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The Land Nemertine *Argonemertes dendyi* (Dakin) in Hawaii (Nemertinea: Hoplonemertinea: Prosorhochmidae)[1]

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ABSTRACT: Land nemertines are here reported in the Hawaiian Islands for the first time. *Argonemertes dendyi*, a native of Western Australia, has been found in moist forest litter at high elevations on the islands of Maui and Hawaii, and has also invaded lava tubes on the latter island. This is the first report of a land nemertine from caves.

LAND NEMERTINES OCCUR ON OCEANIC islands in many parts of the world (Pantin 1961, Moore and Gibson 1981), but none has been recorded previously from the Hawaiian Islands. In a lava tube cave at Kaumana on the Island of Hawaii, F. Howarth found specimens later identified as *Argonemertes dendyi* (Dakin), a native of Western Australia (Dakin 1915). Subsequent search in suitable epigean (surface) habitats of two Hawaiian islands revealed additional specimens of the same species. A brief search of apparently suitable habitat on Kauai was unsuccessful.

Most of the 12 known species of land nemertines are strictly localized in distribution. Different genera appear to have evolved separately, in parallel, in Australia and New Zealand, Bermuda, the Macaronesian Islands (Madeira, Canary, and the Azores), Tristan de Cunha, and the islands of the Indo-Pacific (Moore and Gibson 1981). *Geonemertes pelaensis* Semper occurs on many separate islands in the Indo-Pacific and has been introduced to the Caribbean, but *Argonemertes dendyi* is uniquely widespread. That the species originated in Australia is clear from its possession of characters (e.g., eye multiplication) unique to Australian land nemertines.

Its ability to form a mucous cocoon in which it resists desiccation gives *Argonemertes dendyi* a better chance to survive long-distance transportation, and its protandrous hermaphroditic reproductive strategy probably facilitates its establishment of viable populations in new areas. To date it has been found in the southern and western parts of the British Isles (Pantin 1961), in São Miguel in the Azores (Moore and Moore 1972), in Gran Canaria (P. Brinck, pers. comm.), in a garden in California (F. B. Crandall, pers. comm.), and now in the Hawaiian Islands.

MATERIALS AND METHODS

The worms were transferred to a small dish and narcotized in 7 percent ethanol until re-extended and immobile. This process took only 2 min for the smallest specimens and about 5 min for the larger. They were then fixed and transported back to the laboratory in 80 percent ethanol containing a drop of glycerine.

The histological investigations were carried out at Cambridge University by J. Moore. The specimens were embedded in 56°C melting point paraffin wax, sectioned transversely to the anterior end at 8 μ, and stained with Mallory's triple stain. All six cave specimens and nine of the surface specimens were examined histologically.

Voucher specimens of the material recorded herein are deposited in the Invertebrate Zoology Collection at B. P. Bishop Museum and in the Pantin Collection, at present in the care of J. Moore.

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MATERIAL EXAMINED: Hawaii Island, Kaumana, 290 m, Kaumana Lava Tube, deep cave zone, downslope section, 27 March 1981, F. G. Howarth and R. C. A. Rice, colls., 2 specimens; same data except 5 June 1981, F. G. Howarth, coll., 1 specimen; same data except 6 August 1982, J. Moore, F. G. Howarth, and F. D. Stone, colls., 2 specimens; Hawaii Volcanoes National Park, Ainahou, 800 m, Pa Nene Lava Tube, on moist ceiling twilight zone lower entrance, 30 December 1981, F. G. Howarth, F. D. Stone, colls., 1 specimen; Hawaii Volcanoes National Park, near Thurston Lava Tube, 1190 m, under rotting log, 8 August 1982, J. and N. W. Moore, F. G. Howarth, colls., 1 specimen; Hawaii Volcanoes National Park, Olaa Tract, 1170 m, under rotting logs and sticks, 5 August 1982, J. and N. W. Moore, F. D. Stone, W. P. Mull, and F. G. Howarth, colls., 5 specimens; Hawaii Island, Olaa Forest Reserve, 975 m, under rotting logs, 5 August 1982, J. Moore, F. D. Stone, colls., 2 specimens. Maui Island, Haleakala National Park, Hosmer's Grove, 2075 m, under logs and bark, 14 and 15 August 1982, J. and N. W. Moore, and W. C. Gagné, colls., 5 specimens.

RESULTS AND DISCUSSION

In all of the specimens examined from both cave and epigean habitats, the specialized characters diagnostic of Australian and New Zealand species of land nemertines are clearly present. Multiplication of eyes beyond the primitive number of 4–6 (with additional minor characters) places the specimens in the Australian genus *Argonemertes* (Moore 1975, Moore and Gibson 1981). The color pattern, the position of the posterior gland of the cerebral organ, the size at maturity, and the hermaphrodite condition of some specimens all combine to diagnose the species as *A. dendyi.*

Size and Sex

Argonemertes dendyi is a protandrous hermaphrodite, and males are commonly only 2–3 mm long while females range from 4–25 mm in length. Of the five specimens (3–6 mm long) from surface habitats on Hawaii, three were female and two were hermaphroditic. Those from Maui (6–8 mm long) were all females. One cave specimen was male. It was 12 mm long and is the largest male ever recorded. One cave specimen was a hermaphrodite and was about 16 mm long. The other four cave specimens were females and at 12–20 mm are within the normal size range for females.

Eye Number

Eye multiplication continues with growth in this species, and the longest specimens on record, ca 25 mm from the Azores, have 29–30 eyes. The increase is not at all regular, however. In the Hawaii specimens examined, the epigean specimens (length 3–8 mm) have 6–19 eyes, while the cave specimens (length 12–20 mm) have 7–24 eyes. These numbers do not suggest any reduction in eye number in cave populations, but our sample size is small and the natural variability too great to draw conclusions.

Cephalic Gland

An unusual feature of the specimens from Olaa Forest Reserve, Hawaii, is the replacement of the normal basophilic lobules of the cephalic gland by acidophilic cells of the type characteristic of *Leptonemertes chalicophora* (Graff) and occurring also in *Argonemertes hillii* (Hett). In every other morphological respect, both cave and surface specimens are entirely characteristic of *A. dendyi.*

Biology

In life the worms were whitish translucent, with the larger specimens showing faint longitudinal dorsal stripes and eye spots at the anterior end, as illustrated in Pantin (1961). Proboscis eversion could usually be stimulated, thus diagnosing the worms as nemertines. Epigean specimens were found only in protected moist microhabitats, such as under rotting logs, sticks, and bark. Slime trails on the substrate assisted detection, and invariably there was a rich associated fauna of potential prey species.

Epigean specimens on Hawaii were small (3–6 mm long), while those on Maui were slightly larger (6–8 mm long). The cave specimens were relatively large, cream colored with two dorsal longitudinal brown stripes and dark eye clusters visible at the anterior end. In contrast to their behavior on the surface, all specimens were found fully exposed on moist substrates in the constantly humid cave atmosphere. This is the first report of land nemertines from caves.

A diverse fauna including highly specialized obligate cave species is now known to inhabit the lava tube ecosystem in Hawaii (Howarth 1981). The ecosystem is a discrete one but is tied to surface ecosystems by its allochthonous energy sources. The three main nutrient sources are tree roots (especially of the native pioneer *Metrosideros collina* var. *polymorpha*) penetrating the lava, nutrients transported by percolating ground water, and animals accidentally entering the caves. As is now understood, the major populations of most obligate cave species occur in the smaller interconnected subterranean voids (mesocaverns). These animals colonize larger cave passages only where their specialized environmental requirements are met (Howarth 1983).

Argonemertes dendyi is considered a facultative cavernicole (a species that can live and reproduce in caves but is also found in similar surface microhabitats). They appear not to be accidental in caves, as (1) individuals have been seen regularly in Kaumana Lava Tube, (2) the cave specimens are relatively large, (3) they are not known from surface habitats over the caves, and (4) *A. dendyi* is admirably preadapted to colonize cavelike habitats, as will be explained.

In the search for land nemertines, negative evidence means little. However, the environments immediately above the two caves do not appear suitable for land nemertines. Above Kaumana Lava Tube the rain forest is young and sparse with little deep leaf litter. The habitat above Pa Nene Lava Tube is even less suitable. Pa Nene Lava Tube occurs in a dry, mixed grassland, native shrub habitat with a recent history of disturbance from grazing ungulates. The area receives less than 1400 mm of rain a year.

Land nemertines appear to be well preadapted for living in subterranean voids and in caves (Howarth 1980) because (1) they need continually moist conditions without extremes of temperature, (2) they are able to resist flooding on account of their highly developed excretory system, and (3) they feed as ambush predators. They undoubtedly are able to migrate between caves and other suitable habitats by utilizing the moist regions of deep cracks and the mesocaverns within basaltic lava. They probably occur in other caves on the east slopes of Mauna Loa and Kilauea volcanoes (and elsewhere) but have been overlooked.

When aroused from its ambush or resting site, *Argonemertes dendyi* crawls slowly, leaving a thin slime trail. If alarmed, however, it may move quite quickly by rapidly everting the proboscis, which then lodges on the substrate and is used to pull the body forward. By repeating this process in rapid succession, the nemertine can progress swiftly. Prey preferences in *A. dendyi* are unknown, but presumably any invertebrates, especially arthropods, of appropriate size that can be captured are eaten. The impact of predation by this recently introduced species on the native highly specialized cave fauna remains unknown.

We believe that there is a real possibility that native terrestrial nemertine worms exist in the Hawaiian Islands and hope that this paper encourages field biologists to look for these interesting animals both in Hawaii and on other Pacific islands.

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