964. Disc electrophoresis - II. Method and application to human serum protein. *Ann. N.Y. Acad. Sci.*, 121, Art. 2: 404-436.

DAY, P.R., 1965. Particle fractionation and particle-size analysis. *In* C.A. Black (ed.-in-chief). *Methods of soil analysis*. Part 1: 545-567. No. 9. Agronomy Series, American Soc. of Agronomy, Inc. Madison, Wisconsin.

FRANCKE, O.F., 1974. Nota sobre los generos Opisthophthalmus Peters y Nepabellus nom. nov. (Scorpionida, Scorpionidae) e informe sobre el hallazgo de O. lepturus en la isla del Coco, Costa Rica. Brenesia 4: 31-35.

GOYFFON, M. and LAMY, J., 1973. Une nouvelle sous-espèce d'Androctonus australis L. (Scorpion, Buthidae): Androctonus australis garzoni N. SSP. Characteristiques morphologiques, écologiques et biochimiques. Bull. Soc. Zoo. Fr. Tome 98, No. I, 1973: 137-144.

GOYFFON, M., LE FICHOUX, J & LAMY, J., 1970. Hétérogénéité du protéinogramme de l'hémolymphe des scorpions Androctonus australis L., Androctonus mauretanicus Pocock et Androctonus amoreuxi Aud. et Sav. en gel de polyacrylamide. C.R. Séan. Soc. Biol. 164 (2): 374-378, 2 figs.

GOYFFON, M., STOCKMANN, R., LAMY, J., 1973. Valeur taxonomique de l'électrophorèse en disques des proteines de l'hémolymphe chez le Scorpion: étude du genre Buthotus (Buthidae). C.R. Acad. Sc. Paris. T. 277 Serie D: 61-63.

HAUGHTON, S.H., 1963. The stratigraphic history of Africa south of the Sahara. Oliver and Boyd, Edinburgh.

HEMPRICH, F.G. & EHRENBERG, C.G., 1828 and 1831. Icones et descriptiones corporum naturalium novorum aut minus cognitorum quae ex itineribus per Lybium, Egyptum, Nubium, Dongolan, Syrium, Arabium et Abysinium. Sym. Phys. Arach. Scorp. No. 10. Plates published in 1828 and text in 1831.(Original text not seen and page numbers not available in either Sherborn, C.D., 1926. Index Animalium, II, or Woodward, cat. Libr. B.M. (N.H.) 515).

HEMPRICH, F.G., 1829. Symbolae Physicae seu Icones et descriptiones Insectorum quae ext itinere per Africam borealem et Asiam occidentalem Animalia articualta, Arachnoidea, Scorpiones. Berolini ex officina Academica. 12 pp., 2 pls.

HENNIG, W., 1966. Phylogenetic Systematics (translated by D.D. Davis and R. Zangeril). University of Illinois Press, Urbana. pp. i-vi, 1-263.

HEWITT, J., 1913. The Percy Sladen Memorial Expedition to Great Namaqualand 1912-13. Records and descriptions of the Arachnida of the collection. Ann. Transv. Mus. 4: 146-159, pl. 15. figs.

HEWITT, J., 1918. A survey of the scorpion fauna of South Africa. *Trans. Roy. Soc. South Africa* 6: 89-192, pls xix-xxxii.

——— 1931. A new Solifuge and Scorpion from S.W.A. *Ann S. Afr. Mus.*30 (1): 93-99, 3 text figs.

——— 1934. On several Solifuges, Scorpions and a trapdoor spider from S.W.A. *Ann. Transv. Mus.* 15 (3): 401-412, pl. 7, text figs.

——— 1935. Scientific results of the Vernay Lang Kalahari Expedition Mar .-Sept. 1930. The Trap-door spiders, Scorpions and Solifuges. *Ann. Transv. Mus.* 16 (3): 459-479, 4 pls. 2 text figs.

KARSCH, F., 1879. Scorpiologische Beitrage II. *Mitt. Munchener Ent. Ver.* 3: 97-136.

——— 1879. West-afrikanische Arachniden, gesammelt von Herrn Stabsarzt Dr Falkenstein. *Zeitschr.Ges. Nat. wiss., Berlin* (3) IV: 329-373.

——— 1891. Arachniden von Ceylon und von Minikoy. *Berl. Ent. Zeits* 36 (2) 267-310, 3 pls.

KELLY, K.L. & DEANE, B.J., 1965. *The ISCC-NBS method of designating colors and a dictionary of color names.* Nat. Bur. Standards circ. 553 (reprint ed.): V + 158. ISCC-NBS color-name charts illustrated with centroid colours (suppl. to NBS circ. 553).

KJELLESVIG-WAERING, E.N., 1966. Silurian scorpions of New York. *Jnl. of Palaeontology* v.40 no. 2.

KOCH, C.L., 1845. *Die Arachniden*, Nürnberg 11: 1-174, figs.

KOCH, C.L. 1845. *Die Arachniden*, Nürnberg 12. 1-166, figs.

KÖPPEN, W., 1931. Grundriss des Klimakunde. Berlin.

KRAEPELIN, K., 1894. Revision der Skorpione. II. Scorpionidae und Bothriuridae. *Jahrb. Hamburg Wissench. Anst.* 11: 1-248.

——— 1894. Nachtrag zu Theil 1 der Revision der Skorpione. *Jahrb. Hamburg Wiss. Anst.* 12: 75-96.

KRAEPELIN, K., 1897. Neue und weniger bekannte Skorpione. Jahrb. Hamb. Wiss. Anst. 13: 121-146, 1 pl.

————————— 1898. Die Skorpione Ost-Afrikas. Thierw. Ost-Afrika 4 (5) 1-5 text figs.

————————— 1898. Neue Padipalpen und Skorpione des Hamburger Museums. Mitt. zool. st. Inst. Hamb. 15: 1-6, 1 fig.

————————— 1899. Scorpiones und Pedipalpi. Das Tierreich 8: 1-265, 94 figs.

————————— 1901. Catalogue des Scorpions des collections du Museum d'Historie Naturelle de Paris. Bull. Mus. Hist. nat. Paris 7: 265-274.

————————— 1908. Skorpione und Solifugen Ergebnisse e. Forsch Sudafrika Bd. 1, Lief 2, Densch. med. Nat. Ges. Jena 13: 247-282.

LAMORAL, B.H., 1972. New and Little know Scorpions, Solifuges and Spiders from the Namib Desert, S.W.A. Madoqua Ser. II 1 (54-62): 117-131.

————————— 1973. The Arachnid fauna of the Kalahari Gemsbok National Park. Part 1. A revision of the species of "Mole Solifuges" of the genus Chelypus Purcell, 1901. (Family Hexisopodidae). Koedoe 16: 83-10

————————— 1976. Akentrobuthus leleupi, a new genus and species of humicolous scorpion from eastern Zaire, representing a new subfamily of the Buthidae. Ann. Natal Museum 22 (3): 681-691.

————————— 1977. Parabuthus kalaharicus, a new species of scorpion from the Kalahari Gemsbok National Park in the Republic of South Africa. (Buthidae, Scorpionida). Koedoe 20: 101-107.

————————— 1978. Soil hardness, an important and limiting factor in burrowing scorpions of the genus Opisthophthalmus C.L. Koch, 1837. (Scorpionidae, Scorpionida, Symp. zool. Soc. Lond. (1978). No. 42: 171-181.

LAMORAL, B.H. & REYNDERS, S.C., 1975. A catalogue of the scorpions describe from the Ethiopian Fauna Region up to December 1973. Ann. Natal Muse 22 (2): 489-576.

LAWRENCE, R.F., 1927. Contribution to a knowledge of the fauna of S.W.A. V. Arachnida. Ann. S.Afr. Mus. 25 (1): 1-75, 4 pls.

————————— 1928. Contribution to a knowledge of the fauna of S.W.A. V Arachnida (Part 2). Ann. S. Afr. Mus. 25 (2): 217-312, 4 pls. 1 tex fig.

LAWRENCE, R.F., 1949. A collection of Opiliones and Scorpions from North-East Angola made by Dr A. de Barros Machado in 1948. *Pub. Cult. Comp. Diam. Angola*: 1-20, text figs 1-8.

———————— 1955. Solifugae, Scorpions and Pedipalpi, with checklists and keys to South African families, genera and species. Results of the Lund Univ. Exped. in 1950-51. *S. Afr. Animal Life* 1: 152-262. figs 1-3.

———————— 1961. New scorpions and solifuges from S.W.A. and Angola. *K. fysiogr. Sallsk. Lund Forh.* 31 (15) 1961: 147-160, figs 1-3.

———————— 1962. Solifuges, Scorpions and Chilopoda of the Namib Desert. *Ann. Transv. Mus.* 24: 213-222, figs 1-2.

———————— 1965. New and little known arachnids from the Namib Desert, S.W.A. *Sci Pap. Namib Desert Res. Stn.* 27: 1-12, figs 1-6.

———————— 1966. New and little known scorpions and Solifuges from the Namib Desert and S.W.A., *Sci. Pap. Namib Desert Res. Stn.* 29: 1-1 5 figs.

———————— 1967. Additions to the fauna of S.W.A.: Solifuges, Scorpior and Pedipalpi. *Sci. Pap. Namib Desert Res. Stn.* 34: 1-19, 8 figs.

———————— 1969. A new genus of Psammophile scorpion and new species of *Opisthophthalmus* from the Namib Desert. *Sci. Pap. Namib Desert Res. Stn.* 48: 105-115, 4 figs.

LOXTON, R.F., 1961. A modified chart for the determination of basic soil textural classes in terms of the International classification for soil separates. *S. Afr. J. Agr. Sci.* 4: 507-512.

MARX, H. & RABB, G.B., 1970. Character analysis: an empirical approach applied to advanced snakes. *J. Zool. Lond.* 161: 525-548.

MAURY, E.A., 1969. *Tityus bahiensis* (Perty 1834) en la Argentina (Scorpiones, Buthidae). *Physis*, 29 (78): 159-164.

MAURY, E.A. and SAN MARTIN, P.R., 1973. Revalidacion del genero *Timogenes* Simon 1880 (Scorpiones, Bothriuridae). *Physis*, Sec. C. 32 (84): 129-140.

MAYR, E., LINSLEY, E.G., & USINGER, R.L., 1953. Methods and principles of systematic Zoology. McGraw-Hill Book Company, New York.

MONARD, A., 1930. Matériaux de la mission scientifique suisse en Angola. Scorpions. Bull. Soc. neuchâtel Sci. nat. 54: 37-43, fig.

__________ 1937. Scorpions, Solifuges et Opilions d'Angola Rev. suisse Zool. 44 (13): 251-270.

NEWLANDS, G., 1970. A re-examination of some Southern African Scorpion species. Ann. Transv. Mus. 26 (10): 199-210, 4 figs.

__________ 1972. A description of Hadogenes lawrencei n.sp. (Scoprionidae) with a check list and key to the S.W.A. species of the genus Hadogenes. Madoqua Ser. II, 1 (54-62): 133-140.

__________ 1972. Notes on Psammophilous scorpions and a description of a new species. Ann. Transv. Mus. 27 (12): 241-254, fig 1-3, pl. 22.

__________ 1972. Ecological adaptations of Kruger National Park Scorpionids (Arachnida: scorpionides). Koedoe 15: 37-48.

__________ 1973. Zoogeographical factors involved in the trans-atlantic dispersal pattern of the genus Opisthacanthus Peters. Ann. Transv. Mus. 28 (7): 91-98.

PETERS, W., 1861. Ueber eine neue Eintheiling der Skorpione ... Deutsche K. Akademie Wiss. Zu Berlin, Monatsber: 507-516.

PLATNICK, N.I., 1976. Drifting spiders or continents ? Vicariance biogeography of the spider subfamily Laroniinae (Araneae: Gnaphosidae). Syst. Zool. 25: 101-109.

__________ 1977. Parallelism in phylogeny reconstruction. Syst. Zool. 26: 93-96.

__________ 1977. Cladistic methods in textual, linguistic and phylogenetic analysis. Syst. Zool. 26 (4): 380-385.

__________ 1977. Cladograms, phylogenetic trees, and hypothesis testing. Syst. Zool. 26 (4): 438-442.

PLATNICK, N.I. & NELSON, G., 1978. A method of Analysis for Historical Biogeography. Syst. Zool. 27 (1): 1-16.

POCOCK, R.I., 1890. A revision of the genera of scorpions of the family Buthidae with descriptions of some S. African species. Proc. zool. Soc. Lond. 1890: 114-141, 2 pls.

——————— 1890. Descriptions of two new species of scorpions brought by Emin Pasha from the inland parts of East Africa. Ann. Mag. nat Hist. (6): 98-101.

——————— 1893. Notes on the classification of Scorpions, followed by some observations upon Synonymy with descriptions of new genera and species Ann. Mag. nat. Hist. (6) 12: 303-330, 2 pls.

——————— 1895. On the Arachnida and Myriapoda obtained by Dr Anderson's collector during Mr T. Bent's Expedition to the Hadramaut South Arabia. J. Linn. Soc. (Zool.) 25: 292-316, pl. IX.

——————— 1896. On the species of the South African scorpion Opisthophthalmus contained in the collection of the British Museum. Ann. Mag. nat. Hist. (6) 17: 233-248, pl. x.

——————— 1899. Descriptions of some new species of Scorpions. Ann. Mag. nat. Hist. (7) 3: 411-420.

——————— 1900. Some new Arachnida from Cape Colony. Ann. Mag. nat. Hist. (7) 6: 316-333.

——————— 1901. Descriptions of some new African Arachnida. Ann. Mag. nat. Hist. (7) 7: 284-287.

PURCELL, W.F., 1898. Descriptions of new South African Scorpions in the collection of the South African Museum. Ann. S. Afr. Mus. 1 (i): 1-32, pls i-iv.

——————— 1899. On the species of Opisthophthalmus in the collection of the South African Museum, with descriptions of some new forms. Ann. S. Afr. Mus. 1:131-180.

——————— 1899. New South African Scorpions in the collection of the South African Museum. Ann. S. Afr. Mus. 1: 433-438.

——————— 1901. On some South African Arachnida belonging to the ord Scorpiones, Pedipalpi and Solifugae. Ann. S. Afr. Mus. 2. 137-225, 10 figs.

ROEWER, C.F., 1943. Uber eien neuerworbene Sammlung von Skorpionen des Natur Museums Senckenberg. *Senck. Frankfurt* 26 (4): 205-244, pls 1-6.

ROSEN, D.E., 1978. Vicariant patterns and Historical explanations in Biogeography. *Syst. Zool.* 27 (2): 159-188.

SAN MARTIN, P.R., 1969. Estudio sobre la compleja estructura del esqueleto esclerificado del organo paraxil del genero *Brachiosternus* (Bothriuridae - Scorpionida). *Bol. Soc. Biol. Concepcion*, 41: 13-30

SCHINZ, H., 1887. Exploration dans le Sud Quest de l'Afrique. *L'Afrique explorée et civilisée* 6 & 7: 175-188.

SCHWARZBACH, M., 1963. *Climates of the past*. An introduction to Paleoclimatology. D. van Nostrand Company, Ltd., London.

SIMON, E., 1872. Etudes sur les Scorpions. *Rev. Mag. zool.* (2) 23: 51-59, 97-101, pl. 6.

__________ 1872. Arachnides de Syrie, rapportés par M. Charles Piochard de la Brûlerie (Scorpions et Galéodes). *Annals. Soc. ent. Fr.* (5) 2: 247-264.

__________ 1877. Arachnides recueillis dans le sud de l'Afrique par le Dr Hans Schinz. XXVIII. Etudes Arachnologiques, 20^{e} Memmoire. *Annls Soc. ent. Fr.* 7: 369-384.

STAHNKE, H.L., 1970. Scorpion nomenclature and mensuration. *Ent. News.* 81: 297-316, 10 figs.

TANKARD, A.J., and ROGERS, J., Ms. Progressive Late cenzoic dessication on the west coast of southern Africa.

THORELL, T., 1876. On the classification of scorpions. *Ann. Mag. nat. Hist* (4) 17: 1-15.

__________ 1877. Etudes Scorpionologiques. *Atit. Soc. Ital. Sci. Nat.* 19: 75-272.

TORE-BUENO de la, J.R., 1950. *A glossary of Entomology*. Brooklyn, N;Y.: Brooklyn Entomological Society.

VACHON, M., 1948. Etudes sur les Scorpions *Arch. Inst. Pasteur Alger.* 26. (1): 25-90, figs 1-86.

__________ 1948. Etudes sur les Scorpions. Description de scorpions du Nord de l'Afrique. Ibid. 26 (2): 162-208, figs. 87-147.

__________ 1948. *Idem*. Ibid. 26 (3): 289-316, figs 148-187.

__________ 1948. *Idem*. Ibid. 26 (4): 441-481, figs 188-241.

VACHON, M., 1949. *Idem.* Ibid. 27 (1): 66-100, figs 242-292.

—————— 1949. *Idem.* Ibid. 27 (2): 134-169, figs 293-363.

—————— 1949. *Idem.* Ibid. 27 (3): 281-288, figs 364-371.

—————— 1949. *Idem.* Ibid. 27 (4): 334-396, figs 372-476.

—————— 1952. La réserve naturelle intégrale du Mt Nimba I. Scorpions. Mission M. Lamotte en Guinée (1942). *Mém.* F.A.N., No. 1 *Rés. Mont Nimba* 1952: 9-15, figs 1-12.

—————— 1952. *Etudes sur les Scorpions:* 1-482, figs 1-690. Inst. Pasteur Algeria.

—————— 1955. Remarques préliminaires sur la faune des Scorpions du Soudan oriental *Bull.Mus. Hist., nat. Paris* (2) 27: 371-373.

—————— 1961. Scorpions Le parc national du Niokolo-Koba, Fasc. 2. *Mem. Inst. Franc. Afr. noire* 62: 31-32.

—————— 1967. Le grand scorpion du Sénégal: *Pandinus gambiensis*, Pocock 1899 doit être considére comme une véritable espèce et non comme sous-espèce de *Pandinus imperator* C.L. Koch 1842. *Bull. Inst. fr. Afr. noire* 29A (4): 1534-1537, 11 figs.

—————— 1969 . Complément à la description d'*Isometrus madagassus*, Scorpion Buthidae. *Senckenberg. biol.* 50 (5/6): 417-420.

—————— 1969 . *Grosphus griveaudi*, nouvelle espèce de Scorpion Buthidae malgache. *Bull. Mus. Hist. nat. Paris* 41 (2): 476-483.

—————— 1973. Etude des caractères utilisés pour classer les famille et les genres de Scorpions (Arachnides) *Bull. Mus. Hist. nat. Paris* (3) Zool. 104: 857-958, figs 1-243.

VACHON, M. & STOCKMANN, R., 1968. Contribution a l'étude des Scorpions africains appartenant au genre *Buthotus* Vachon, 1949 et étude de la variabilité. *Monitore zool. ital. Firenze* 2 suppl.: 81-149, 69 figs.

VAN DER EYK, J.J. MACVICAR, C.N. & DE VILLIERS, J.M., 1969. Soils of the Tugela Basin. A study in subtropical Africa. Natal Town and Regiona Planning reports, Vol. 15.

VAN ZINDEREN BAKKER, E.M., 1975. The origin and palaeo-environment of the Namib Desert biome. J. Biogeography, 2: 65-73.

VAN ZINDEREN BAKKER, E.M., 1976. The evolution of late-cenozoic palaeo-climates of southern Africa. Palaeoecology of Africa, 9: 160-202.

WERNER, F., 1902. Die Skorpione, Pedipalpen and Solifugen in der zoologisc vergleichend-anatomischen Sammlung der Universität Wien. Verh. kk. zool-bot. Ges. Wien 52: 595-608.

__________ 1916. Uber einige Skorpione und Gliederspinne des Naturhistorischen Museums in Wiesbaden. Jahr. nass. ver. Natk. 69: 79-97.

__________ 1933. Die von Dr Fritz Haas auf der Schomburgk-Afrik-Expedition 1931-32 gesammelten Skorpione. Senck. biol. Frankfurt 15 (5-6): 323-324, 3 text figs.

__________ 1936. Neu Eingänge von Skorpionen im Zoologischen Museum in Hamburg. Festschrift f. Embrifk.Strand Riga 2: 171-193, 12 text fig

APPENDIX I

GAZETTEER OF LOCALITY NAMES

The majority of localities listed are in South West Africa and the sequence of data is as follows:

LOCALITY (followed by a lot number if a farm), MAGISTERIAL DISTRICT in brackets, abbreviated COUNTRY NAME, LATITUDINAL AND LONGITUDINAL readings. The names and boundaries of the magisterial districts used in this gazetteer are shown in fig. 1.2. Localities outside South West Africa are not followed by a magisterial district reference.

eg: Aandster 147, (Maltahöhe), S W A, $25^{0}24'$S $16^{0}00'$E
Aha Mts (Grootfontein), S W A, $19^{0}47'$S $21^{0}00'$E

KEY TO ABBREVIATIONS

A : Angola
B : Botswana
C : Cape Province, South Africa
S W A: South West Africa
Mt,Mts: Mountain(s)
riv.: river (banks or vicinity)

Aandster 147, (Maltahöhe), S W A, 25°24'S 15°58'E

Aar 16, (Luderitz), S W A, 26°46'S 16°28'E

Aarpan , C, 27°23'S 20°43'E

Agate Beach, (Luderitz), S W A, 26°36'S 15°09'E

Aha Mts, Bushmanland , S W A, 19°47'S 21°00'E

Ai-Ais, (Karasburg), S W A, 27°56'S 17°27'E

Albrechtshöhe 44, (Karibib), S W A, 21°56'S 16°08'E

Alte Feste, Windhoek (Windhoek), S W A, 22°34'S 17°06'E

Ameib 60, (Karibib), S W A, 21°49'S 15°40'E

Amichab Mts, (Walvis Bay), S W A, 23°10'S 15°32'E

Andara, Kavango , S W A, 18°02'S 21°29'E

Anenous, C, 29°17'S 17°34'E

Angra Fria, (Skeleton coast Park), S W A, 18°20'S 11°58'E

Annabis 677, Damaraland , S W A, 20°00'S 14°38'E

Annisfontein, Richtersveld, C, 28°25'S 16°53'E

Arigap Riv, (Karasburg), S W A, 28°29'S 18°43'E

Aris 29, (Windhoek), S W A, 22°43'S 17°07'E

Arnhem 222, (Windhoek), S W A, 22°43'S 18°06'E

Aroab, (Keetmanshop), S W A, 26°48'S 19°39'E

Auas Mts, Aris 29, (Windhoek), S W A, 22°42'S 17°09'E

Augrabies Falls, C, 28°35'S 20°23'E

Auob and Nossob riv. confluence, C, 26°26'S 20°38'E

Auob riv. 11 km N of Twee Rivieren, C, 26°22'S 20°36'E

Auob riv. 34 km S of Mata Mata, C, 25°59'S 20°16'E

Aus, Etosha Game Park, (Outjo), S W A, 19°15'S 16°15'E

Aus, (Luderitz), S W A, 26°40'S 16°16'E

Auspanplatz (Windhoek), S W A, 22°41'S 17°07'E

Avis Dam, (Windhoek), S W A, 22°35'S 17°07'E

Avro 194, (Windhoek), S W A,	23°32'S	17°42'E
Awasib dunes, (Luderitz), S W A,	25°15'S	15°43'E
Bakers Bay, (Luderitz), S W A,	27°42'S	15°32'E
Barby 26, (Bethanien), S W A,	25°50'S	16°35'E
Bayip, C,	25°18'S	20°09'E
Beacon 39, Owambo , S W A,	17°20'S	17°45'E
Belda 361, (Karasburg), S W A,	28°27'S	18°01'E
Bergkranz 370, (Windhoek), S W A,	22°52'S	16°14'E
Berseba, Namaland, (Keetmanshoop), S W A,	25°59'S	17°47'E
Berseba, 10 km S of, Namaland, (Keetmanshoop), S W A,	26°07'S	17°46'E
Berseba, 10 km W of, Namaland, (Keetmanshoop), S W A,	26°02'S	17°42'E
Berseba, 48 km W of, Namaland, (Keetmanshoop), S W A,	26°07'S	17°27'E
Bitterwater, Etosha Game Park, (Outjo), S W A,	18°57'S	15°08'E
Blässkranz 7, Naukluft Mts, (Maltahöhe), S W A,	24°08'S	16°15'E
Blinkoog 30, (Karasburg), S W A,	27°40'S	19°04'E
Bloeddrif, Orange riv. Richtersveld, C,	28°21'S	16°48'E
Bloedkoppie, (Swakopmund), S W A,	22°49'S	15°24'E
Brakwater 48, (Windhoek), S W A,	22°23'S	17°04'E
Brandberg Basiskamp, Damaraland , S W A,	21°08'S	14°33'E
Brandberg Mts, Northern Valley, Damaraland , S.W.A,	21°05'S	14°40'E
Brandberg Wes Myn, Damaraland , S W A,	21°08'S	14°33'E
Bruckaros, Namaland, (Keetmanshoop), S W A,	25°53'S	17°47'E
Cape Cross, (Swakopmund), S W A,	21°43'S	13°58'E
Cape Cross, 5 km N of, (Swakopmund), S W A,	21°43'S	13°56'E
Cape Fria, (Skeleton coast Park), S W A,	18°26'S	12°01'E
Chamais, (Luderitz), S W A,	27°51'S	15°43'E
Chamais Gate, (Luderitz), S W A,	27°52'S	15°44'E
Chitapua, A,	14°±15'S	15°±15'E

Churutabis 108, (Bethanien), S W A, 27°22'S 17°28'E

Claratal 18, (Windhoek), S W A, 22°50'S 16°51'E

Daan Viljoen Game Reserve, (Windhoek), S W A, 22°36'S 16°47'E

De Jager 279, (Gobabis), S W A, 23°13'S 18°44'E

De Jager 279, (Gobabis), S W A, 23°13'S 18°44'E

De Waal 22, (Gobabis), S W A, 23°22'S 18°53'E

Djab 26, (Windhoek), S W A, 23°16'S 16°12'E

Döbra 49, (Windhoek), S W A, 22°24'S 17°06'E

Dolondolo, A, 13°±45'S 13°00+'E

Donkins Bay, C, 31°55'S 18°16'E

Dreylingen farm 48, (Bethanien), S W A, 26°10'S 17°01'E

Düdoabib Ost 57, (Windhoek), S W A, 23°13'S 17°39'E

Duineveld, (Rehoboth), S W A, 23°55'S 17°32'E

Dunedin Star, Skeleton Coast, S W A, 18°13'S 11°56'E

Eava 383, (Gobabis), S W A, 22°06'S 18°58'E

Elandshoek 771, Otavi Highlands, (Tsumeb), S W A, 19°26'S 17°42'E

Emeritus 123, (Karibib), S W A, 23°00'S 15°46'E

Epukiro Reserve 268, (Gobabis), S W A, 21°43'S 19°05'E

Erongo Mts, (Omaruru), S W A, 21°40'S 15°40'E

Erongo West 83, (Omaruru), S W A, 21°40'S 15°50'E

Eros 69, (Windhoek), S W A, 22°32'S 17°07'E

Espinheira, A, 16°46'S 12°24'E

Excelsior 286, (Windhoek), S W A, 22°27'S 17°38'E

Fazenda Valle, Sobreiro, Moçamedes, A, 15°00'+S 12°±15'E

Finkenstein 71, (Windhoek), S W A, 22°35'S 17°16'E

Fish River Canyon, (Karasburg), S W A, 27°37'S 17°37'E

Fonteine 717, Damaraland, S W A, 20°20'S 14°06'E

Fransfontein, Damaraland, S W A, 20°13'S 15°00'E

Frischgewaagd 289, (Windhoek), S W A, 22°32'S 17°50'E
Gaerdes F. Nature Park, (Okahandja), S W A, 21°52'S 17°03'E
Gamkarab 176, (Outjo), S W A, 20°01'S 16°23'E
Ganab, (Walvis Bay), S W A, 23°07'S 15°35'E
Gasib, Etosha Game Park, (Outjo), S W A, 19°19'S 16°14'E
Gautscha Pan, Bushmanland, S W A, 19°48'S 20°32'E
Gemsbokvlakte, Etosha Game Park, (Outjo), S W A, 19°13'S 16°07'E
Ghaub 47, Otavi Highlands, (Tsumeb), S W A, 19°29'S 17°41'E
Ghobab 381, (Rehoboth), S W A, 23°26'S 17°21'E
Goais 13, 8 km S of Helmeninghausen, (Bethanien), S W A, 25°56'S 16°57'E
Gobabeb, Namib Desert Park, (Walvis Bay), S W A, 23°34'S 15°03'E
Göllschau 20, (Windhoek), S W A, 23°18'S 16°33'E
Goodhouse, C, 29°S 18°13'E
Goreangab Dam, (Windhoek), S W A, 22°32'S 17°02'E
Gorob Mine, Namib Desert Park, (Walvis Bay), S W A, 23°33'E 15°25'E
Gorrasis 99, (Maltahöhe), S W A, 25°24'S 15°58'E
Grootberg 191, Damaraland, S W A, 19°46'S 14°15'E
Groot Kolk, C, 24°54'S 20°06E
Grosse Bucht, (Luderitz), S W A, 26°45'S 15°06'E
Grünau, (Karasburg), S W A, 27°47'S 18°20'E
Guibes, or Kuibis, (Bethanien), S W A, 26°41'S 16°52'E
Guruchab, (Keetmanshoop), S W A, 26°30'S 18°50'E
Halali, Etosha Game Park, (Tsumeb), S W A, 19°02'S 16°28'E
Hanaus, Namaland, (Mariental), S W A, 25°15'S 17°42'E
Hardap Dam, (Mariental), S W A, 24°30'S 17°52'E
Hartmannberge, Kaokoland, S W A, 17°30'S 12°23'E
Hazeldene, (Outjo), S W A, 19°22'S 14°38'E
Heide 407, (Rehoboth), S W A, 23°31'S 17°22'E

Hentiesbaai, (Swakopmund), S W A, 22°08'S 14°18'E

Heusis 329, (Windhoek), S W A, 22°37'S 16°42'E

Hoachanas 120, (Mariental), S W A, 23°56'S 18°04'E

Hoanib riv. mouth, Skeleton coast Park, S W A, 19°27'S 12°44'E

Hoas 273, (Outjo), S W A, 19°55'S 14°45'E

Hoasas 16, (Otjiwarongo), S W A, 20°20'S 16°36'E

Hobas 374, 16 km East of Great Fish riv. canyon, (Karasburg), S W A, 27°38'S 17°46'E

Hoffnung 66, (Windhoek), S W A, 22°27'S 17°11'E

Hohenheim 24, (Windhoek), S W A, 23°16'S 16°22'E

Homob, Etosha Game Park, (Outjo), S W A, 19°03'S 16°13'E

Hondeklipbaai, C, 30°19'S 17°16'E

Hoogland 132, (Maltahöhe), S W A, 24°45'S 16°14'E

Hottentot Bay, Diamond Area, (Luderitz), S W A, 26°07'S 14°57'E

Houmoed, C, 26°22'S 20°31'E

Huabmond, Skeleton coast Park, (Swakopmund), S W A, 20°55'S 13°26'E

Huams 67, (Maltahöhe), S W A, 25°36'S 17°03'E

Huns 106, (Bethanien), S W A, 27°22'S 17°14'E

Iona, A, 16°50'S 12°20'E

Isabis 19, (Windhoek), S W A, 23°25'S 16°30'E

Jakkalsputs, Richtersveld, C, 28°39'S 16°55'E

Jansdraai, C, 25°53'S 20°49'E

Kakaokroon 487, Damaraland, S W A, 20°23'S 14°50'E

Kake, (Caprivi Strip), S W A, 18°05'S 21°31'E

Kam Rivier, (Rehoboth), S W A, 24°08'S 16°50'E

Kamanjab, (Outjo), S W A, 19°37'S 14°47'E

Kameelsleep, C, 25°50'S 20°44'E

Kamkas 20, (Maltahöhe), S W A, 24°36'S 16°33'E

Kamombonde Oos 86, (Omaruru), S W A, 21°34'S 16°03'E

Kangas 371, (Rehoboth), S W A, 23°36'S 17°03'E

Kaoko Otavi, Kaokoland , S W A, 18°18'S 13°42'E

Kapako, Kavango , S W A, 18°01'S 21°23'E

Karasburg, (Karasburg), S W A, 28°01'S 18°45'E

Katima Molilo, (Caprivi Strip), S W A, 17°30'S 24°16'E

Keetmanshoop, (Keetmanshoop), S W A, 26°35'S 18°08'E

Keilberg 743, Otavi Highlands, (Grootfontein), S W A, 19°34'S 17°40'E

Keimasmund 88, (Karasburg), S W A, 28°47'S 19°11'E

Keres 39, (Windhoek), S W A, 22°38'S 16°55'E

Khorixas, formerly Welwitchia, Damaraland, S W A, 20°22'S 14°56'E

Khumib River, Skeleton coast Park, S W A, 18°53'S 12°24'E

Kiriis 233, (Keetmanshoop), S W A, 26°24'S 19°40'E

Klein Aub 350, (Rehoboth), S W A, 23°48'S 16°39'E

Klein Karasburg, (Keetmanshoop), S W A, 27°17'S 18°05'E

Klein-Skrypan, C, 26°09'S 20°16'E

Klein Windhoek, (Windhoek), S W A, 22°35'S 17°08'E

Koa Valley, ± 21 km S W of Goodhouse, C, 29°04'S 18°06'E

Kochena 308, (Keetmanshoop), S W A, 27°01'S 18°49'E

Koichab Pan, (Luderitz), S W A, 26°18'S 15°36'E

Koichab River Bed, (Luderitz), S W A, 26°15'S 16°05'E

Kolmanskop, (Luderitz), S W A, 26°43'S 15°15'E

Kongola, (Caprivi Strip), S W A, 17°45'S 23°25'E

Kos 28, (Windhoek), S W A, 23°16'S 16°08'E

Kranzberg 59, (Karibib), S W A, 21°58'S 15°39'E

Kub, (Mariental), S W A, 24°17'S 17°30'E

Kuboos, Richtersveld, C, 28°26'S 16°59'E

Kubub 15, (Luderitz), S W A,	26°44'	16°17'E
Kuibis, (Bethanien), S W A,	26°41'S	16°52'E
Kuibis North 168, (Bethanien), S W A,	26°28'S	16°48'E
Kuiseb Canyon, (Walvis Bay), S W A,	23°35'S	15°35'E
Kuiseb River Bed, near Gobabeb, (Walvis Bay), S W A,	23°35'S	15°03'E
Kuyper 666, Damaraland , S W A,	20°00'S	14°23'E
Kwang , C,	25°20'S	20°30'E
Leonardville, (Gobabis), S W A,	23°31'S	18°50'E
Lichtenstein Mitte 366, (Windhoek), S W A,	22°48'S	16°58'E
Louwshoop 330, (Karasburg), S W A,	28°07'S	18°07'E
Lucira, A,	13°54'S	12°44'E
Lüderitzbucht, (Luderitz), S W A,	26°35'S	15°10'E
Makalani 191, Grootberg Mts area, Damaraland, S W A,	19°45'S	14°14'E
Makambu, Kavango, S W A,	17°27'S,	18°28'E
Makarikari Pans, now Makgadkgadi, B,	20°40'S	25°40'E
Maltahöhe, (Maltahöhe), S W A,	24°50'S	16°59'E
Maluila, A,	15°±30'S	13°00+'E
Mara 114, (Bethanien), S W A,	27°50'S	17°20'E
Marienfluss, Marien riv., Kaokoland, S W A,	17°08'S	12°17'E
Mariental, (Mariental), S W A,	24°38'S	17°58'E
Mata Mata, C,	25°53'S	20°01'E
Matchless Myn, (Windhoek), S W A,	22°42'S	17°19'E
Meob Bay Camp, (Walvis Bay), S W A,	24°42'S	14°47'E
Messum Crater area, Damaraland, S W A,	21°16'S	14°13'E
Mile 14, (Swakopmund), S W A,	22°28'S	14°28'E
Mocamedes, A,	15°10'S	12°10'E
Molepolole, B,	24°25'S	25°32'E
Molteblick, Moltkeblick, (Windhoek), S W A,	22°39'S	17°10'E

Mooiriver , (Bethanien), S W A, 27°21'S 17°20'E

Moravet, C, 25°28'S 20°30'E

Möwebaai, 4 km N of, Skeleton coast Park, S W A, 19°19'S 12°40'E

Möwebaai, 8 km NE of, Skeleton coast Park, S W A, 19°17'S 12°42'E

Möwebaai, Möwe Point, Skeleton coast Park, S W A, 19°20'S 12°43'E

Mukorob 14, Namaland, (Keetmanshoop), S W A, 25°32'S 18°09'E

Nabas, C, 28°18'S 17°20'E

Namuskluft 88, (Luderitz), S W A, 27°53'S 16°50'E

Namutoni, (Tsumeb), S W A, 18°48'S 16°56'E

Narib 4, (Maltahöhe), S W A, 24°04' 16°03E

Narudas Süd 268, (Karasburg), S W A, 27°22'S 18°51'E

Naukluft Mts., (Maltahöhe), S W A, 24°10'S 16°10'E

Naus 27, (Bethanien), S W A, 25°48'S 16°30'E

Nauzerus 229, (Rehoboth), S W A, 23°51'S 16°19'E

Neisip 34, (Luderitz), S W A, 26°17'S 16°35'E

Neuland 98, (Luderitz), S W A, 26°11'S 16°19'E

Noachabeb 97, (Keetmanshoop), S W A, 27°24'S 18°30'E

Noordoewer, (Karasburg), S W A, 28°42'S 17°36'E

Nossob Rest Camp, C, 25°25'S 20°37'E

Nowantes, Kaokoland, S W A, 18°19'S 12°51'E

Nubuamis 37, (Windhoek), S W A, 22°28'S 17°04'E

Numaskloof, Brandberg Mts., Damaraland, S W A, 21°07'S 14°24'E

Numasplato, Damaraland, S W A, 21°08'S 14°30'S

Numasvallei, Damaraland, S W A, 21°07'S 14°24'E

Obib Berge, (Luderitz), S W A, 28°05'S 16°45'E

Obibwasser, (Luderitz), S W A, 28°00'S 16°40'E

Ohopoho, Kaokoland, S W A, now called: Opuwa

Okahandja, (Okahandja), S W A, 21°58'S 16°56'E

Okamiparara 335, (Otjiwarongo), S W A, 20°25'S 17°28'E

Okaukuejo, Etosha Game Park, (Outjo), S W A, 19°11'S 15°53'E

Okawao, Etosha Game Park, (Outjo), S W A, 18°59'S 14°43'E

Okodeka, Etosha Game Park, (Outjo), S W A, 18°59'S 15°49'E

Okonjembo, Kaokoland, S W A, Now called Nowantes

Omaruru, (Omaruru), S.W A, 21°26'S 15°56'E

Omaruru riv. mouth, (Swakopmund), S W A, 22°05'S 14°14'E

Omatjenguma, Kaokoland, S W A, 17°58'S 12°21'E

Ombazu, Kaokoland, S W A, 17°43'S 13°47'E

Ombombo-Ovambo, Kaokoland, S W A, 17°59'S 14°15'E

Ombu 130, (Omaruru), S W A, 21°41'S 15°41'E

Onanis 121, (Karibib), S W A, 22°48'S 15°42'E

Oncocua, A, 16°34'S 13°28'E

Ondarusu, near Kunene riv. Kaokoland, S W A, 17°25'S 13°55'E

Onderste Narries Farm, C, 28°34'S 19°50'E

Onguati 236, Damaraland, S W A, 19°46'S 14°38'E

Onguma 314, (Tsumeb), S W A, 18°44'S 17°03'E

Onverwag 412, Ugab riv. Bridge, Damaraland, S W A, 20°49'S 14°58'E

Onze Rust 192, (Mariental), S W A 24°07'S 18°00'E

Opuwa, formerly Ohopoho, Kaokoland, S W A, 18°04'S 13°51'E

Orongo, Owambo, S W A, 17°40'S 15°17'E

Ortmansbaum Farm 120, (Karasburg), S W A, 28°19'S 18°43'E

Orumana, Kaokoland, S W A, 18°15'S 13°54'E

Orupembe, also see Anabib waterhole, Kaokoland, S W A, 18°11'S 12°31'E

Oshakati, Owambo, S W A, 17°47'S 15°42'E

Otjewi, Kaokoland, S W A, 17°29'S 13°56'E

Otjijangasemo, Kaokoland, S W A, 17°27'S 13°15'E

Otjikoko-Süd 67, (Omaruru), S W A, 21°19'S 16°23'E

Otjikoto, (Tsumeb), S W A, 19°11'S 17°33'E

Otjinungwa, Kaokoland, S W A, 17°55'S 12°20'E

Otjitambi 25, (Outjo), S W A, 19°49'S 15°10'E

Otjitanda, Kaokoland, S W A, 17°38'S 12°46'E

Otjitundua, Kaokoland, S W A, 18°39'S 14°14'E

Otjituo, Hereroland, S W A, 19°40'S 18°36'E

Otjombaue, Damaraland, S W A, 21°23'S 15°10'E

Outjo, (Outjo), S W A, 20°07'S 16°09'E

Ovambo Grens, Owambo, S W A, 18°30'S 16°45'E

Palmfontein farm, Grootberg Mts. area, Damaraland, S W A, 19°40'S 14°14'E

Pastoril do Sul, Moçamedes, A, 15°±15'S 12°±30'E

Paulinenhof 72, (Windhoek), S W A, 22°40'S 17°17'E

Pella Mission, C, 28°59'S 19°10'E

Perdepan 516, (Gobabis), S W A, 23°40'S 19°00'E

Plaas 631, (Outjo), S W A, 19°23'S 14°44'E

Plateau 38, (Luderitz), S W A, 26°40'S 16°30'E

Pofadder, C, 29°08'S 19°23E

Pollentswa Riv. 5 Miles from Nossob riv., B, 25°05'S 20°26'E

Popa Falls, Kavango, S W A, 18°07'S 21°33'E

Port Nolloth, C, 29°15'S 16°52'E

Porto Alexandre, A, 15°50'S 11°51'E

Portsmut 33, Hakos Mts., (Windhoek), S W A, 23°11'S 16°24'E

Praia Madalena, Moçamedes, A, 14°±30'S 12°±15'E

Purros, Kaokoland, S W A, 18°47'S 12°55'E

Quibis, see Kuibis

Ramboekas Pan, B, 24°47'S 20°15'E

Regenstein 32, (Windhoek), S W A, 22°44'S 17°00'E

Rehoboth, (Rehoboth), S W A, 23°19'S 17°05'E

Rehoboth, 5 km W of, (Rehoboth), S.W.A, 23°23'S 17°00'E

Remhoogte 227, (Maltahöhe), S W A, 23°58'S 16°17'E

Richthofen 126, (Windhoek), S W A, 22°34'S 17°45'E

Richtersveld, C, 28°15'S 17°10'E

Rietfontein, Hereroland, S W A, 21°54'S 20°55'E

Rocky point, Skeleton coast Park,S W A, 19°01'S 12°29'E

Rooibank, (Walvis Bay), S W A, 23°12'S 14°41'E

Rooiberg 70, (Luderitz), S W A, 27°09'S 16°47'E

Rooibrak, C, 26°03'S 20°27'E

Rooikop, Namib Desert Park, (Walvis Bay), S W A, 22°59'S 14°40'E

Rosh Pinah, (Luderitz), S W A 27°58'S 16°44'E

Rossing Mts., (Swakopmund), S W A, 22°30'S 14°36'E

Rostock 393, (Windhoek), S W A, 23°22'S 15°55'E

Ruacana, Owambo, S W A, 17°23'S 14°15'E

Rudenau Nord 6, (Okahandja), S W A, 22°05'S 16°42'E

Rundu, Kavango, S W A, 17°55'S 19°43'E

Sa da Bandeira, Huila, A, 14°54'S 13°35'E

Saddle Hill, (Luderitz), S W A, 25°54'S 14°55'E

Saffier 148, (Maltahöhe), S W A, 25°27'S 16°06'E

Samahaling 277, (Keetmanshoop), S W A, 27°02'S 19°35'E

Samangeigei, Kavango, S W A, 19°06'S 20°12'E

Sandamap 64, Damaraland, S W A, 21°56'S 15°16'E

Sandmund 270, (Karasburg), S W A, 27°17'S 18°57'E

Sangwali, (Caprivi Strip), S W A, 18°17'S 23°37'E

Sanitatas, Kaokoland, S W A, 18°17'S 12°40'E

Sarusas, Skeleton coast Park, S W A, 18°50'S 12°30'E

Scheidthof 293, (Windhoek), S W A, 22°42'S 18°03'E

Schwarzkuppen 104, (Keetmanshoop), S W A, 27°23'S 18°20'E

Sesfontein, Kaokoland, S W A, 19°07'S 13°36'E

Sesriem 137, (Maltahöhe), S W A, 24°33'S 15°50'E

Seven Pans,C, 25°26'S 20°22'E

Simon De Wit Bridge, (Grootfontein), S W A, 19°34'S 18°07'E

Sissekab 54, (Grootfontein), S W A, 19°19'S 17°12'E

Skaap River, (Keetmanshoop), S W A, 26°37'S 18°07'E

Smithfield Beach, (Luderitz), S W A, 26°35'S 15°09E

Spencer Bay, (Luderitz), S W A, 25°43'S 14°50'E

Spencer Bay Water, (Luderitz), S W A, 25°47'S 14°54'E

Spitzkoppe Gross -, Farm 71 and Mts., Damaraland, S W A, 21°50'S 15°10'E

Spitzkoppe Klein -, Damaraland, S W A, 21°50'S 15°05'E

Springbok, C, 29°40'S 17°53'E

Springbokvlakte, C, 28°23'S 17°04'E

Sterkstroom 320, (Keetmanshoop), S W A, 25°43'S 19°19'E

Sukses Dam, Etosha Game Park, (Outjo), S W A, 18°59'S 15°29'S

Sutherland, C, 32°24'S 20°40'E

S.W.A. Admin. Borehole 6453, Bushmanland, S W A, 19°22'S 19°37'E

Swakopmund, (Swakopmund), S W A, 22°41'S 14°32'E

Swakop riv. bed, 20 km from Swakopmund, (Swakopmund), S W A, 22°39'S 14°44'E

Swakop riv. Canyon, (Swakopmund), S W A, 22°47'S 15°04'E

Swakop riv. mouth, (Swakopmund), S W A, 22°41'S 14°33'E

Swartbaas West 276, (Keetmanshoop), S W A, 27°01'S 19°42'E

Swartberg, (Luderitz), S W A, 27°08'S 15°26'E

Swartbooisdrift, Cunene riv., Kaokoland, S W A, 17°20'S 13°52'E

Swartmodder farm, C, 27°58'S 20°34'E

Swartpoort, Richtersveld near Ochta, C, 28°07'S 16°56'E

Tantus 30, (Windhoek), S W A, 23°08'S 16°15'E

Tinkas Mts., (Karibib), S W A, 22°43'S 15°29'E

Tinkas Plains, (Swakopmund), S W A, 22°50'S 15°25'E

Torra Bay, Skeleton coast Park, (Swakopmund), S W A, 20°12'S 13°11'E

Torra Bay, 30 km SE of, (Swakopmund), S W A, 20°23'S 13°22'E

Toz Du Cunene, A, 17°16'S 11°48'E

Trekkopje 120, (Karibib), S W A, 22°19'S 15°07'E

Truidia 300, (Outjo), S W A, 19°32'S 15°20'E

Tses, (Keetmanshoop), S W A, 25°53'S 18°07'E

Tsirub 13, (Luderitz), S W A, 26°52'S 16°02'E

Tsotsana, Kavango, S W A, 19°04'S 20°47'E

Tsuwandes 107, (Outjo), S W A, 20°13'S 15°38'E

Tumas Mountains, Namib Desert Park,(Walvis Bay), S W A, 23°07'S 15°30'E

Twee Rivieren, C, 26°30'S 20°35'E

Twilight, (Mariental), S W A, 24°17'S 17°50'E

Twilight 113, (Mariental), S W A, 24°12'S 17°56'E

Twyfelfontein 584, Damaraland, S W A, 20°35'S 14°22'E

Ugab Drift, Damaraland, S W A, 20°59'S 14°47'E

Ugab River Bridge, See Onverwag farm

Ugab riv. mouth, (Swakopmund), S W A, 21°12'S 13°36'E

Uis, Damaraland, S W A, 21°09'S 14°47'E

Uitsig 82, (Bethanien), S W A, 27°37'S 17°10'E

Unjab River, 3 km from river mouth, (Swakopmund), S W A, 20'09'S 13°13'E

Unjab river mouth, 10 km N of, (Swakopmund), S W A, 20°06'S 13°06'E

Unjabmond, (Swakopmund), S W A, 20°09'S 13°10'E

Upington, 8 km NW of, C, 28°31'S 21°05'E

Us 162, (Karasburg), S W A, 27°25'S 18°38'E

Vaalbank 319, (Mariental), S W A, 23°56'S 18°55'E

Valencia 42, Hakos Mts., (Windhoek), S W A, 23°11'S 16°30'E

Vanzylsrus, C, 26°52'S 22°04'E

Vioolsdrift, (Karasburg), S W A, 28°46'S 17°37'E

Visrivier, near Uis Mine, Damaraland, S W A, 21°09'S 14°47'E

Vrede 719, Damaraland, S W A, 20°23'S 14°14'E

Vredenhof 301, (Karasburg), S W A, 27°37'S 18°48'E

Waltersdorf 202, (Grootfontein), S W A, 19°54'S 18°21'E

Walvis Bay, (Walvis Bay), S W A, 22°56'S 14°29'E

Warmbad, (Karasburg), S W A, 28°27'S 18°44'E

Warmquelle (Kaokoland), S W A, 19°10'S 13°16'E

Wasservalle 382, (Windhoek), S W A, 22°55'S 16°25'E

Waterberg 416, (Otjiwarongo), S W A, 20°31'S 17°16'E

Welwitchia, (Outjo), S W A, see Khorixas

Wilhelmstal 8, (Karibib), S W A, 21°54'S 16°20'E

Williston, C, 31°21'S 20°55'E

Windhoek, (Windhoek), S W A, 22°34'S 17°06'E

Witmanshaar 25, (Bethanien), S W A, 25°48'S 16°42'E

Wlotzkas Baken, (Swakopmund), S W A, 22°25'S 14°28'E

Zebrafontein, Damaraland, S W A, 20°39'S 15°14'E

Zebra Mountains, Kaokoland, S W A, 17°08'S 13°27'E

Zebra Pan, Namib Desert Park (Walvis Bay), S W A, 23°30'S 15°29'E

Zuidrivier, Namib Desert Park, (Walvis Bay), S W A, 23°32'S 15°00'E

Zwartbank, (Walvis Bay), S W A, 23°22'S 14°54'E

Symp. zool. Soc. Lond. (1978) No. 42, 171–181

Soil Hardness, an Important and Limiting Factor in Burrowing Scorpions of the Genus *Opisthophthalmus* C. L. Koch, 1837 (Scorpionidae, Scorpionida)

B. H. LAMORAL

Natal Museum, Pietermaritzburg, South Africa

SYNOPSIS

All scorpions of the genus *Opisthophthalmus* find shelter by digging burrows in the ground. Field and laboratory data show that habitat selection, distribution and range of each species investigated are directly correlated to a particular soil type. The most important factors affecting soil type selection are soil hardness or strength, and, to a much lesser and variable extent, texture, but not specific and exclusive geological composition.

Arbitrary categories of soil hardness are designated, with the first and last categories representing the softest and hardest burrowing substrata, respectively, for the species of *Opisthophthalmus* investigated. Each category is delimited by a range of soil hardness measurements expressed in $\mathrm{kg\,cm^{-2}}$. Soils in which scorpions burrow can be classified within one or more of these categories.

Soils tested were analysed for percentage content of clay, silt and sand and their textural classes determined from Loxton's (1961) standard chart. No direct correlation between soil textural classes and hardnesses could be found.

The data collected on surface soil hardness reveal that in all cases where populations of two or more species are adjacent or partially sympatric, definite intraspecific hardness requirements and interspecifically non-overlapping hardness categories ensure that these species are ecologically entirely allopatric; thus avoiding competition for burrowing sites. In species with distribution ranges that never overlap, the intraspecific hardness requirements do overlap in some cases, but this is of no consequence as these species are totally allopatric in any case.

Additional implications and sensory mechanisms possibly involved in soil hardness discrimination are discussed.

INTRODUCTION

Habitat selection and distribution of species in scorpions, as in other animals, is governed by an interaction of various ecological factors, and the survival of populations is dependent on the following three prerequisites: (1) food, (2) reproduction and (3) shelter from adverse climate and predators.

All scorpions of the genus *Opisthophthalmus* find shelter by digging burrows in the ground, and the main objectives of this paper are:

(1) to determine whether habitat selection, distribution and range of species are correlated to a soil type;
(2) to determine the more important factors affecting soil type selection;
(3) to establish widely applicable parameters for (2);
(4) to investigate the effects of (1) on apparently sympatric species.

All fieldwork described was carried out while conducting a survey on the systematics of the scorpion fauna of South West Africa.

MATERIAL AND METHODS

Data were obtained for 19 of the ~~28~~ 24 species of *Opisthophthalmus* occurring in South West Africa. *O. carinatus* (Peters, 1861) and *O. wahlbergi* (Thorell, 1876) are used in this paper to illustrate the results and conclusions found to apply to other species investigated. The results obtained for other species are reported in a paper in preparation.

The main factor responsible for the hardness of the soil is the cohesive force holding its component particles together. Hence the greater the cohesive forces between soil particles, the harder the soil and the greater the force required to penetrate or break up this soil in activities such as burrowing.

Soil hardnesses were measured using either a "clockhouse C. 50" pocket penetrometer or a "proctor" penetrometer as described by Davidson (1965: 472–478). Penetrometers measure resistance to vertical penetration. All the penetration force readings obtained are expressed in kg cm^{-2} and were taken from undisturbed dry soil around burrow entrances. Readings were also taken from undisturbed soil at different levels below surface and at the bottom of excavated burrows.

Soil samples from the substrata investigated were brought back for laboratory use. Twelve were analysed for percentage content of clay, silt and sand using the hydrometer technique described by Day (1965). Their textural classes were determined from Loxton's (1961) standard chart, to investigate any possible correlation with soil hardness.

The soil samples were also used in vivaria and choice chambers to test horizontal surface selection of soil hardness.

RESULTS

Soil Hardness Categories

Dry soils

Using soil hardness as a criterion, soils in which burrowing scorpions were found are classified as in Table I. Consecutive arbitrary categories of soil hardnesses, represented by Roman numerals, are designated,

TABLE 1

Soil categories classified according to hardness ranges expressed as penetration force ranges

Categories	Penetration force ranges in kg cm^{-2}	Categories	Penetration force ranges in kg cm^{-2}
I	0·02–0·1	XII	8·1– 9
II	0·11–0·5	XIII	9·1–10
III	0·51–1·0	XIV	10·1–12
IV	1·01–1·5	XV	12·1–14
V	1·51–2·0	XVI	14·1–16
VI	2·1 –3	XVII	16·1–18
VII	3·1 –4	XVIII	18·1–20
VIII	4·1 –5	XIX	20·1–22
IX	5·1 –6	XX	22·1–24
X	6·1 –7	XXI	24·1–26
XI	7·1 –8	XXII	26·1–28

with the first and last categories representing the softest and hardest burrowing substrata respectively. Each category is delimited by a range of dry soil hardness measurements expressed in kg cm^{-2}. Soils tested for each species were then classified within one or more of these categories.

Readings taken from dry soils at different levels below surface and at the bottom of excavated burrows were found to fall well within the range obtained for surface readings, as shown in Table II.

Damp soils

Readings obtained from slightly damp soils at the bottom of certain burrows tended to be lower than those from dry surface soils, as exemplified by readings for samples 6 and 8 in Table II. Davidson (1965: fig. 37–3) illustrates the relation of water content of soil to penetration resistance and shows that an increase in water content decreases penetration resistance. This factor has not been taken into consideration in the present survey as it is felt that presence of or increases in moisture content are too irregular and inconsistent, in an arid region such as South West Africa, to represent a significant factor. It does, however, mean that in a few instances, a species may be able to colonize areas with harder soils after a heavy and penetrating rainfall.

Soil Hardness and Textural Classes

The results obtained for the 12 soil samples, textural class analysis and concurrent hardnesses are shown in Table II. A direct correlation between textural classes and hardness of soils would require that: (1) the

TABLE II

Results obtained from soil sample analyses and soil hardness readings (soil textural classes following Loxton, 1961)

					Range of penetrometer readings in kg cm^{-2} as a measure of soil hardness	
Sample	Clay (%)	Silt (%)	Sand (%)	Soil textural class	Surface	Bottom of burrow
1	7	12·7	80·3	Sandy loam	15–17	14–16
2	8·5	5·6	85·9	Loamy sand	23–25	23–25
3	8·5	8·5	83	Sandy loam	3–4	3–4
4	5·6	2·8	91·6	Sand	1·5–2	1·5–2
5	14·1	7·1	78·8	Sandy loam	3–3·5	3–3·5
6	12·7	33·9	53·4	Silt loam	4–5	2–3(*)
7	2·8	Nil	97·2	Sand	1–1·5	1·5–2
8	8	10	82	Sandy loam	8–9	4–5(*)
9	2·8	8·5	88·7	Loam sand	1·8–3	2–4
10	5·6	2·8	91·6	Sand	2·5–3·5	2·5–3·0
11	Nil	1·4	98·6	Sand	1·5–2	1·5–2
12	1·4	Nil	98·6	Sand	0·3–0·5	0·4–0·7

* Slightly damp soil.

penetrometer readings obtained for any particular textural class should fall within a constant range and (2) soils with high sand and low clay and silt percentage contents should yield low penetrometer readings and conversely soils with higher clay and silt (particularly the former) and lower sand contents should yield higher penetrometer readings.

The results in Table II strongly illustrate that such requirements are not met and that no direct correlation exists. Results for samples 1 and 5, both sandy loams, show this lack of correlation. If anything, one would anticipate a higher range of penetrometer readings for sample 5 than for 1 as the former had significantly higher clay and lower sand content than the latter. Other examples of lack of correlation are provided by comparing samples 2 and 9, 10 and 12 and 2 and 6 where the last has the highest clay and silt content recorded for any of the 12 samples analysed.

The reasons for this lack of correlation are unknown and probably stem from a variety of factors such as variable degree of compaction, soil pH and presence or absence of certain inorganic chemicals which affect cohesive forces between soil particles.

Had there been a correlation between the hardness and textural classes of soils, one could have allocated groups of the soil categories in Table I to each of the textural classes described by Loxton (1961), but the lack of correlation demonstrated has shown that this would be misleading in a significant number of cases.

Surface Soil Selection

Field data

The data plotted in Fig. 1 illustrate burrow frequency for penetrometer reading ranges taken around 50 burrows each of adjacent populations of *O. wahlbergi* and *O. carinatus*. Figure 2 indicates the location and distribution of the burrows from which sample readings for Fig. 1 were obtained as well as the 30 m × 4 m strip transected for data plotted in Fig. 3. This strip was transected to test the extent to which burrowing site selection might be influenced by the proportional availability of different soil hardnesses in the total area investigated.

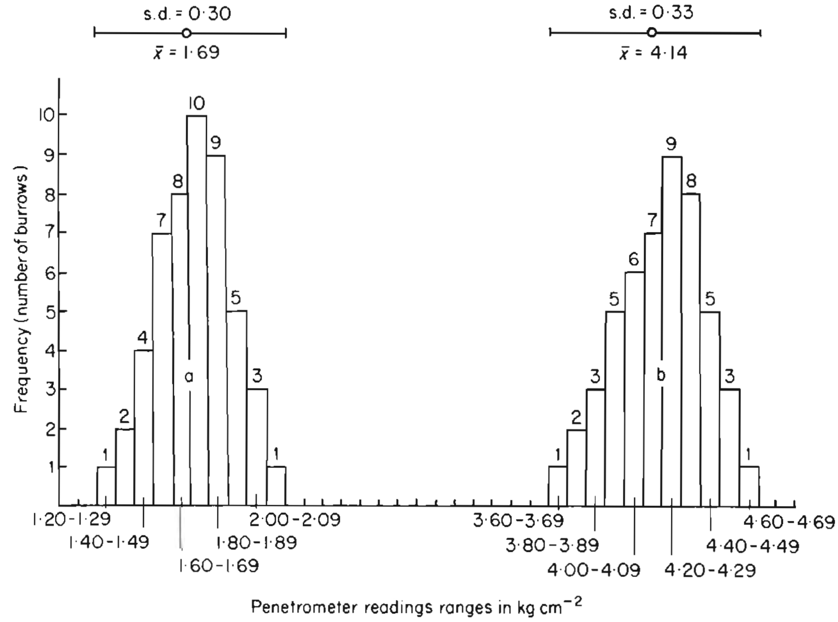


FIG. 1. Histograms for the distributions of (left) the 50 burrows of *Opisthophthalmus wahlbergi* and (right) the 50 burrows of *O. carinatus* mapped in Fig. 2.

Figure 1 shows that individuals of *O. wahlbergi* dug their burrows only in soil with surface hardness ranges of categories IV and V and *O. carinatus* within ranges of categories VII and VIII. Figure 2 shows the distinct ecological allopatry of the two species investigated and Fig. 3 indicates a definite tendency for a higher frequency of burrows on surfaces with hardness readings near the optimal conditions indicated in Fig. 1 for *O. carinatus*. Transects carried out for *O. wahlbergi* and six other species of *Opisthophthalmus* yielded similar conclusions, namely that there is a high primary intraspecific tendency to select burrowing substrata that fall within a specific range of hardness and that there is a

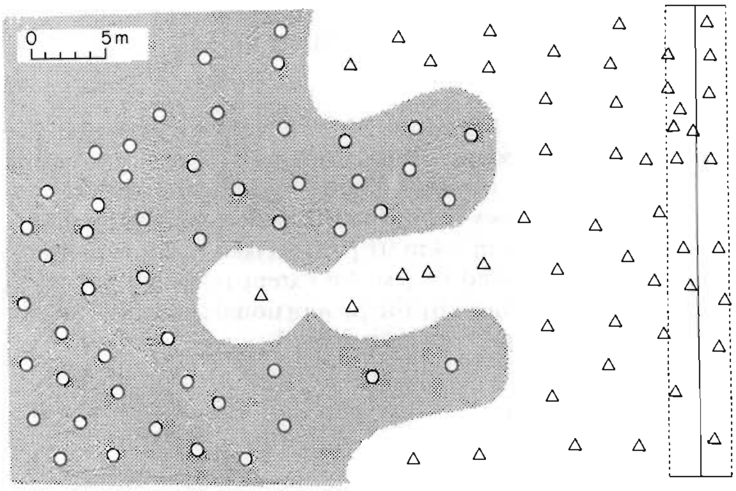


FIG. 2. Distribution of 50 burrows of *Opisthophthalmus wahlbergi* (○) and *O. carinatus* (△) from which penetrometer readings in Fig. 1 were taken. Stippled area represents soil surface with category ranges III–V and unstippled VII–IX. Total area surveyed 1440 m^2. The area transected for the data in Fig. 3 is delimited by broken lines. Scale as indicated.

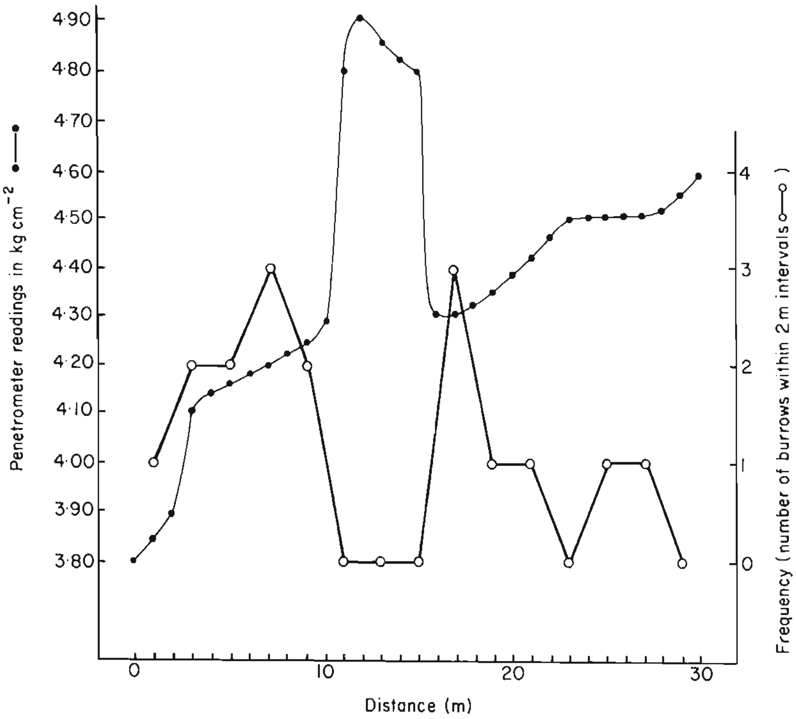


FIG. 3. Results of the transect delimited in Fig. 2 for *Opisthophthalmus carinatus* to show relationship of burrow frequency (○) and soil hardness (●), plotted over a distance of 30 m.

secondary tendency towards optimal hardness selection within that range.

Laboratory data

Selection of surface soil hardness was tested in the laboratory with four females and four males of *O. wahlbergi* in the following manner. Three soil samples, each with a different surface hardness (below, within and above the optimum range) were randomly placed next to each other in each of 16 oblong vivaria. These were thoroughly moistened and allowed to settle and dry. Each of the eight specimens was then allowed to burrow in one of these choice chambers. The experiment was later repeated using the same specimens. The number of tests carried out and results of site selection appear in Tables III and IV. These results show that all females (Table III) burrowed in soil categories falling within the ranges recorded in field measurements (Fig. 1). The same applies to males (Table IV) except in one instance where specimen 2, choice chamber 2, burrowed in soil category VI.

Sub-Surface Soil Selection

Field measurements of soil hardnesses taken at 10 cm intervals along the underground path of burrows of 10 specimens (eight females and two males) of *O. wahlbergi* and 10 specimens of *O. carinatus* (seven females and three males) all fall within the ranges of readings recorded in Fig. 1 for each of these two species. Records of the paths followed by these burrows and penetration readings of soil in the vicinity of the path show a definite correlation between directional changes of the burrow and either increases or decreases of hardnesses outside the limits of the optimal ranges for each species. These results indicate that the paths followed by burrows of these two species are determined by selection of soil hardnesses compatible with intraspecific optimal ranges.

DISCUSSION

This discussion is based on the results described above and on those obtained for the 17 other species of *Opisthophthalmus* investigated but not reported in this paper.

The most significant finding to emerge from the data collected on soil hardness is that habitat selection distribution and range of each species is directly correlated to a range of soil hardness. Histograms of intraspecific distribution of burrows within a soil hardness range exhibit a normal distribution, as in Fig. 1, and indicate that within each range of soil hardness there is an optimal smaller range. Figure 3 indicates that there is a higher frequency of burrows in the smaller optimal hardness

TABLE III

Results of choice chamber experiments on surface soil selection for burrowing sites in females of Opisthophthalmus wahlbergi

Specimen, sex	Choice chamber	Soil category distribution in choice chamber	Soil category selected for burrow, indicated with + followed by specific category in brackets
1, ♀	1	II–III	
		IV–V	+(IV)
		VI–VII	
	2	V	+(V)
		VI–VII	
		II–III	
2, ♀	1	IV–V	+(V)
		II–III	
		VI–VII	
	2	VI–VII	
		II–III	
		IV–V	+(V)
3, ♀	1	VI	
		IV–V	+(V)
		III	
	2	VI–VII	
		III	
		IV–V	+(IV)
4, ♀	1	V	+(V)
		II–III	
		VI–VII	
	2	VII	
		IV–V	+(IV)
		III	

range because this smaller range is selected from an available wider range and not because a high percentage of the area studied consists of soil with optimal hardness range. In other words the frequency of burrows is higher in optimal soils than in sub-optimal soils within the overall range of soil hardnesses recorded for each species.

Samples taken from adjacent and sympatric populations show that the soil hardness requirement for each species is probably the most

TABLE IV

Results of choice chamber experiments on surface soil selection for burrowing sites in males of Opisthophthalmus wahlbergi

Specimen, sex	Choice chamber	Soil categories distribution in choice chamber	Soil category selected for burrow, indicated with + followed by specific category in brackets
1, ♂	1	VI	
		II–III	
		IV–V	+(V)
	2	IV–V	+(IV)
		VI	
		III	
2, ♂	1	III	
		V	+(V)
		VI	
	2	IV–V	
		VI–VII	+(VI)
		III	
3, ♂	1	VII	
		III	
		IV–VI	+(IV)
	2	IV	+(IV)
		VI	
		II–III	
4, ♂	1	II–VII	
		IV–V	+(V)
		VI	
	2	II–III	
		VI	
		IV–V	+(V)

important ecological factor controlling competition for burrow sites. This is clearly illustrated in Figs 1 and 2 for *O. wahlbergi* and *O. carinatus* and competition for burrowing sites between these two species is prevented by an interspecific difference of one category, namely category VI, and there is no overlap of any kind. Hence, one can state that in all cases where populations of two or more species are adjacent or partially sympatric, definite intraspecific hardness requirements and interspecifically non-overlapping hardness categories ensure that these species are ecologically entirely allopatric; thus avoiding competition for burrowing sites. In species with distribution ranges that never overlap, the intraspecific hardness requirements do overlap in some cases, but this is of no consequence as these species are totally allopatric in any case. For instance, the soil hardness category ranges for *O. adustus* Kraepelin, 1908 and *O. carinatus* are VI–VII and VII–VIII respectively, and therefore overlap, but these two species are totally allopatric.

In species that are widely distributed over large regions, the intraspecific soil hardness range can vary between the extremes of the range but this variation was found to be clinal. Such variation is particularly marked when the widely distributed species is sympatric with different species at opposite ends of its range. This variation probably evolved as an adaptation ensuring avoidance of competition for burrowing sites where the distribution ranges of different species meet.

Species burrowing in soft soils (low soil categories) tend to be restricted to a smaller range of soil hardness than those burrowing in very hard soils (high soil categories). The reason for this is unknown but is possibly explained by the morphological adaptations described at the end of this paper.

Intraspecific restriction of burrow sites to a particular soil hardness range has probably played an important part in the speciation of *Opisthophthalmus* and also probably explains the large number of species occurring in southern Africa.

The argument in favour of such postulation is supported by the following. The climatic and ensuing vegetational changes that have taken place during and after the last four glaciations must have caused numerous changes in soil hardnesses of the African sub-continent. Marked changes across population ranges probably acted as an intraspecific isolating mechanism and favoured subspeciation and ultimately speciation.

The sensory receptors and mechanisms used by species of *Opisthophthalmus* to select optimal soil hardnesses are a matter of conjecture at this stage. Carthy (1968) proposed that pectines function in the selection of substrata with particular sand grain size, and are therefore capable of determining soil texture. But texture as shown in this paper cannot be directly correlated to soil hardness.

All species of *Opisthophthalmus* studied are cheliceral burrowers. The chelicerae are used to break up the soil and the anterior two pairs of legs to scrape and shift excavated soil out of the burrow. Tension receptors on cheliceral muscles could transmit information on the amount of force required to break up a soil, but it is not known whether such receptors are present on these muscles. The lyriform slit sense organs present on the chelicerae and legs are probably involved.

APPENDIX 2

All the species of *Opisthophthalmus* investigated display either a small or large degree of morphological adaptation to burrowing activities. Species burrowing in hard soils have powerful chelicerae and short robust legs laterally and distally provided with rows of stout, spine-like setae distributed so as to improve functional efficiency in burrowing in this type of substrate. Psammophilous species have long and slender chelicerae, long legs with long ungues, a pad of numerous fine setae on the ventral surface of the tarsi and sweeplike rows of long setae on the anterior and posterior edges of tibia, protarsi and tarsi of legs I and II.

ACKNOWLEDGEMENTS

Fieldwork was carried out during tenure of a field running expense grant from the CSIR which also supported my attendance at this conference with a travel grant. This assistance is gratefully acknowledged. I am indebted to Mr A. Cass of the Department of Soil Science at Natal University for his advice and loan of equipment.

REFERENCES

Carthy, J. D. (1968). The pectines of scorpions. *Symp. zool. Soc. Lond.* No. 23: 251–261.

Davidson, D. T. (1965). Penetrometer measurements. In *Methods of soil analysis.* Part 1: 472–484. Black, C. A. (ed.-in-chief). (No. 9, Agronomy Series.) Madison, Wisconsin: American Soc. of Agronomy, Inc.

Day, P. R. (1965). Particle fractionation and particle-size analysis. In *Methods of soil analysis.* Part 1: 545–567. Black, C. A. (ed.-in-chief). (No. 9, Agronomy Series.) Madison, Wisconsin: American Soc. of Agronomy, Inc.

Loxton, R. F. (1961). A modified chart for the determination of basic soil textural classes in terms of the international classification for soil separates. *S. Afr. J. Sci.* **4**: 507–512.