NORTHERNMOST OCCURRENCES OF THE PROTISTAN PATHOGEN, *COELOMOMYCES STEGOMYIAE* VAR. *STEGOMYIAE*

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ABSTRACT. Now reported as parasitizing the ovaries of female *Aedes albopictus* on Kabeshima (33.33N × 129.53E), *Coelomomyces stegomyiae* var. *stegomyiae* had been found earlier in larvae of this mosquito on Mikura-jima (33.53N × 139.35E). These findings from 2 widely separated little Japanese islands constitute the parasite's most northerly records to date. Few previous reports of *Coelomomyces* spp., none concerning *C. stegomyiae*, have involved adult mosquitoes. Possible reasons for this are advanced.

In 1990 one of us (T.S.) discovered resting sporangia of the protistan pathogen *Coelomomyces* in the ovaries of 2 adult female *Aedes (Stegomyia) albopictus* (Skuse) collected from human bait on the island of Kabeshima (33.33N × 129.53E). This tiny island lies just offshore from northern Saga Prefecture of Japan's southernmost major island, Kyushu. Both parasitized mosquitoes were captured there during routine monthly collections undertaken to determine population trends in this species and *Ae. (Stg.) riversi* Bohart and Ingram, the first in evergreen forest at Tajima Shrine on July 20 and the second in bamboo forest on September 26.

Aedes albopictus was the original host from larvae of which Keilin (1921) described the genotype, *C. stegomyiae*, from Kajang, Malaysia. Then and until lately (Couch and Bland 1985) *Coelomomyces* was regarded as a fungus. However, the 5-kingdom concept is currently reallocating many organisms from their former major taxa to new allegiances, the Fungi being extracted from the plant kingdom to constitute a kingdom of their own; and some entities previously considered as fungal being transferred elsewhere. Among the latter, *Coelomomyces* moves to the kingdom Protista, in which its status within the phylum Chytridiomycota awaits clarification (see Laird 1990, for the relevant rationale and references).

Couch and Bland (1985 — Table VIII) list numerous records of *C. stegomyiae* var. *stegomyiae* Keilin from *Ae. albopictus* and 15 other Culicidae. Eight of these are referable to the subgenus *Stegomyia*, four to other subgenera of *Aedes*, and one each to the genera *Armigeres*, *Culex* and *Wyeomyia*. The relevant hosts range from Zambia to SE Asia then on to Japan, the Philippines, some South Pacific islands and the continental United States. All earlier reports of the pathogen are tropical, except for that from the USA (Florida's Everglades National Park, ca. 25.30N) and 2 temperate ones from Japan.

The earliest Japanese record of *C. stegomyiae* var. *stegomyiae* was due to Dr. O. Suenaga. He found it in larval *Ae. riversi*. The collection site was listed in the Couch and Bland Table as "unknown," but this is not so. For in 1964 two slides made from a parasitized larva of *Ae. riversi* were shown to one of us (M.L.) at the University of Nagasaki, by Dr. N. Omori. The material was labeled as having been collected by Dr. Suenaga on May 28 1954 from a tree hole on Oshima (32.02N × 128.26E), an island of the Danjo group some 160 km SW of Nagasaki (32.45N × 129.52E). Recognizing the pathogen as a species of *Coelomomyces*, probably *C. stegomyiae sensu lato*, M.L. (who as Chief of the World Health Organization's Environmental Biology Unit, Geneva, was then directing WHO's global survey for candidate biocontrol agents of vectors) informed Dr. Omori of this activity. As one of its taxonomic collaborators Dr. J.N. Couch of the University of North Carolina was studying all *Coelomomyces* collections resulting from this survey, one of the 2 Oshima slides was duly sent to him. Field data accompanying it were apparently mislaid prior to the publication of the Couch and Bland (1985) monograph.

The first new species of *Coelomomyces* to be described from Japan was *C. ponticulus* Nolan and Mogi (1980). It originated, in mixed infections with the nominotypical variety of *C. stegomyiae*, from larval *Ae. (Stg.) flavopictus* Yamada collected by one of us (M.M.) on Mikura-jima (33.53N × 139.35E), a small island far south of Sagami Bay, SW of Yokohama, Honshu. On present evidence, therefore, the northernmost limit of the natural range of *C. stegomyiae* var. *stegomyiae* is at this island's latitude.

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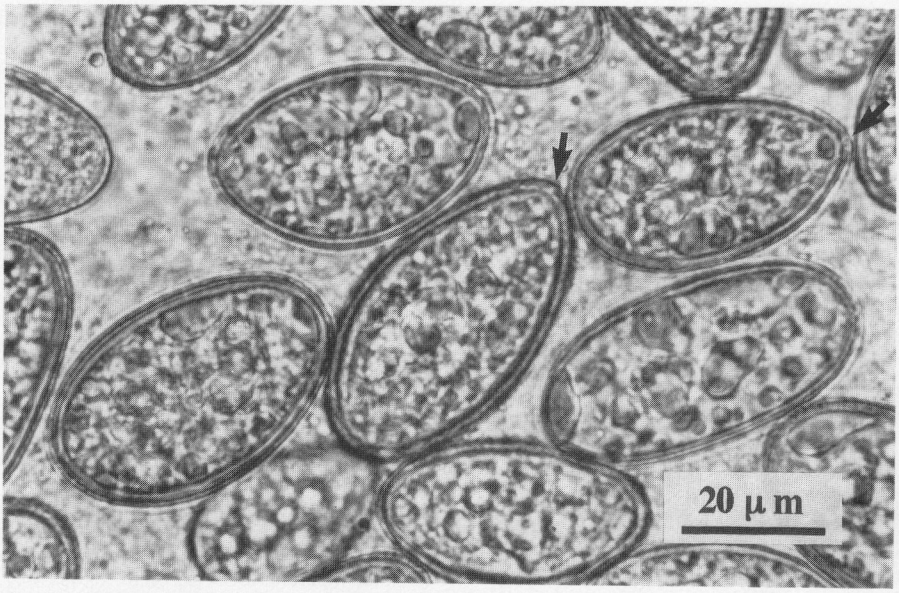

Fig. 1. Resting sporangia of *Coelomomyces stegomyiae* var. *stegomyiae* (fresh examples in physiological saline); the arrows indicate slight tapering towards one pole, as found in up to 20% of Kabeshima material from larval *Aedes albopictus*.

Its next most northerly records from anywhere in the world are the 2 from *Ae. albopictus* reported herein from Kabeshima, which lies only 20′ south of Mikura-jima from which, however, it is separated by 9°14′ of longitude; an E-W distance little short of that separating eastern Honshu from western Kyushu.

Most of our Kabeshima resting sporangia are ellipsoid (Fig. 1), in conformity with *C. stegomyiae* var. *stegomyiae*, from which Couch and Bland differentiate only *C. stegomyiae* var. *chapmani* Laird et al. (1980). The latter, while having at least half of its resting sporangia shaped as in var. *stegomyiae*, has up to 50% of them "characterized by bipolar pointing resulting in a typically fusiform shape" (Couch and Bland 1985). Interestingly, up to 20% of the Kabeshima resting sporangia are slightly tapered toward one pole (arrows, Fig. 1). Nevertheless, this feature, while more evident than in a diversity of var. *stegomyiae* material seen over the years by M.L., is not to be confused with the decided pointing (which is usually bipolar at that) of var. *chapmani* as illustrated by Laird et al. (1980, Fig. 4) and by Couch and Bland (1985, Fig. 555).

As in both varieties of *C. stegomyiae*, the resting sporangia from Kabeshima *Ae. albopictus* display surface ornamentation of widely spaced punctae characterized by depressed margins. These average 0.5 μm in diameter, and are 1–5 μm apart from one another. The thickness of the sporangial wall is within the range of 1.5–4 μm. Overall dimensions, as measured from photomicrographs of fresh examples in physiological saline, are 17.6–29.9 × 24.2–54.3 μm (23.0 ± 2.5 × 38.4 ± 5.2 μm, mean ± SD, $n = 124$).

The Kabeshima resting sporangia thus agree well in their general form and ornamentation with *Coelomomyces stegomyiae* var. *stegomyiae*. Their size is not only very close to that reported by Keilin (1921) — 20–30 × 37.5–57 μm — but agrees well with subsequent findings from the type host (Table VIII of Couch and Bland 1985); in which, however, some of the materially larger dimensions reported from certain hosts presumably (as recognized by the latter investigators) reflect inaccuracies due to faulty technique.

Mikura-jima and Kabeshima are, like Oshima, small islands characterized by natural forests of broad-leaved evergreen trees, rich in rot-holes. These, by accumulating rainwater runoff, are the primordial larval habitats for *Ae. albopictus*, *Ae. flavopictus*, *Ae. riversi* and various other known and potential hosts of *C. stegomyiae* var. *stegomyiae*. With regard to potential hosts (see Couch and Bland 1985, Table VIII for likely Japanese ones), 5 mosquito species additional to now-verified Japanese hosts were identified during the Kabeshima project. Two of these, *Armigeres subalbatus* (Coq.) and *Tripteroides bambusa* (Yamada), are with *Ae. albopictus* hosts for *C. stegomyiae* var. *chapmani* in the vicinity of Taitung (23.01N, 120.14E), Taiwan (Laird et al. 1980).

The present records of *C. stegomyiae* var. *stegomyiae* from Kabeshima appear to be the first

for this pathogen from adult mosquitoes. Of the 64 species and varieties of *Coelomomyces* validated by Couch and Bland (1985), all but one (from Chironomidae) parasitize Culicidae. The chironomid example and all but 8 of those from mosquitoes are known only from larvae. Seven of these 8 (including those from the above Kabeshima *Ae. albopictus*) have been reported from both larvae and adults of their hosts. The remaining one, *C. walkeri* van Thiel (1954), is known from adults only.

The predominance of larval records for *Coelomomyces* spp. may reflect both the wider practice of surveying for aquatic stages of mosquito pests and vectors, and the relative ease of recognizing resting sporangia in intact larvae. An apparently low adult incidence might be simply an artefact due to dissection of adult mosquitoes (by no means a routine procedure) being prerequisite to discovering infections. It is thus submitted that ovarian infections are probably commoner than the literature suggests, and that oviposition by parasitized females constitutes a natural means of dispersing the infective stages of *Coelomomyces* among larval habitats.

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