J. Zool., Lond. (1990) **220,** 249–256

A new species of land planarian preying on termites in Kenya (Platyhelminthes: Turbellaria: Tricladida: Terricola)

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(Accepted 22 March 1989)

(With 2 figures in the text)

A new species of land planarian is described from Kenya. *Microplana termitophaga* sp. nov. preys on termites by capturing them at the openings to their nest. The pharynx is unusually far forwards for a land planarian and this is probably related to the active nature of the prey. There is an anterior depression caused by the termination of parenchymal longitudinal muscle bundles which might act as a sucker. All specimens are immature which leads to some difficulty in assigning the species to a genus.

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Introduction

All land planarians are predators, most feeding on slow-moving invertebrates such as earthworms and slugs. This paper concerns land planarians from Kenya which were first observed in 1982 feeding on termites at the opening of air shafts into the termites' nest. This remarkable habit has been recorded only once previously amongst land planarians, by Sheppe (1970) who recorded unidentified geoplanids feeding at the mouth of chimneys of *Odontotermes latericius* in Zambia. The worms were not further described but geoplanids possess many eyes, whereas the worms from Kenya possess only two eyes and are thus of the family Rhynchodemidae.

Undoubtedly, the worms have not previously been described and are a new species. However, the available specimens are all immature and triclad taxonomy is largely dependent upon the

0952-8369/90/002249+08 $03·00

anatomy of the genitalia. Thus we have had some difficulty in placing the new species into an extant genus and propose that it be placed in the most likely genus within its subfamily.

Materials and methods

Observations were made on the living specimens by JPECD and RMN. Some specimens were preserved in 80% alcohol and 11 were received by HDJ *via* the British Museum (Natural History) for further examination. All were examined by temporary clearing in wood-tar creosote. Two were serially sectioned at 10 μm thickness, the body being divided into 3 portions. The centre portion was sectioned transversely, the anterior and posterior portions sagittally, though because of twisting and coiling sectional planes are imprecise. Sections were stained in haematoxylin/eosin.

Family RHYNCHODEMIDAE Graff, 1896.
Subfamily MICROPLANINAE Pantin, 1953.
Genus *Microplana* Vejdovsky, 1890.
Microplana termitophaga sp. nov.

Material examined: Holotype—one set of sagittal and transverse sections on 12 slides, BM(NH) 1988.10.28.1. Paratypes—one set of sagittal and transverse sections on 11 slides, retained by HDJ. Nine further preserved specimens, 5 in BM(NH) 1988.10.28.2–6, 4 in National Museums of Kenya, NMK PM1. Collected 28.10.1982 by RMN. All specimens sexually immature. HDJ has received 3 further intact specimens and 3 fragments collected 12.88. by R.M.N., all immature.

Type locality: Loresho Ridge, Nairobi, Kenya, altitude approximately 1768 m. The worms were collected from openings to air passages in the nests of termites (*Odontotermes* spp.) where they were observed feeding on the workers. The termites were in an area that was originally forested, was later under coffee, but has been a garden for 35 years.

Etymology: the specific name is descriptive being derived from *termite* and *-phaga*, 'eaters'.

Observations on living animals

The planarians were usually found around dusk, during or after heavy rain when the soil is soaked and the termites active. Occasionally they were found in nearby leaf litter.

The worms are very extensible. One specimen extended to over 35 mm and contracted to about 17 mm. Another extended to 25 mm and contracted to 12 mm. They are broad oval in cross-section but the anterior end is circular when extended. Dorsally they are dark charcoal grey or black with a median darker streak. Under a dissecting microscope the colour appears granular and is subepidermal. Ventrally they are pearly white. The two eyes are terminal, facing forwards when the head is retracted, but lateral when it is extended. The eyes are black with a white rim. The worms glide in their own mucus on a narrow ventral gliding sole. They can go straight but on a smooth surface move in a zigzag track with the head moving from side to side. Longitudinal contraction is very rapid.

The worms were preying on termites of two as yet undetermined species of *Odontotermes*, one larger and one smaller, mostly the latter. (The smaller species has been provisionally identified as *O. montanus* Harris, and the larger as *O. kibarensis* Fuller.) These build open, vertical air shafts with raised rims. The planarians approach the rim crawling and extended. They can apparently detect air shafts in which termites are active near the rim and avoid shafts without such activity. They anchor themselves by their posterior end (presumably by mucous adhesion) on the rim or often 2–3 cm below the rim inside the shaft. They then elongate the front half down into the shaft, the anterior end becoming very thin and slowly searching from side to side. When a worker is touched by the anterior end of a worm, the worm attaches to the victim (presumably by the sticky property of the mucus) and contracts sharply, thus pulling the victim up the air shaft. The worm curls into a loop, ventral side inwards, with the worker trapped in mucus. The termite soon stops moving and the worm remains in this position for about 10 minutes. Presumably the pharynx is extended into the prey during this period. The exoskeleton of the dead worker is then left covered in mucus. The mucus is very sticky when fresh and will entangle soldiers that walk on it. However, it soon loses its stickiness and small ants may appear and remove the carcass. Several carcasses may be seen in the area where a worm has been feeding.

The worms can apparently detect whether the termite is a soldier without actually touching it and usually withdraw sharply if approaching a soldier. On one occasion a worm was observed trying to drag out a worker between two soldiers. One soldier took a bite at the worm which dropped the worker and rapidly withdrew, shedding mucus for some minutes. On another occasion a worm did attack and consume a soldier, but the remaining soldiers appeared nervous and when the same worm tried again all the termites retreated down the shaft out of reach. When a worker is taken there is usually no sign of alarm in the remaining termites.

External features and features visible in cleared specimens (Fig. 1)

The preserved specimens are variously coiled and twisted but range from 7 mm to about 22 mm (Table I). Larger specimens are about 2 mm wide with a dorso-ventral height of about 1·5 mm. They are oval in cross-section with a central, narrow, slightly raised, ventral creeping sole about a quarter of the ventral width. The specimens are all contracted longitudinally, evidenced by the telescoping of the anterior end and corrugations of the body wall (and in section by folding of the nerve cords). The anterior end is blunt and terminates in a folded depression variously shaped in different individuals. The two eyes are almost terminal and are positioned either side of the anterior depression. The body is of uniform width and height except for a slight thickening at the level of the pharynx. The posterior end is blunt. The colour in spirit is a buff-colour with a diffuse blackish pigment subepidermally on the dorsal surface which concentrates into a central darker longitudinal line. The pharyngeal opening is about a quarter of the length from the anterior end (Table I).

Internal anatomy visible in section (Fig. 2)

The dorsal, lateral and ventro-lateral epidermis is about 15 μm thick, composed of cuboid-columnar cells with copious rhabdites and basal oval nuclei, but apparently devoid of cilia. The rhabdites are produced subepidermally. The epidermis of the creeping sole is about 15 μm thick and composed of thin columnar cells with distal elongate nuclei and with copious cilia about 5 μm long.

Immediately subepidermally there is a very thin layer, one or two fibres thick only, of circular muscle fibres. Inside this there is a layer of parenchymal cells (cyanophilic) and longitudinal muscle about 100 μm thick. The longitudinal muscle is in discrete bundles, about 110 in number, in the centre of this layer, and thus about 50 μm below the surface. Ventrally the parenchymal layer is thickened to about 150 μm and includes the pair of ventral nerve cords. Further longitudinal and transverse muscle fibres lie dorsal to the nerve cords. Occasional very thin strands of parenchyma and muscle run dorso-ventrally between the digestive diverticula.

The epidermis of the anterior depression consists of non-ciliated columnar cells about 20 μm

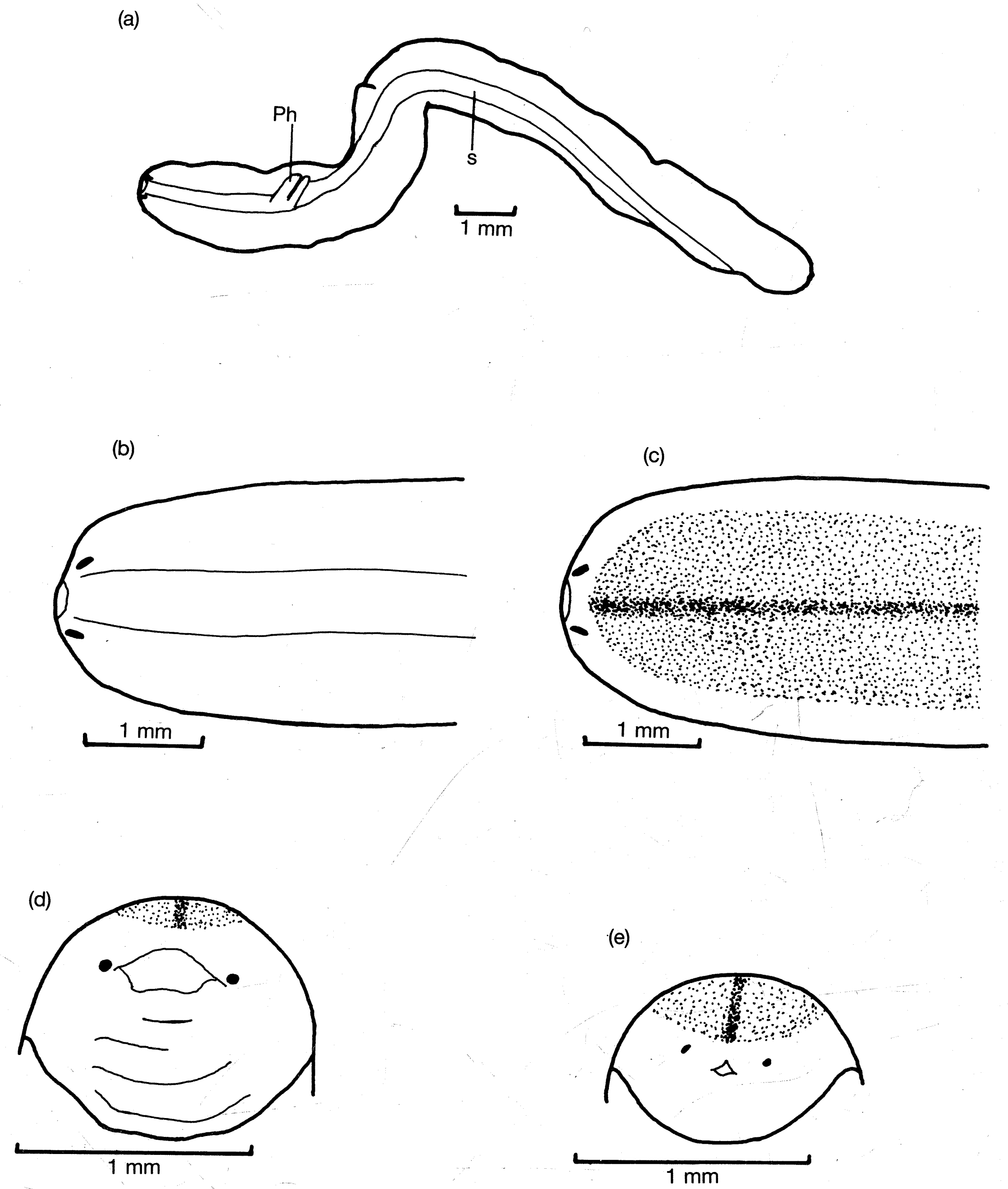

FIG. 1. *Microplana termitophaga* external features. (a) Entire specimen seen more or less from the ventral surface, though the posterior end is twisted. Anterior is to the left, the two eyes and anterior depression being shown. Ph = pharynx (viewed by transparency); s = ciliated creeping sole. (b) Ventral view of the head showing the eyes, anterior depression and creeping sole. (c) Dorsal view of the head showing the eyes, anterior depression and dorsal pigmentation. (d) Anterior, end-on, view of the head showing the eyes and the form of the anterior depression. (e) Anterior, end-on, view of the head of another specimen to show the variable form of the anterior depression.

TABLE I

*Dimensions of individual specimens of **Microplana termitophaga**. A-Ph is the distance from the anterior end to the pharynx. Ph: L ratio is ratio of A-Ph: body length. The holotype and specimen 3 are now sectioned. *Specimen 5 has a damaged rear end*

Specimen	Body length (mm)	A-Ph (mm)	Ph:L ratio	Distance between eyes (mm)
Holotype	11	3	0·27	0·4
2	22	4·5	0·2	0·45
3	20	3	0·15	0·5
4	14	3·5	0·25	0·4
5	11*	4	—	0·45
6	Posterior portion only			
7	7	2	0·28	0·35
8	14	4	0·25	0·5
9	13	3	0·23	0·43
10	14	3	0·21	0·41
11	10	2·5	0·25	0·55
			Mean 0·23	0·44
			S.E. 0·01	0·02

long, and is underlain by columnar mesodermal cells of similar length. The ciliated epidermis of the sole terminates at the ventral margin of the depression. This depression is formed by the insertion of the parenchymal longitudinal muscle bundles at the anterior end, which thus pull the anterior end inwards.

The eyes are large, about 50 μm by 100 μm with a thin black pigment surrounding the retinal cells. The open end of the pigment cup normally faces forwards (see above) but in the preserved specimens they face slightly towards the midline due to strong anterior contraction.

The nerve cords are ventrally positioned, about 150 μm apart, and there are occasional transverse commissures between them. Anteriorly each cord expands to about twice its width elsewhere, but there is no anterior fusion of the two cords.

In one of the sectioned specimens the pharynx is short and conical, its length being less than the width of the body. The pharynx in the other sectioned specimen is longer than the width of the body. The pharyngeal length of preserved specimens is probably much shorter than in life due to contraction of the pharyngeal musculature. The root of the pharynx is anterior to the pharyngeal opening and, in section, there is a posterior extension of the pharyngeal chamber that would normally accommodate the distal end of the pharynx. The pharyngeal epithelium is densely ciliated with cilia about 2·5 μm long. The pharyngeal musculature consists of an outer layer of circular muscle, a thick layer of longitudinal muscle and another layer of circular muscle surrounding the lumen. The pharynx leads into a fairly typical triclad digestive system. In transverse sections, the digestive diverticula comprise some 60% of the cross-sectional area. Individual cells are indistinct, but they are composed of coarse granular eosinophilic cytoplasm vacuolated distally; the vacuoles are 15–30 μm in diameter. Nuclei are basal.

None of the specimens seems to be mature, on examination by clearing there was no detectable sign of genitalia nor gonopore. Neither of the sectioned specimens shows any sign of gonads nor genitalia.

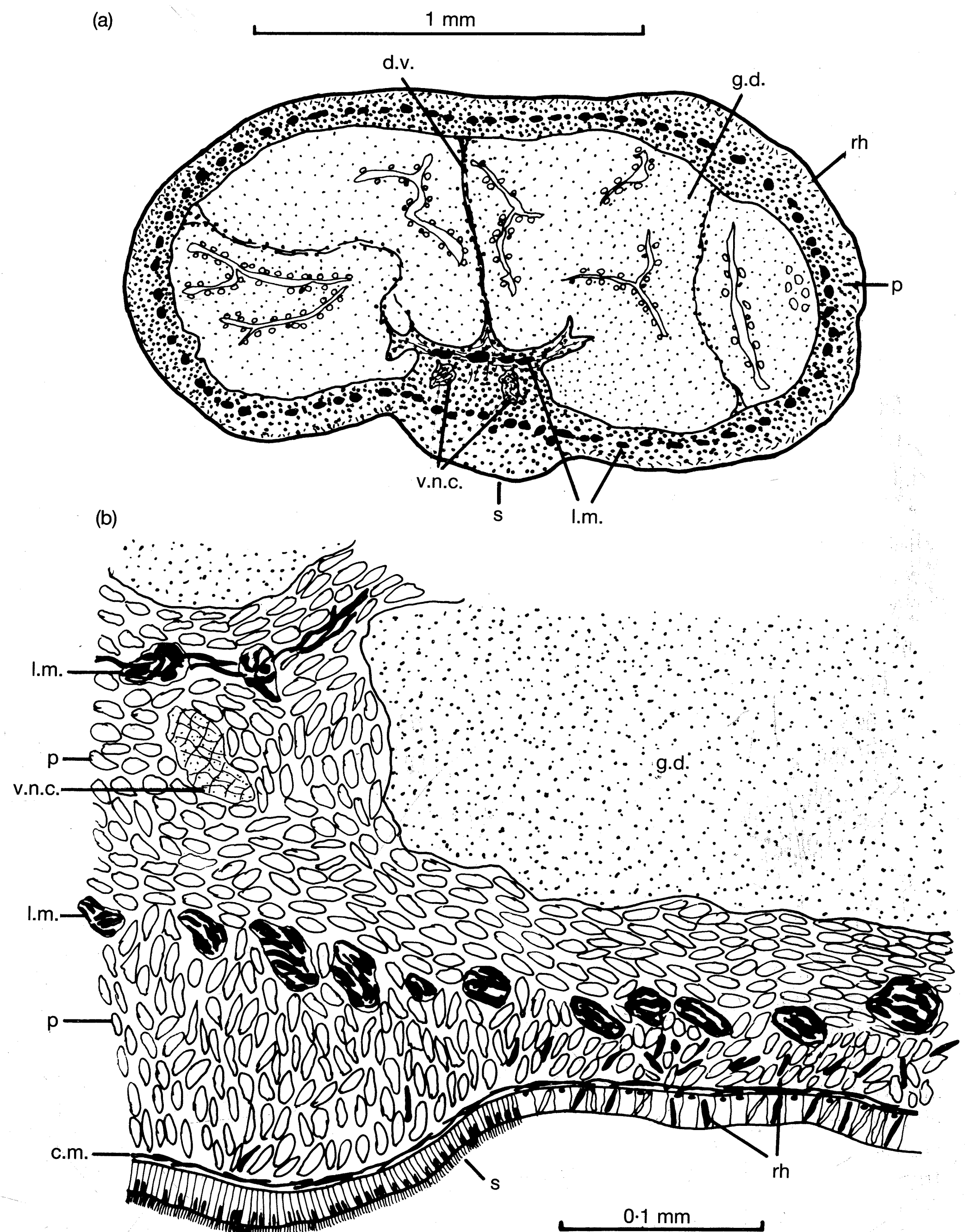

FIG. 2. *Microplana termitophaga*. (a) Transverse section posterior to the pharynx. (b) Enlarged view of ventral portion of (a) to show detail of musculature. c.m. = circular muscle fibres; d.v. = dorso-ventral strand of muscle and parenchymal cells; g.d. = cells of the gut diverticula; l.m. = bundles of longitudinal muscle; p = parenchymal cells; rh = rhabdites; s = ciliated creeping sole; v.n.c. = ventral nerve cord.

Discussion

The worms undoubtedly belong to a new species, but are difficult to assign to a genus. The family Rhynchodemidae consists of two subfamilies: subfamily Rhynchodeminae Hyman, 1943 (definition in part—strong subcutaneous longitudinal muscle fibres aggregated into distinct bundles); and subfamily Microplaninae Pantin, 1953 (definition in part—weak subcutaneous longitudinal muscle not aggregated into bundles). Since subcutaneous longitudinal muscle is absent in *termitophaga*, it clearly belongs to the Microplaninae rather than the Rhynchodeminae.

The Microplaninae currently comprises six valid genera (Beauchamp, 1961): *Microplana* Vejdovsky, 1890; *Othelosoma* Gray, 1869; *Diporodemus* Hyman, 1938; *Geobenazzia* Minelli, 1974; *Pseudartiocotylus* Ikeda, 1911; *Incapora* Marcus, 1953. *Incapora* can be eliminated as a candidate genus since it has two ventral orifices leading to the posterior limbs of the gut. *Diporodemus* and *Geobenazzia* are characterized by genital details, but since the present specimens are immature we cannot assign *termitophaga* to either; but on other characters and geographical distribution both are unlikely as candidate genera. *Pseudartiocotylus*, from Sri Lanka, is incompletely described and cannot be defined at present (Hyman, 1943). *Othelosoma* possesses strongly developed parenchymal muscle dorsally to form an anterior retractor, but the parenchymal longitudinal muscle in *termitophaga* is equally strong dorsally and ventrally. This leaves us with *Microplana*. This is again principally defined on genitalia (Microplaninae with a genito-intestinal canal). Thus the critical features are undeveloped in our specimens but since it is the subfamilial genus and there is little doubt about the subfamily, we propose to assign *termitophaga* to *Microplana*.

One of the features of *termitophaga* is the retractile anterior end caused by the anterior termination of the parenchymal longitudinal muscles. Such a feature was noted by Graff (1899) in certain species he assigned to the genus *Amblyplana*. The figure of the anterior end of *A. teres* in Graff (Plate LII, 9) is identical to the situation in *termitophaga*. Many of the listed species of *Amblyplana* are from Africa, which also suggests that it might be a valid genus for *termitophaga*. However, subsequent revisions (Hyman, 1943; Pantin, 1953) have shown that the species placed by Graff in *Amblyplana* are either *Othelosoma* or so inadequately described that they are best placed in the subfamilial genus, *Microplana*. Since, for reasons discussed above, *termitophaga* cannot be an *Othelosoma*, we are again left with *Microplana*. Thus the species *termitophaga* is here placed in the genus *Microplana*, but in the full realization that this may be revised if mature specimens become available for study.

Microplana termitophaga shows some anatomical features worthy of comment. The pharynx is unusually far forward in the body. In most land planarians the pharynx is halfway along or even in the rear half of the body, but here it is only a quarter of the way along the body (Fig. 1; Table I). The posterior digestive rami are thus about three times as long as the anterior one. The anterior positioning of the pharynx may reflect the nature of the prey in this species. Most land planarians apparently feed on carrion or slow-moving prey such as earthworms and slugs. Termites are much more vigorous and the anterior position of the pharynx means that it can be applied to the prey more quickly. Alternatively, the posterior portion may be relatively longer because of its role as an anchor during feeding.

The digestive diverticula occupy a considerable proportion of a transverse section, some 60%, and there are very thin strands of parenchymal tissue between neighbouring diverticula. This could partly be the result of nutritive state, the sectioned specimens being well fed, but in comparison with other land planarians this is a large proportion. (Relative area is not normally quantified and will vary with precise sectional plane, but a glance at a transverse section of other species is enough to establish the difference.)

The feeding habit is remarkable, though there are very few other detailed observations of land planarians feeding. It seems that the sticky property of mucus is used to capture prey termites, and whether the anterior depression acts as a sucker remains to be seen. (There are rhynchodemids with a differentiated anterior sucker—*Cotyloplana.*) The brief observations of Sheppe (1970) on the unidentified geoplanids are very similar, but field notes taken at the time (Sheppe, pers. comm.) add little detail. Though specimens of the planarians were preserved at the time we have been unable to trace them for comparison.

The immature state of all the examined specimens may indicate that maturity occurs at other seasons, but some land planarians are known to be able to reproduce by fission (e.g. *Bipalium kewense*, see Winsor, 1983). It is possible that *M. termitophaga* may also reproduce by similar means, only becoming sexually mature under certain conditions. The small fragments collected in 12.88 tend to confirm this suggestion; the worms fragment readily (R. M. Newson, pers. obs.).

This is only the second published record of any land planarian from Kenya. Beauchamp (1913) recorded three specimens of *Othelosoma cylindrica* (as *Amblyplana cylindrica* n. sp.) from the slopes of Mount Kenya. During the collection of *M. termitophaga* specimens in 12.88, R. M. Newson also found two specimens of *Bipalium kewense* in the same locality, the first record from Kenya. The only other African records of this species are from Zimbabwe and South Africa (Winsor, 1983).

We are grateful to Professor R. E. Ogren, Wilkes College, Wilkes-Barre, PA 18766, USA, for taxonomic advice, and to Dr R. K. Bagine, National Museums of Kenya, for identification of the termites.

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J. Zool., Lond. (1990) **220,** 257–277

Scaling of speed and endurance in garter snakes: a comparison of cross-sectional and longitudinal allometries

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(Accepted 17 May 1989)

(With 5 figures in the text)

This study used cross-sectional (one observation per each of several individuals of different size) and longitudinal (more than one observation through time per individual) methods to determine the effects of size on speed and endurance of *Thamnophis sirtalis fitchi.* The cross-sectional sample consisted of 497 snakes from a single population. Log of mean burst speed in this group measured over 50 cm (*V*50) was a quadratic function of log of snout–vent length (SVL); the slope of this polynomial ranged from about 1·6 to −0·3 for the smallest to the largest snakes (maximal *V*50 at 50·6 cm SVL). Longitudinal measurements of log *V*50 also were quadratically related to log SVL, but the slopes varied depending on year in which performance was measured. Cross-sectional allometry revealed that the slope of the regression relating log(endurance) to log(SVL) was about 2·3, and longitudinal estimates of this quantity ranged from 0·5 to 3·2, depending on the year. Sex did not affect burst speed, but females had significantly less endurance than males of equal SVL, and pregnancy had a significant detrimental effect on both speed and endurance. Regressions with SVL as the independent variable were used to generate size-corrected (residual) values of speed, endurance and mass, and each of these residuals had significant repeatability. For example, during 1986 the short-term repeatabilities (Pearson's r) of speed and endurance residuals were 0·65 ($P<0{\cdot}001$) and 0·57 ($P<0{\cdot}001$). From 1986 to 1987, year-to-year repeatabilities of speed, endurance and mass residuals were 0·25 ($P=0{\cdot}001$), 0·22 ($P=0{\cdot}005$) and 0·47 ($P<0{\cdot}001$), respectively. Analysis of these three respective residual values of 264 neonatal snakes from 34 litters revealed highly significant percent variance components attributable to litter of 14%, 34% and 36%, yielding respective heritabilities of 0·28, 0·68 and 0·72. Speed and endurance residuals had a low but significant positive correlation ($r=0{\cdot}26$, $n=497$), due apparently to snakes with poor performance: high speed is not linked with high endurance. A squared value of the mass residual had a significant negative correlation with both speed residual ($r=-0{\cdot}105$, $n=497$) and endurance residual (−0·24), suggesting that snakes deviating from a mean value of mass relative to length have a slight decrement in locomotor performance. Longitudinal estimates of the scaling of mass with length revealed significant variation associated with different ages of snakes and different years of the study that could not be obtained from cross-sectional data.

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