

Hochbergia moroteuthensis gen. et sp. nov., a giant protistan parasite from the giant squid *Moroteuthis robusta* (Mollusca: Cephalopoda)

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ABSTRACT: A new species of giant unicellular parasite inhabiting the gills of squid *Moroteuthis robusta* is described from specimens collected from the northeastern Pacific Ocean. *Hochbergia moroteuthensis* gen. et sp. nov. belongs to a recently reported group of protistans whose taxonomic affinities are as yet unknown. Members of the group parasitize cephalopods and have a characteristic aspect: most of the body wall is raised into close-fitting triangular plates and there is a holdfast region, devoid of plates, by which the parasites attach to the host. *H. moroteuthensis* is the first species of the group to be named. The general form of the body, the precise number and arrangement of plates, and the morphology of the holdfast region are described.

INTRODUCTION

Among the diverse taxa of symbionts of cephalopods is a recently reported group of giant, gill-inhabiting protistans (McLean et al. 1987). These unicellular organisms have a characteristic appearance: their surface is raised into triangular plates which are arranged around numerous foci (McLean et al. 1987; Figs. 1 to 5 of this paper). The taxonomic affinities of these parasites are not yet certain, but they possess trichocysts similar to those of dinoflagellates. In this paper, we provide the first taxonomic description of a member of this group of parasites; the new species inhabits the giant squid *Moroteuthis robusta*.

MATERIALS AND METHODS

Two giant squid *Moroteuthis robusta* (Verrill, 1876) were collected in 1982 from the vicinity of the Friday Harbor Laboratories, San Juan Island, Washington, USA. The first specimen was netted in June by a local fisherman; the second specimen was found on a beach near Mineral Point in July. The parasites were fixed in 3% glutaraldehyde (Ladd) in 0.1 M phosphate buffer (pH 7.3) with 0.35 M sucrose (room temp., 1 h), rinsed briefly in buffer with sucrose, and postfixed in 1%

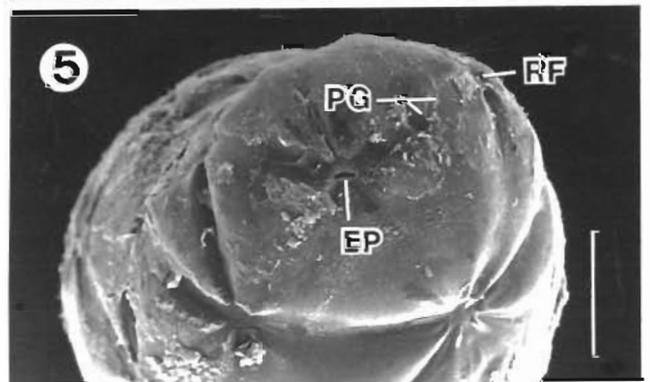
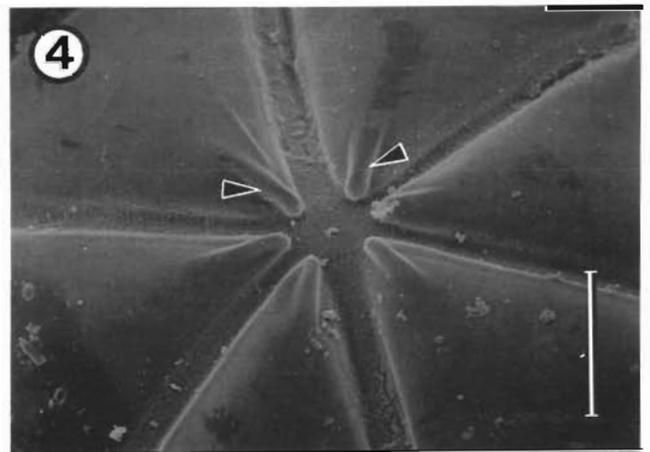
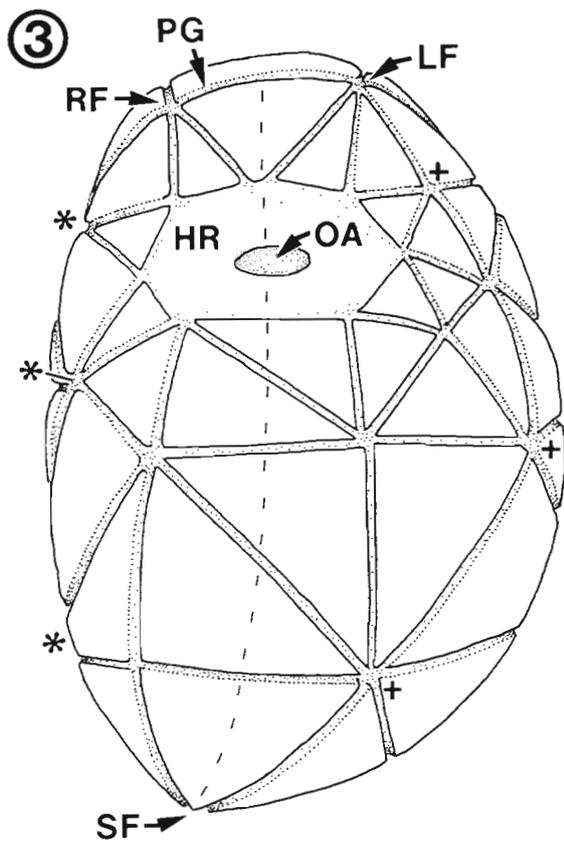
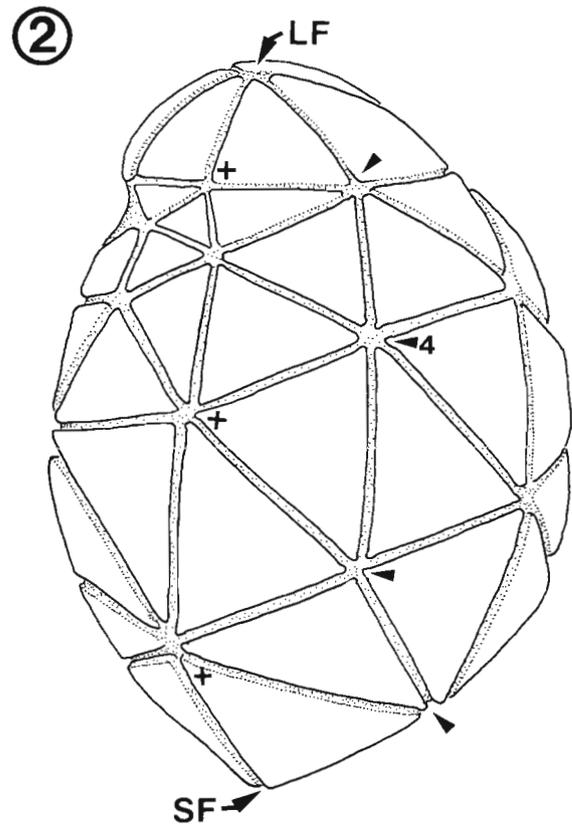
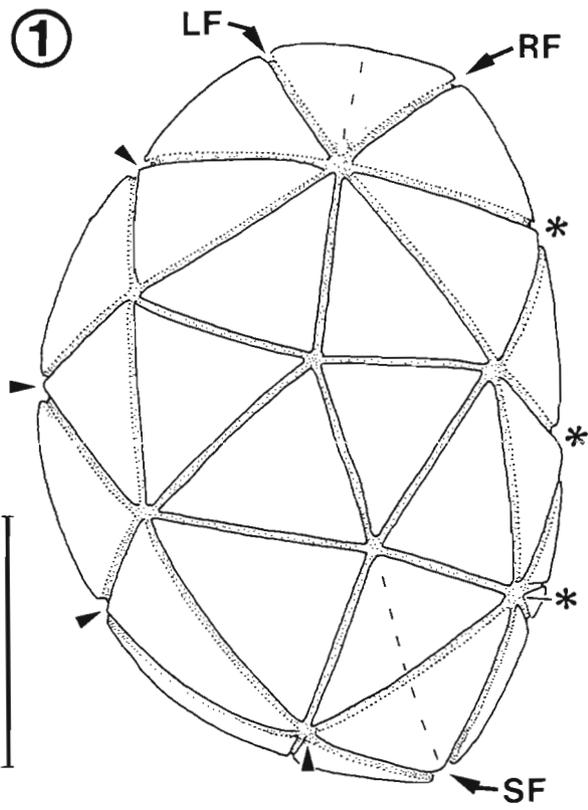
osmium tetroxide in 0.1 M phosphate buffer (pH 7.3) with 0.35 M sucrose (on ice, 1 h).

Doubly fixed specimens were dehydrated in an ethanol series, transferred through 2 changes of dimethoxypropane, and critical-point dried in CO₂. They were attached to stubs with Double Stick Scotch Tape and coated with Au/Pd. The specimens were examined with a JEOL JSM-35 scanning electron microscope as well as with a dissecting microscope. Cell length and width measurements were made of fixed, resin-embedded specimens (n = 40; McLean et al. 1987). The arrangement of surface plates and dimensions of the elongate pore, triangular plates, and oval aperture were determined from both critical-point dried specimens (n = 2), and resin-embedded specimens (n = 5).

RESULTS

General morphology

The body is ovoid in outline. The raised triangular plates characteristic of this group of parasites are arranged around foci in a pattern that is constant for the species presently being described (see 'Description' below and Fig. 3 of McLean et al. 1987). Two types of foci can be distinguished: those surrounded by a con-



tinuous series (or whorl) of plates are termed 'complete foci'; those around which the cell wall is not raised into a complete whorl of plates are termed 'incomplete foci'. Triangular plates are absent from the part of the cell, designated the 'holdfast region', by which the parasites attach to the host (Fig. 3). Thus, incomplete foci border the holdfast region. The cell wall of the holdfast region bears an 'oval aperture'. An attachment apparatus evidently emerges from the latter but did not come away from the host when the parasites were removed. The holdfast region is subterminally located. The end of the cell nearest the holdfast is hereafter called the 'holdfast end'. McLean et al. (1987) stated that this is the wide end of the cell but we have since found this to be the narrow end in some species, including *Hochbergia moroteuthensis*. The holdfast end of the cell bears 2 foci; the opposite end of the body has a single focus (Figs. 1 and 3). One focus at the holdfast end contains an 'elongate pore' (see Fig. 4 in McLean et al. 1987). Thus, contrary to McLean et al. (1987), the elongate pore is situated at the narrow end of the cell only in species with the holdfast at the narrow end. The pore, of unknown function, is readily seen only by SEM (Fig. 5).

The 2 foci at the holdfast end of the cell share 2 plates and are joined by the groove between the plates (Fig. 3). The groove, hereafter called the 'polar groove', coincides with a plane that separates the cell into a 'holdfast side' (Fig. 3) and a 'dorsal side' (Fig. 1). Both the holdfast side and the dorsal side are bisected by a curved line of near bilateral symmetry. The lines of near symmetry arise perpendicularly from the middle of the polar groove at the holdfast end and extend to the single focus at the opposite end of the cell. 'Left' and 'right' sides of the cell are designated as if the holdfast region were located anteroventrally.

Description

Hochbergia gen. nov.

Diagnosis. Ovoid, cyst-like protistans with surface elaborated into low triangular plates separated by grooves; plates arranged in groups around numerous

foci. Color varies from white to yellow-orange. Holdfast region, located near the narrow end of cell bearing the polar groove, lacks plates and bears an oval aperture through which cytoplasmic extensions presumably emerge to anchor the parasite to the gills of the host. One focus at holdfast end of cell bears an elongate pore. Surface of plates smooth but may have a short ridge at each corner, or a shallow indentation along each edge. Single large nucleus present in cell. Cell enclosed by an extracellular wall. Cytoplasm contains trichocysts of dinoflagellate type.

Type species: *Hochbergia moroteuthensis*.

Etymology: *Hochbergia* is named after Dr F. G. Hochberg of the Santa Barbara Museum of Natural History, in recognition of his numerous contributions to the study of cephalopod symbionts.

Hochbergia moroteuthensis gen. et sp. nov.

Yellow-orange in life, 1.19 to 1.99 mm long (average 1.62, \pm 0.23 mm SD) by 0.70 to 1.33 mm wide (average 1.05 \pm 0.19 mm SD). Cells slightly flattened, ovoid; widest toward end of cell lacking the holdfast region. Arrangement of triangular surface plates constant (Figs. 1 to 3). Plates in groups of 4 to 7 around 24 complete foci and 7 incomplete foci. Surface of plates smooth, but raised into a short ridge at each corner. Grooves between plates moderately broad and shallow but somewhat variable depending on location and cell size. Plates vary in size from ca 150 μ m per side to 500 μ m per side. The smallest plates are located around the incomplete foci to the sides of the holdfast region; the largest plates are located on the widest part of the holdfast side.

Left focus at holdfast end bears the elongate pore and is surrounded by 6 plates. Elongate pore measures ca 50 by 10 μ m. Right focus at holdfast end has 5 plates and evidently lacks an elongate pore. Two foci connected by the polar groove are complete. Thus, holdfast region is separated from 2 holdfast-end foci and polar groove by a row of plates. Oval aperture measures ca 150 μ m wide and 60 μ m tall.

Single focus at end of cell opposite the polar groove

Fig. 1 to 5. *Hochbergia moroteuthensis*. Fig. 1 to 3. Camera lucida drawings showing stereotypic arrangement of triangular surface plates around foci. Scale bar = 0.5 mm. HR: holdfast region; LF: left focus at holdfast end; OA: oval aperture; PG: polar groove at holdfast end; RF: right focus at holdfast end; SF: single focus at end opposite polar groove. Arrowheads indicate corresponding foci on Figs. 1 and 2; asterisks indicate corresponding foci on Figs. 1 and 3; crosses indicate corresponding foci on Figs. 2 and 3. Fig. 1. Dorsal side. Dashed line indicates line of near bilateral symmetry. Fig. 2. Left side. Note that holdfast side lies to left and dorsal side lies to right. The number 4 indicates location of focus shown in Fig. 4. Fig. 3. Holdfast side. Dashed line indicates line of near bilateral symmetry. Note the incomplete foci (see text) bordering the holdfast region. Fig. 4. SEM of focus indicated on Fig. 2, showing characteristic short ridges (arrowheads) on apices of triangular plates. Scale bar = 100 μ m. Fig. 5. SEM showing elongate pore (EP) in left focus at holdfast end of cell. This specimen swelled slightly during preparation; the grooves between triangular plates are shallower and thus the elongate pore is more evident than usual. PG: location of polar groove; RF: location of right focus at holdfast end. Scale bar = 500 μ m

surrounded by 4 plates. One of latter lies on holdfast side, one spans each side of cell between dorsal and holdfast sides, one lies on dorsal side. Sides of body not perfectly bilaterally symmetric: left side has 12 more plates and 6 more foci than right side and thus appears more inflated than right side.

Taxonomic summary

Specimens deposited: The types, whole specimens fixed in osmium tetroxide and mounted on separate SEM stubs, have been deposited in the Santa Barbara Museum of Natural History. HOLOTYPE (SBMNH 33919), PARATYPE (SBMNH 33920).

Host: *Moroteuthis robusta* (Verrill, 1876) (Cephalopoda: Onychoteuthidae).

Type locality: USA, Washington, Puget Sound, vicinity of San Juan Island.

DISCUSSION

There are no previously described species of the group of squid gill parasites to which *Hochbergia moroteuthensis* belongs. Taxonomic affinities of the group are discussed in McLean et al. (1987).

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LITERATURE CITED

McLean, N., Hochberg, F. G., Shinn, G. L. (1987). Giant protistan parasites on the gills of cephalopods (Mollusca). *Dis. aquat. Org.* 3: 119-125

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