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ECOLOGICAL ADAPTATIONS OF KRUGER NATIONAL PARK SCORPIONIDS (ARACHNIDA: SCORPIONIDES)

by

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Abstract – The morphology of scorpionids is greatly influenced by the ecological background. In the Kruger National Park, scorpions occupy various basic habitat types and accordingly afford suitable material for the study of ecological adaptations which are discussed in this paper.

Introduction

The taxonomy of Kruger National Park scorpions has been admirably dealt with by Lawrence (1955, 1964 and 1967). Ecological adaptations essential to the understanding of these scorpions have not yet received attention.

Scorpionids of the Kruger National Park are divided amongst two subfamilies, namely Scorpiininae and Ischnurinae. Ecologically considered, scorpions of these subfamilies range from lithophilous to psammophilous species and accordingly form a suitable group for the study of ecological adaptations.

Discussion

Subfamily: Ischnurinae
Genus: *Hadogenes* Kraepelin

Only one species, *Hadogenes troglodytes* (Peters), occurs in the Kruger National Park. Exfoliated granite outcrops, narrow rock crevices and cracks are the chosen habitats of this strictly lithophilous species (Figs. 1 and 2). The ecological adaptations are as follow:

1. Tarsi

Hadogenes can cling to flat rock surfaces with surprising tenacity. From the author's cinematographic studies of tarsi in action, it is evident that this grip is effected as follows. (a) The leg is lowered such that the pretarsus makes contact with the rock surface (Fig. 3a, b). The pretarsus consists of two ungues and an unguicular spine, the latter which merely

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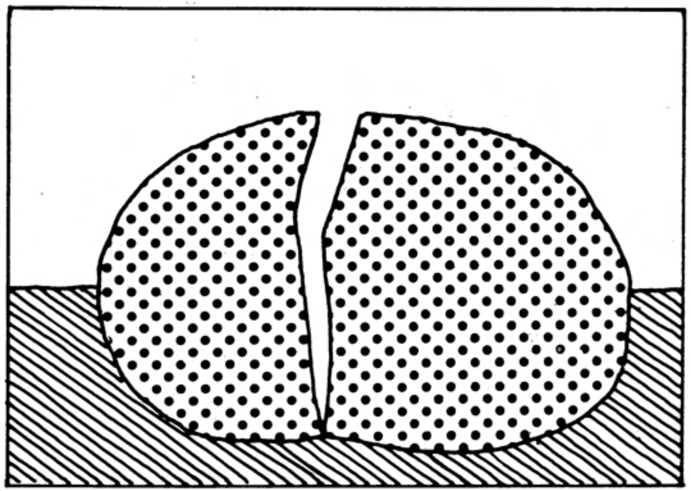

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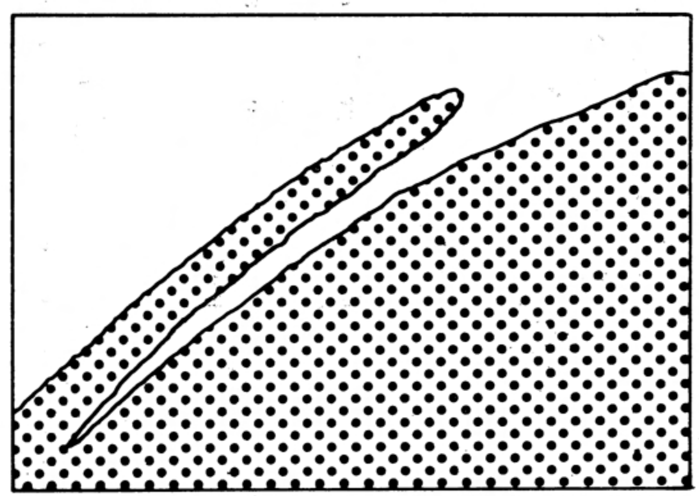

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Figs. 1 and 2. Habitats of *Hadogenes* in rock crack and exfoliated granite.

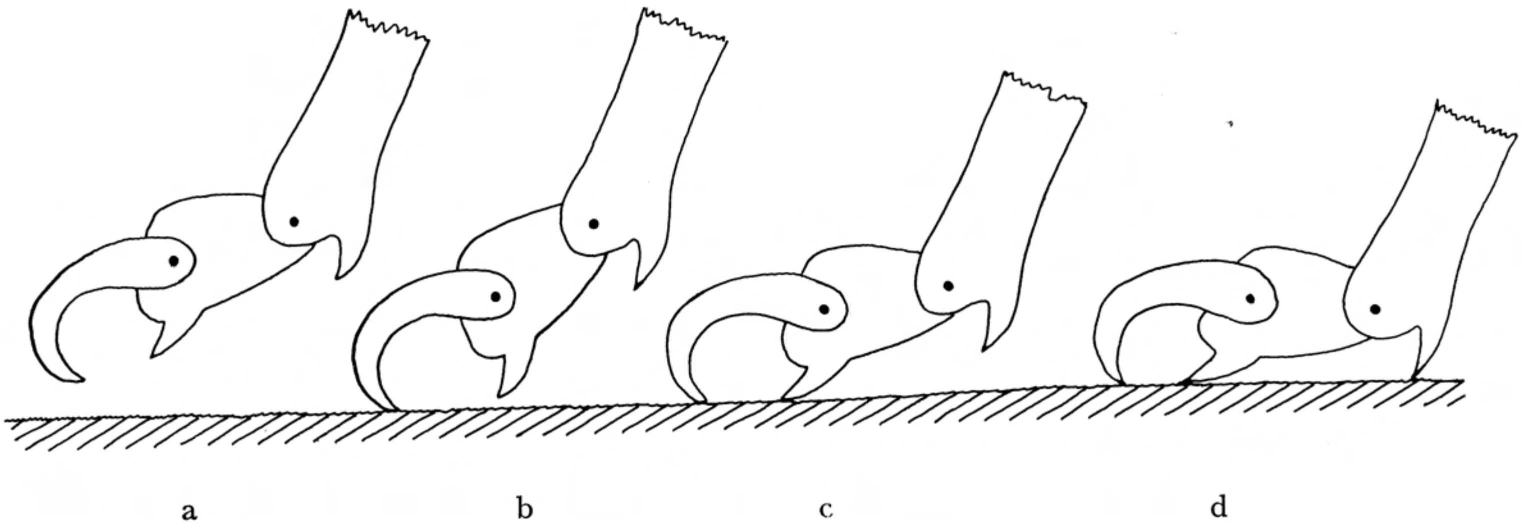


Fig. 3 a—d. The mechanism by which tarsi of *Hadogenes* grip rock surfaces.

acts as a heel. The ungues are slightly recurved and the sharp points hook between the fine granules of the rock surface. (b) Further lowering of the leg swings tarsomere II down so that its distal spines make contact with the rock surface (Fig. 3c). (c) By pushing the leg down until the distal spines of tarsomere I make contact with the rock, the rock surface is pinched between the ungues and the spines of tarsomere II (Fig. 3d). Functionally, the distal spines of tarsomere I appear to act as a heel similar to the unguicular spine of the pretarsus. Obviously this grip can only be achieved on rocks with a granular surface (Fig. 4 a). The grip is maintained provided the angle between tarsomeres I and II is held by muscle action and to release the grip, the reverse procedure is followed.

2. Pedipalps

The pedipalps of *Hadogenes* are powerfully developed, heavily sclerotized and constitute the primary defensive and aggressive armament of this scorpion. As the normal habitats of rock scorpions are generally rather wide, deep and narrow, some degree of lateral shielding is desirable but in *troglodytes*, this is not well developed. In *lawrencei* Newlands, the exceptionally long pedipalps are folded so that the long curved chela span a wide arc which extends from the third abdominal tergite across the front of the scorpion (Fig. 4 b). This shields the entire cephalothoracic region when the scorpion is normally positioned in its habitat. The pedipalps of *Hadogenes* are very flat, this being an adaptation to their habitat.

3. Caudal segments

Caudal segments II and V and the vesicle are markedly laterally compressed. In the normal resting posture, the tail is curled and rests on its side. To sting prey, the tail is extended sideways and the posterior region of the abdomen is bent laterally to allow the sting to pass over the pedipalps. In this position, the lateral compression of the caudal segments enables the sting to pass over the chela in very confined spaces.

4. Trunk

The cephalothorax and pre-abdomen of *Hadogenes* are very wide and flat. Thus, a specimen with a body mass of 25 g is able to creep into a 1 cm rock crack. It should be noted that *Hadogenes* are amongst the largest scorpions in the world with body masses up to 32 gm (not gravid) and lengths up to 210 millimetres. *Pandinus*, the largest scorpions, while not as long, have larger chela and more rounded trunks.

The carapace of the cephalothorax is very flat compared with other scorpions but the superciliary ridges are pronounced (Fig. 5 a, b). These heavily sclerotized ridges appear to protect the median ocelli lenses when this scorpion creeps into narrow crevices. Many museum specimens have badly scratched superciliary ridges while the ocelli lenses are seldom scratched. It is interesting to note that the ocular tubercle has posterior and anterior trichobothria on each side which presumably assist the scorpion in assessing the height of the roof above the ocelli.

Fig. 4 a. Tarsus of *Hadogenes* gripping a granular rock surface. 4 b. *Hadogenes lawrencei* showing large anterior span of pedipalps and the degree of dorso – ventral compression.

4a

4b

5a

5b

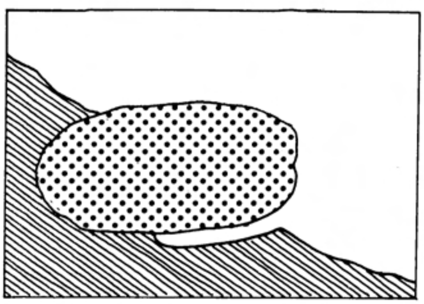
Fig. 5. Stereo–pair (best viewed with pocket stereoscope or two equal convex lenses) showing carapace flatness and superciliary ridge height.

5. Trichobothria

The pedipalps and caudal segments of *Hadogenes* are richly endowed with trichobothria which enable this scorpion to detect both prey and predators in good time.

Genus: *Opisthacanthus* Peters

Ecologically and morphologically, *Opisthacanthus* is intermediate between *Hadogenes* and *Cheloctonus*. Two species occur in the Kruger National Park, namely *O. laevipes* Pocock and *O. chrysopus* Peters. Species of this genus generally scrape soil out beneath rocks to create shallow tunnels or excavations between 10 and 30 cm long (Fig. 6). While *laevipes* is com-



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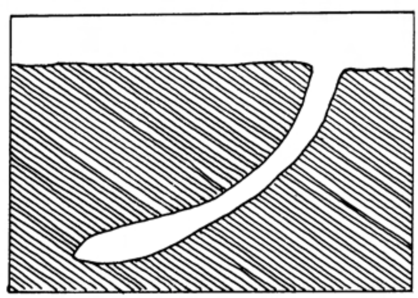

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Fig. 6. Excavation of *Opisthacanthus* beneath rock. Fig. 7. Burrow of *Cheloctonus*.

monly found beneath rocks, *chrysopus* is frequently found beneath the bark of trees.

1. Tarsi

Structurally and functionally, the tarsi of *Opisthacanthus* are very similar to those of *Hadogenes* and this may be associated with the predominantly rupiculous habit of these scorpions.

2. Pedipalps

Pedipalps are much shorter and stouter than those of *Hadogenes*.

3. Caudal segments

The caudal segments are shorter and more rounded than those of *Hadogenes* and only segments IV and V show signs of being slightly laterally compressed.

4. Trunk

The trunk is slightly dorso-ventrally compressed and this is associated with the rupiculous habitat of these scorpions. The superciliary ridge is reduced and does not protrude above the height of the median ocelli lenses. There are four trichobothria surrounding the ocular tubercle as in *Hadogenes*.

Genus: *Cheloctonus* Pocock

In the Kruger National Park, this genus is represented by a single species, *Chelotonus jonesi* Pocock. This species is a burrower and makes tunnels in the open veld which are oval in cross section and 15 to 30 cm deep (Fig. 7). In the author's experience, this species is associated with pelitic soils such as black turf. Ecological adaptations distinguish *Cheloctonus* from *Hadogenes* and *Opisthacanthus*.

1. Tarsi

The tarsi of *Cheloctonus* are not adapted to climbing over rock surfaces and there are long slender bristles on each side in place of the distal apical spines present in *Hadogenes* and *Opisthacanthus*. It is suspected that these bristles increase the effective surface area of the tarsus and enables the scorpion to walk over sandy surfaces more easily.

The distal leg segments lack the rows of setae and spines present in *Opisthophtalmus* which facilitate soil transport during burrow digging.

2. Pedipalps

The pedipalps are very short with broad well rounded chela. The chela provide protection and when the scorpion is in its burrow, the broad chela can effectively seal off the burrow at any point along its length (Newlands, 1969).

3. Caudal segments

The caudal segments are round in cross section and relatively much thicker than those of *Opisthacanthus*. Segment V is equipped with prominent ventro-lateral keels composed of denticles. This arrangement assists in tail scraping operations. Tail scraping is employed to move soil scraped up by legs I and II and is achieved by pushing backwards with the tail curled over to one side.

4. Trunk

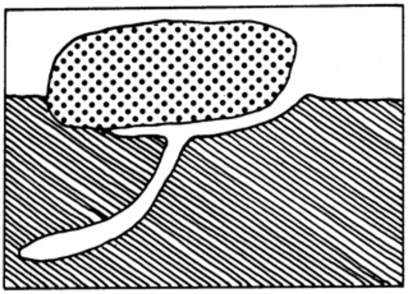
In *Cheloctonus*, the trunk is almost cylindrical with no indication of dorso-ventral compression and the carapace is strongly curved about its longitudinal axis. The superciliary ridges are virtually absent and afford no protection to the median ocelli lenses which protrude above the ridges. Two trichobothria, one on each side, are positioned behind the median ocelli and these probably serve to indicate the height of the burrow ceiling above the carapace. This is supported by studying museum specimens in which, during their life, these trichobothria had broken off (in aged adult scorpions, trichobothria and spines are frequently missing). In cases where the trichobothria are missing, the ocelli lenses are invariably scratched dorsally. This suggests that without the trichobothria, the scorpion is not aware of the burrow's ceiling height above the carapace and may scratch the ocelli lenses on the ceiling during movements in the burrow.

5. Trichobothria

Cheloctonus has relatively few palpal and caudal trichobothria compared to *Hadogenes* and *Opisthacanthus*. The burrow made by *Cheloctonus* is precisely tailored to suit its body size and accordingly offers better protection than the rock cracks and shallow excavations inhabited by *Hadogenes* and *Opisthacanthus*. It is thus feasible that the need to detect predators is reduced in *Cheloctonus*. It is also possible that trichobothria, especially on the pedipalps, could be a hindrance during burrow construction and tail scraping operations.

Subfamily: Scorpioninae
Genus: *Opisthophthalmus* Koch

Two species of *Opisthophthalmus* occur in the Kruger National Park, the pelophilous *O. glabrifrons* Peters and the psammophilous *O. ecristatus* Pocock. Both species are proficient burrowers, *glabrifrons* preferring the loamy soils and *ecristatus* semiconsolidated Kalahari type sand. The latter is thus only found in a narrow belt north of the Zoutpansberg and the northern tip of the Kruger National Park. The burrows of *glabrifrons* are often made beneath rocks but also in the open veld and generally measure between 40 and 60 cm in length by 18–25 cm deep (Fig. 8). In cross section the burrow is oval, generally about three and a half times as wide as high. The burrows of *ecristatus* are always made in the open veld and normally exceed a metre in length while the depth is be-



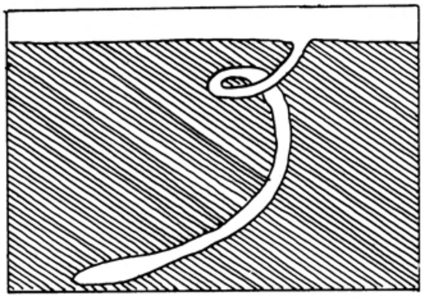


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Fig. 8. Burrow of *Opisthophthalmus glabrifons* beneath rock. Fig. 9. Burrow of *O. ecristatus* in sand.

tween 40 and 60 centimetres. About 10 cm down, there is a loop of about 360° after which the burrow gently spirals downwards (Fig. 9). During winter months, the burrow entrance is sealed off with sand.

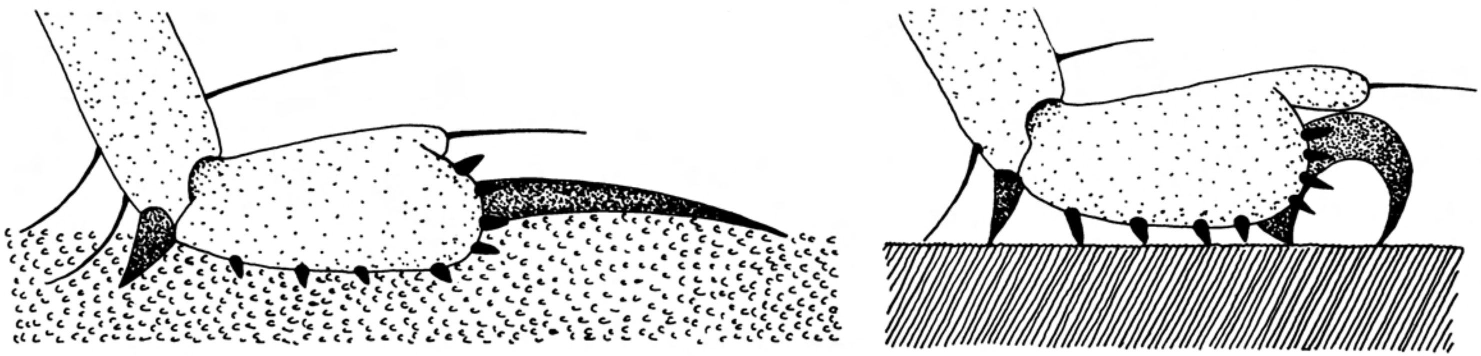
1. Tarsi

The tarsi differ from those of *Cheloctonus* in having a greater number of shorter spines along the ventral surface of tarsomere II and the distal lobes. Stout setae are far more numerous and there are several short setae distally on tarsomere I. These tarsal setae presumably increase the surface area to facilitate walking on sandy surfaces.

The patella, tibia and tarsomere I of legs I and II are richly endowed with setae and long spines, especially along the outer edge. This is associated with the burrowing behaviour, for soil loosened by biting with the chelicerae is scraped out by legs I and II while the body is bridged on the chela and legs III and IV (Newlands, 1972). In *ecristatus* the setae are longer and more numerous, which is in keeping with trends in psammophilous scorpions as it increases the effective surface area (Newlands, 1972). The ungues of *glabrifrons* are sharply curved as in *Cheloctonus* and equal length, while those of *ecristatus* are almost straight with the outer ungue much longer than the inner. In psammophilous scorpions, the ungues are not sharply curved and this means that instead of the pointed tip making contact with the surface, the entire length of the ungue makes contact with the surface, thus greatly increasing its effective area (Figs. 10 a and b). In sand, it is advantageous to have a large area in contact with the surface to prevent the tarsi from sinking into the sand when walking.

2. Pedipalps

The pedipalps are stout and the chela have large, well rounded lobes which enable the scorpion to seal off the burrow when necessary (Newlands, 1969). Scorpions always face the entrace when resting in burrows



a b

Figs. 10a and b. Tarsus of psammophilous scorpion showing how long ungues and setae increase the effective surface area. Tarsus of a pelophilous scorpion.

and *Opisthophthalmus* is equipped with numerous trichobothria along the pedipalps which facilitate prey and predator detection.

3. Caudal segments

In both *glabrifrons* and *ecristatus*, caudal segment V is modified to facilitate sand scraping. The dorso-ventral keels are composed of sclerotized denticles in between which are long setae. The setae form a comb-like row and considerably increase the effective surface area of the segment. In *ecristatus* this feature is better developed than in *glabrifrons*. The tail is used to push soil out of the burrow. Sometimes, *ecristatus* seals off the burrow entrance with sand by pushing it backwards with the tail. In *ecristatus*, the posterior ventral surface of segment V and all the ventral keels are sclerotized, presumably to strengthen them for this process.

4. Trunk

The trunk is similar in section to that of *Cheloctonus* but the cephalothorax differs in several respects. Firstly, there is a superciliary ridge which is higher than the ocelli lenses and protects them from abrasion. There are two trichobothria, one on each side behind the ocular tubercle as in *Cheloctonus*.

The position of the median ocelli is far back on the carapace in *glabrifrons* and at the centre in *ecristatus*. The author has suggested (1972) that the position of the median ocelli on the carapace is a function of the soil hardness in which a given species generally burrows. To loosen soil during burrow construction, *Opisthophthalmus* bites the soil with the very large chelicerae before scraping it out with legs I and II. Species inhabiting hard ground require larger, more powerful cheliceral muscles to enable the cherlicerae to bite the soil loose than species inhabiting semiconsolidated sandy areas. Large cheliceral muscles leave less space in the cephalothroax for the supraoesophageal ganglion and its connections to the median ocelli. Thus, species of *Opisthophthalmus* such as *glabrifrons*, which inhabit hard soils, have their median ocelli positioned far back on the cephalothorax. Psammophilous species such as *ecristatus* have their ocelli more centrally positioned.

Summary

Lithophilous scorpionids are dorso-ventrally compressed and have tarsi which lock on to granules of rock surfaces, enabling these scorpions to walk up vertical rock surfaces without difficulty. Burrowing scorpionids are much narrower, have well rounded chela and the tails are adapted to soil scraping operations. The tarsi of psammophilous species are equipped with long setae which increase the effective surface area of the tarsus and enable the scorpion to walk over loose sand without sinking in. All the scorpions studied have sensory hairs in the region of the ocular tubercle which serve to indicate the ceiling height of the habitat. Some species have raised superciliary ridges which afford mechanical protection of the ocelli lenses.

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