

REEF AND SHORE FAUNA OF HAWAII

Section 2: Platyhelminthes through Phoronida
and

Section 3: Sipuncula through Annelida

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Chapter VI

Phylum PHORONIDA

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PHORONIDS are exclusively marine animals living in cylindrical tubes of their own secretion. The tubes may be covered with sand grains and arranged vertically in soft sediments or the animals may encrust or burrow in hard substrates (e.g., corals, rocks, shells, barnacles). This group of small, widely distributed benthic invertebrates comprises only 2 genera, *Phoronis* and *Phoronopsis*. Three species of *Phoronis* are known from Hawaiian waters (Emig 1982).

Until recently the only evidence of phoronids in Hawaiian waters has been the presence of their actinotroch larvae in the plankton. Zooplankton samples have periodically yielded advanced actinotrochs since 1945 (A. H. Banner, pers. comm.), but the location of phoronid populations remained unknown until 1976 when 3 phoronid species were collected from shallow coral-reef habitats in Kaneohe Bay, Oahu. Two species, *Phoronis ovalis* and *Phoronis hippocrepia*, burrow into calcareous materials and were found in the course of sorting benthic carbonate samples processed by acid dissolution, a technique devised by Brock and Brock (1977). The third species, *Phoronis psammophila*, came from a subtidal sand flat where it forms vertically oriented, sand-encrusted tubes. These 3 species of phoronids from Hawaiian waters were identified by Emig (1977) and the distribution of *Phoronis hippocrepia* was included in an unpublished environmental report by Brock (1976).

Adult morphology (Fig. 2.VI.1). The phoronid body is vermiform and divided into 3 regions, each with a coelomic cavity (coel): the epistome (or protosome), with a proto-coel; the lophophore (or mesosome), with a mesocoel; and the trunk (or metasome), with a divided metacoel. The lophophore is the anteriormost region and is a tentacular extension of the mesosome surrounding the mouth but not the anus. The lophophore functions in food gathering (ciliary bands on the lophophoral tentacles filter particulate organic matter from the water and convey it to the mouth), respiration, and protection (Emig 1976). A transverse mesentery,

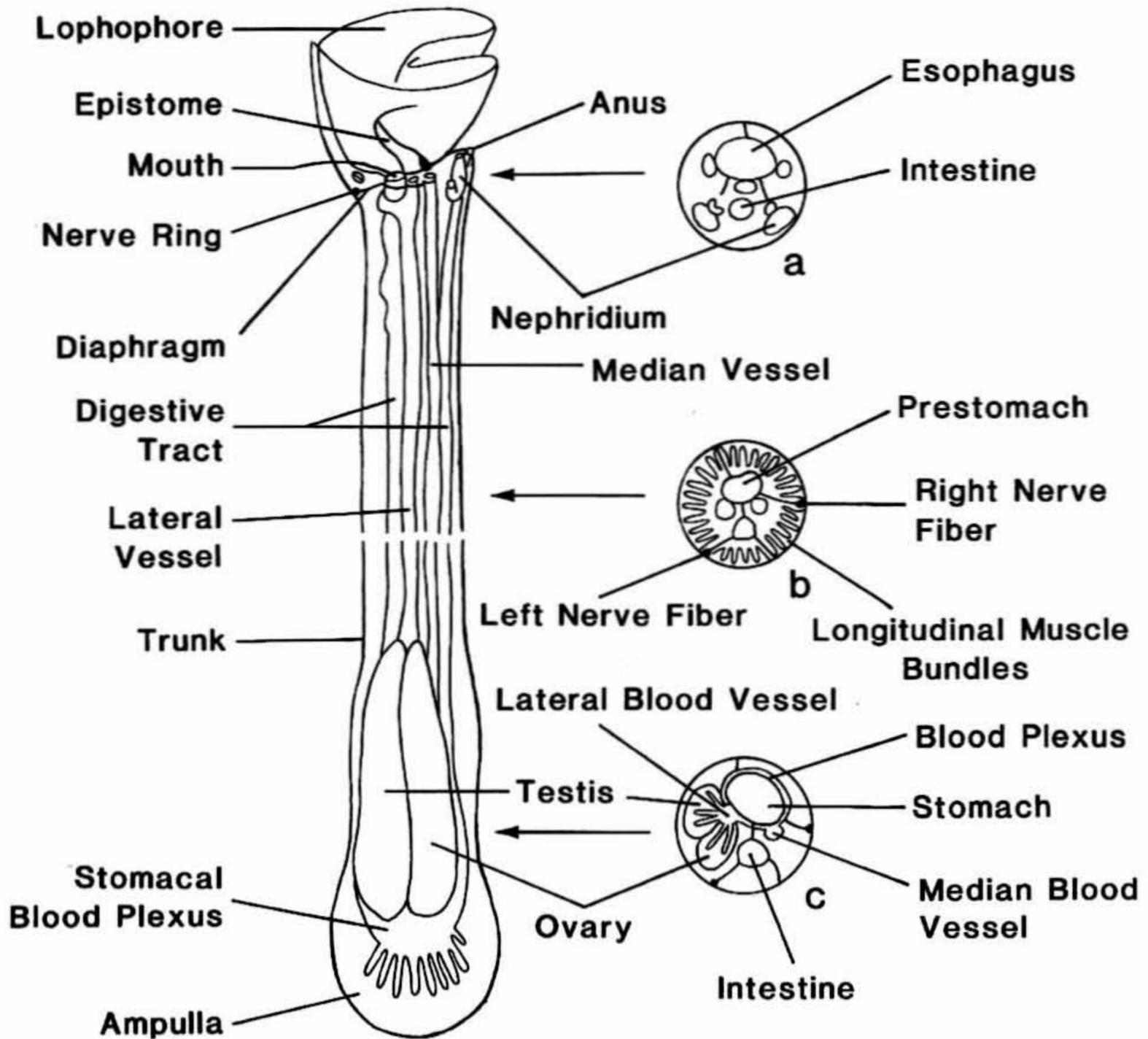


Figure 2.VI.1.—Diagram of an adult phoronid (*Phoronis psammophila*), with cross sections at 3 levels: a, nephridial; b, muscular; c, ampullary.

the diaphragm, is located at the base of the lophophore. The trunk contains the main organs and is slender and cylindrical with an end-bulb, or ampulla, which is used for burrowing and anchorage in the tube. The U-shaped digestive tract extends through the trunk. The anus lies near the mouth but is separated from it by the lophophore and the epistome. Nephridia (excretory organs) are located on both sides of the intestine near an anal papilla. The nephridia open into the trunk coelom by 1 or 2 funnels and to the exterior by a nephridiopore on either side of the anus. Ripe gametes (eggs and sperm) as well as excretory wastes pass to the exterior via the nephridia. The circulatory system contains red blood corpuscles and comprises 2 longitudinal vessels (3 in *Phoronis ovalis*) uniting in the stomacal blood plexus and in the lophophoral vessel. The nervous system is basiepithelial; a ganglion between the mouth and anus connects to a nerve ring at the level of the diaphragm, and to 1 or 2 giant nerve fibers.

Most phoronids are hermaphroditic (an individual produces both eggs and sperm), but some are dioecious (produce only eggs or sperm). The gonads are attached to the lateral blood vessel and its capillary caeca adjacent to the stomach. Accessory sex glands develop in the lophophoral cavity and may be concerned

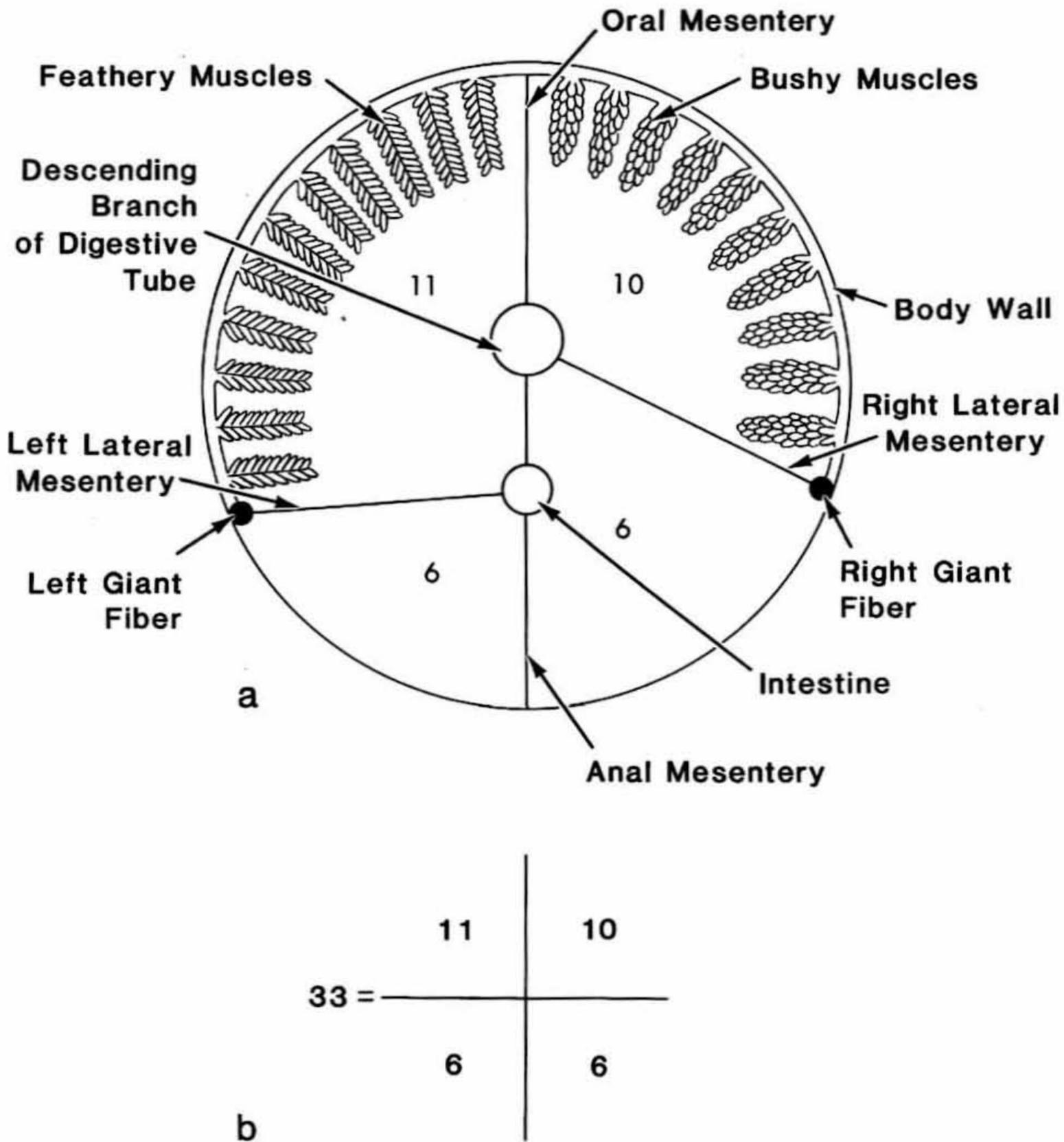


Figure 2.VI.2.—a, cross section through the trunk of a diagrammatic phoronid showing the arrangement of longitudinal mesenteries dividing the trunk into 4 unequal compartments, and the 2 types of longitudinal body-wall muscles (bushy and feathery) recognized. Muscles are all of 1 type for any given species, although the number in each quadrant varies from individual to individual and may change with age (body-wall muscles in lower compartments not shown); b, the conventional muscle formula for Figure 2.VI.2a.

with sperm distribution and, in some species, with embryo brooding. The trunk coelom is divided into 4 compartments by longitudinal mesenteries, which are used to establish the formulae describing the arrangement of the longitudinal muscle bundles of the trunk wall (Figs. 2.VI.2a,b). This formula and the shape of the longitudinal muscles in section (bushy or feathery, Fig. 2.VI.2a) are key taxonomic features.

Larval morphology (Fig. 2.VI.3). The typical phoronid larva is an actinotroch that usually has a lengthy planktonic existence, although *Phoronis ovalis* is an

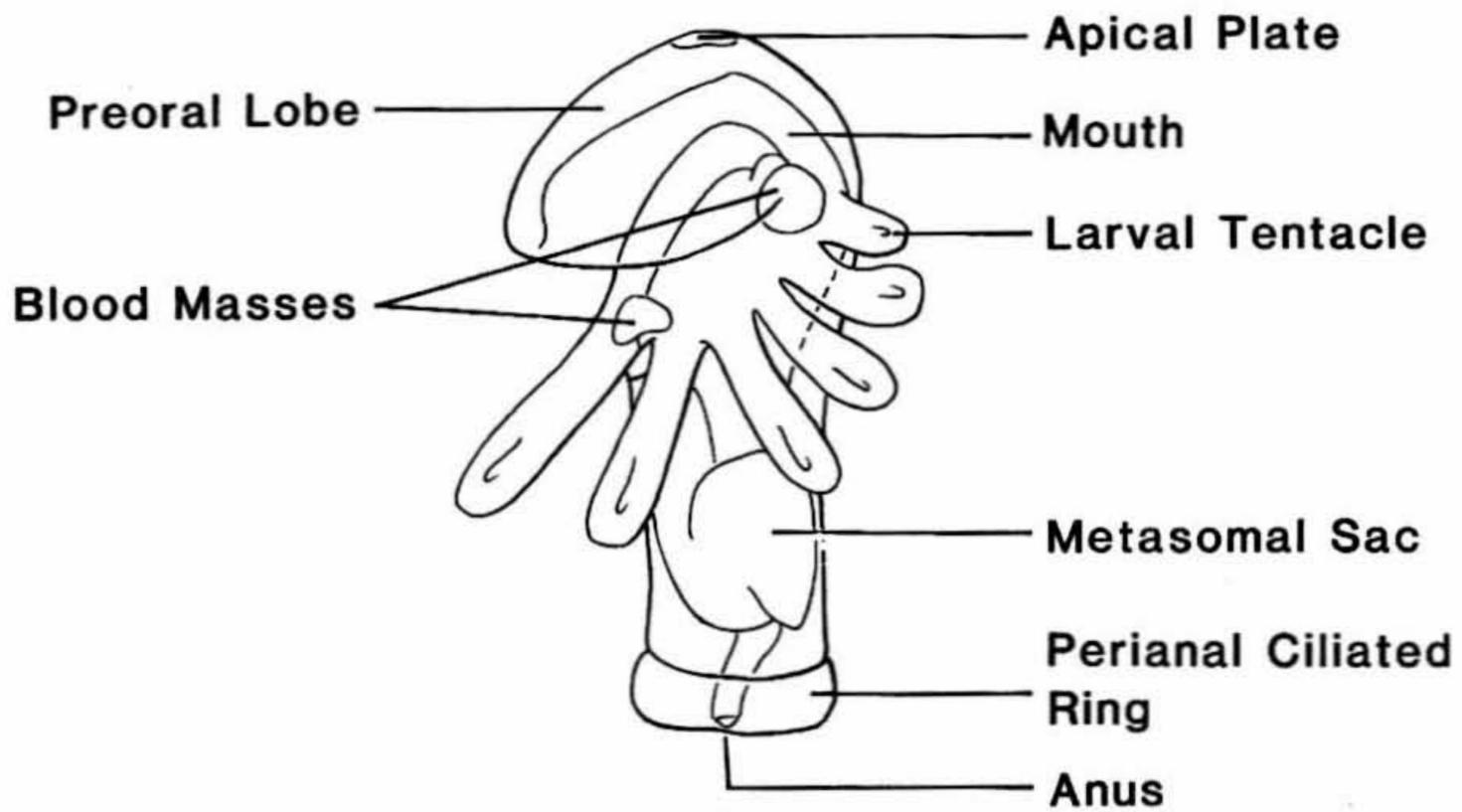


Figure 2.VI.3.—Diagram of an actinotroch larva (*Phoronis psammophila*) approaching metamorphosis.

exception (Emig 1982). The actinotroch is composed of 3 regions, each with a coelomic cavity, but the collar coelom (or incipient lophophoral coelom) appears only in later stages of development.

A preoral hood or lobe bears the apical plate, or larval neural ganglion, that is characteristic of most actinotroch larvae. The main swimming and feeding structures are an anterior circle of ciliated tentacles and a posterior ciliated ring. Larvae approaching metamorphosis develop definitive lophophoral tentacles at the bases of the larval tentacles and a metasomal pouch within the elongating metasome. At metamorphosis the metasomal pouch everts to form the trunk; burrowing and tube formation follow. The larval digestive tube is straight and lacks the prestomach but becomes U-shaped following eversion of the metasomal pouch at metamorphosis (Zimmer 1978; Emig 1979; Herrmann 1979).

Phoronis ovalis produces lecithotrophic larvae that have a short pelagic life (4 days) before developing into crawling, sluglike larvae (Figs. 2.VI.4a,b) that settle, curl up under a thin membrane (Figs. 2.VI.4c,d), and eventually burrow into the underlying carbonate substrates (Silén 1954).

PHORONID STUDY TECHNIQUES

Features of taxonomic importance used in the identification of adult phoronids include lophophoral tentacle arrangement, nephridial morphology, giant nerve fiber number, longitudinal trunk body-wall muscle formula, gonads, and accessory sex-gland characteristics (Emig 1974, 1979). Most of these features can only be determined after histological examination. At the time of collection, specimens should be placed in Bouin's fixative, dehydrated, embedded in paraffin wax, sectioned at 7 μm , and stained in Azan (Heidenhain method). Details of the embedding, sectioning, and staining techniques can be found in Galigher and Kozloff (1971). The habitat from which specimens are collected can also be useful in identification of the species.

The following key to the identification of known adult Hawaiian phoronids is based on readily visible external structures.

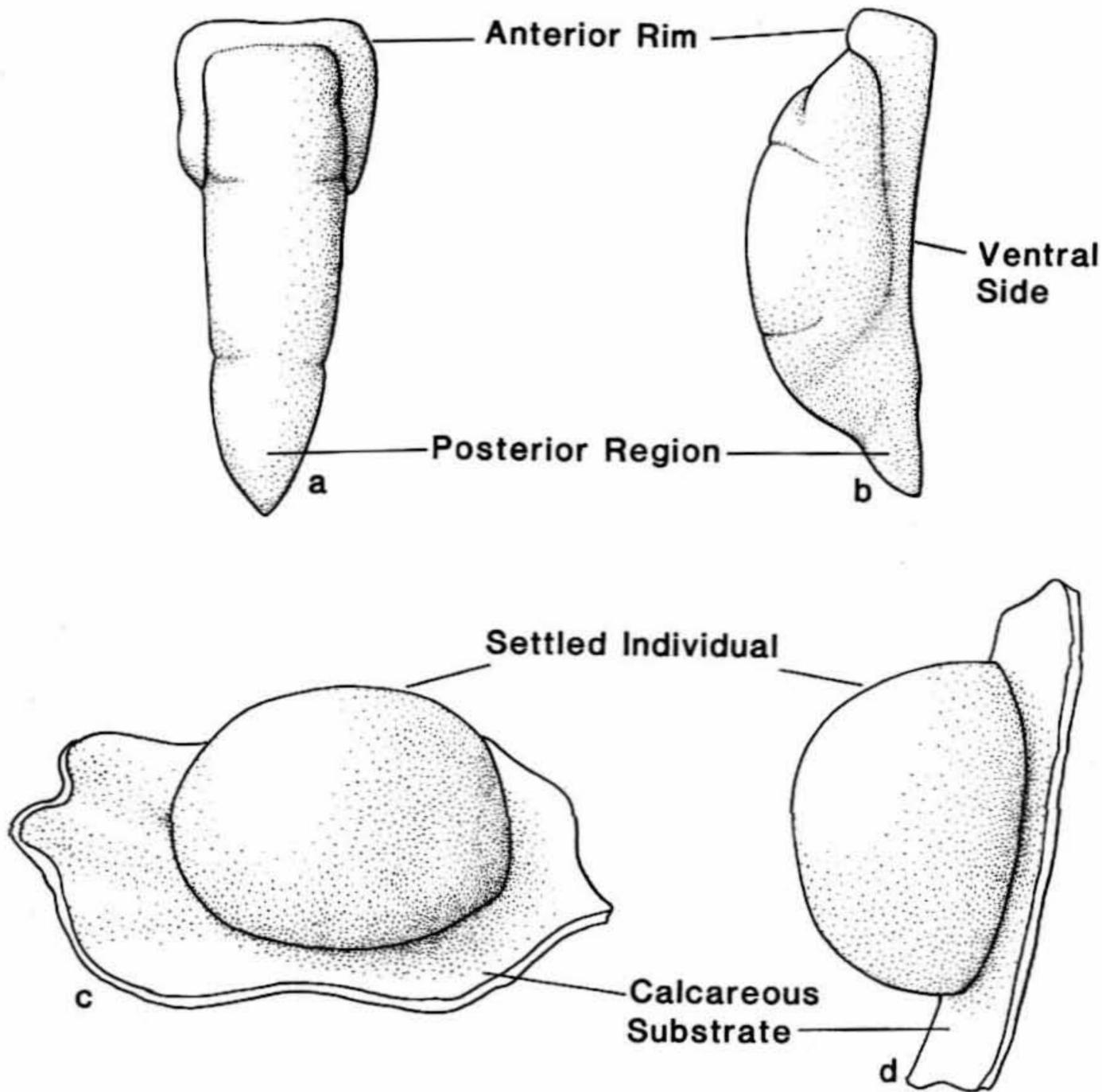


Figure 2.VI.4.—*Phoronis ovalis* larvae: a, dorsal and b, lateral view of fifth-day larva at the creeping stage; c, dorsal and d, lateral view of seventh-day larva at settlement (from Silén 1954).

KEY TO HAWAIIAN PHORONIDA

- 1 Tube straight, vertically oriented in sediment, and covered with attached sand grains; adults 15 to 44 mm long (contracted)
 - *Phoronis psammophila*
- Tube membranous, often sinuous and contained within calcareous materials (except for the aperture); adults 2 to 30 mm long..... 2
- 2(1) Tentacle bases form simple oval shape; adults minute, 2 to 6 mm long (contracted) *Phoronis ovalis*
- Tentacle bases form horseshoe shape; adults 5 to 30 mm long (contracted) *Phoronis hippocrepia*

Phoronis hippocrepia Wright, 1856

This species (Figs. 2.VI.5a-c) is flesh-colored, about 5 to 30 mm long when contracted, and has a horseshoe-shaped lophophore composed of as many as 150 tentacles. The nephridia have a single ascending branch (Fig. 2.VI.6a) forming 2 horizontal chambers; the lower one opens by 2 coelomic funnels (the anal funnel

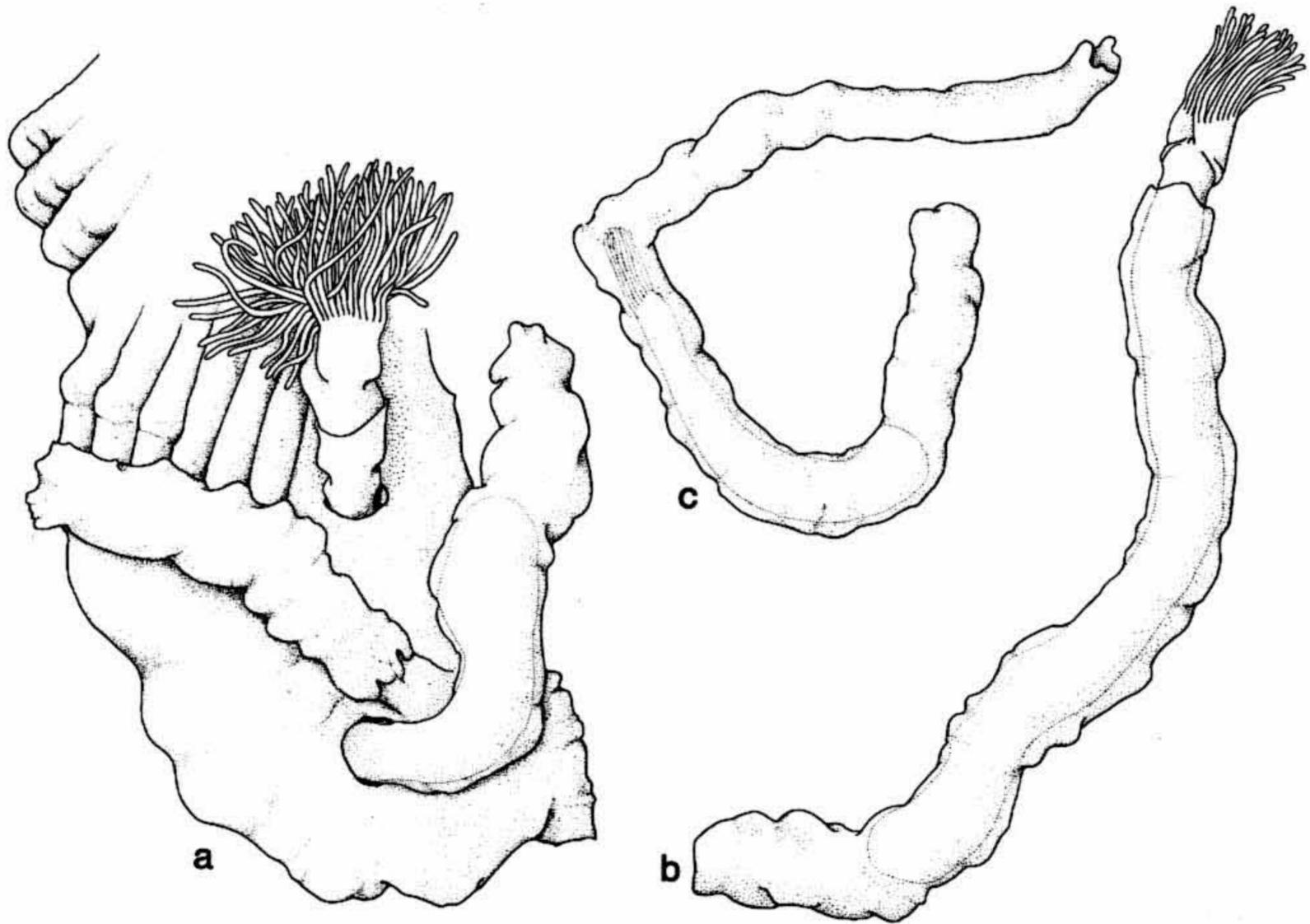


Figure 2.VI. 5.—*Phoronis hippocrepeia*, whole animal: a, *in situ* within an empty barnacle shell; b, removed from the shell, an individual with the anterior region and lophophore protruding from its tube; c, the position of a retracted individual within its tube.

is larger than the oral funnel). Two giant nerve fibers are present, 1 on the left (4 to 10 μm in diameter) and 1 on the right (1 to 7 μm in diameter). The longitudinal muscles, of the bushy type, vary according to the following conventional formula (see Fig. 2.VI.2):

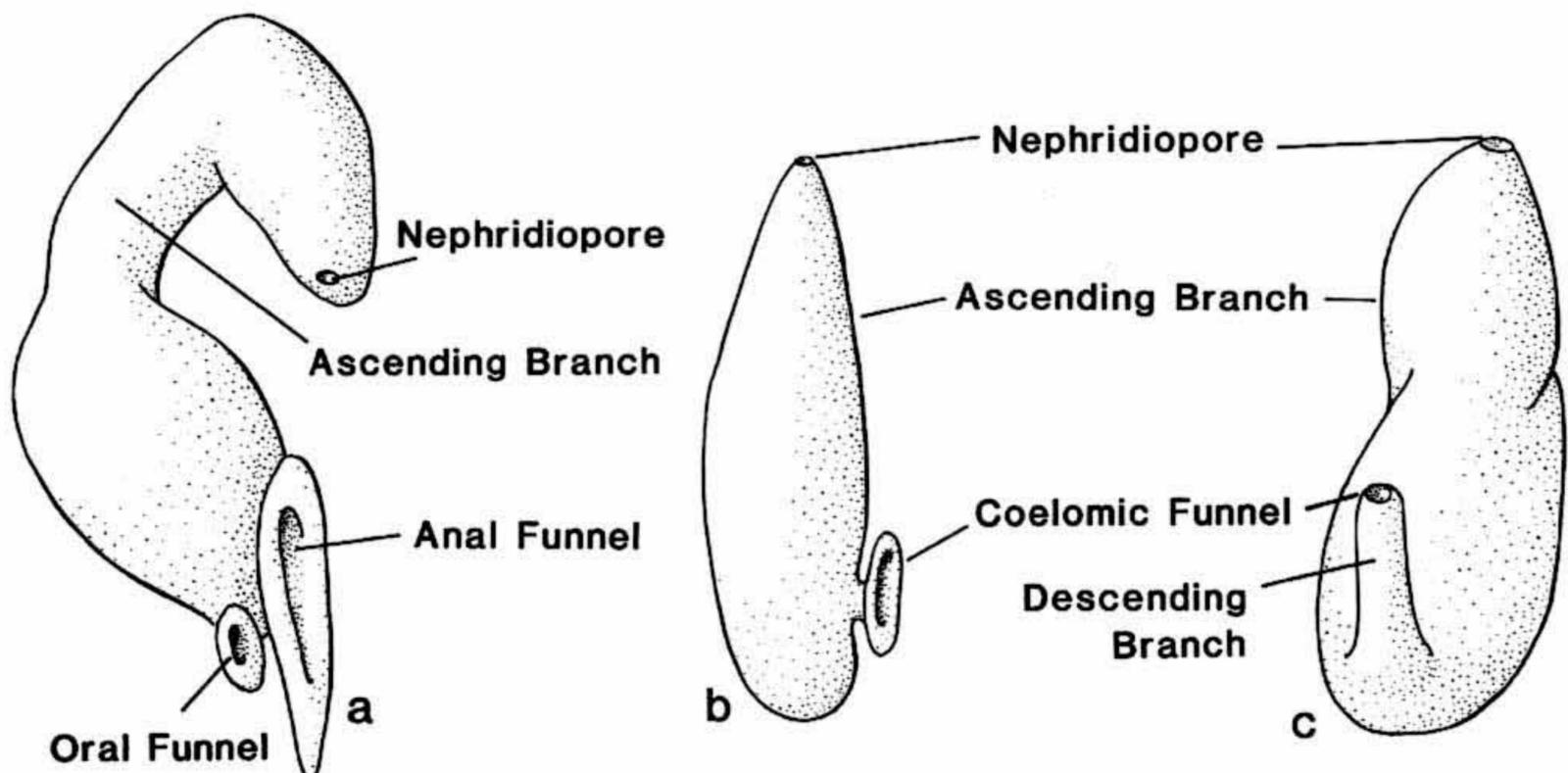


Figure 2.VI.6.—Structure of nephridia: a, *Phoronis hippocrepeia*; b, *P. ovalis*; c, *P. psammophila*.

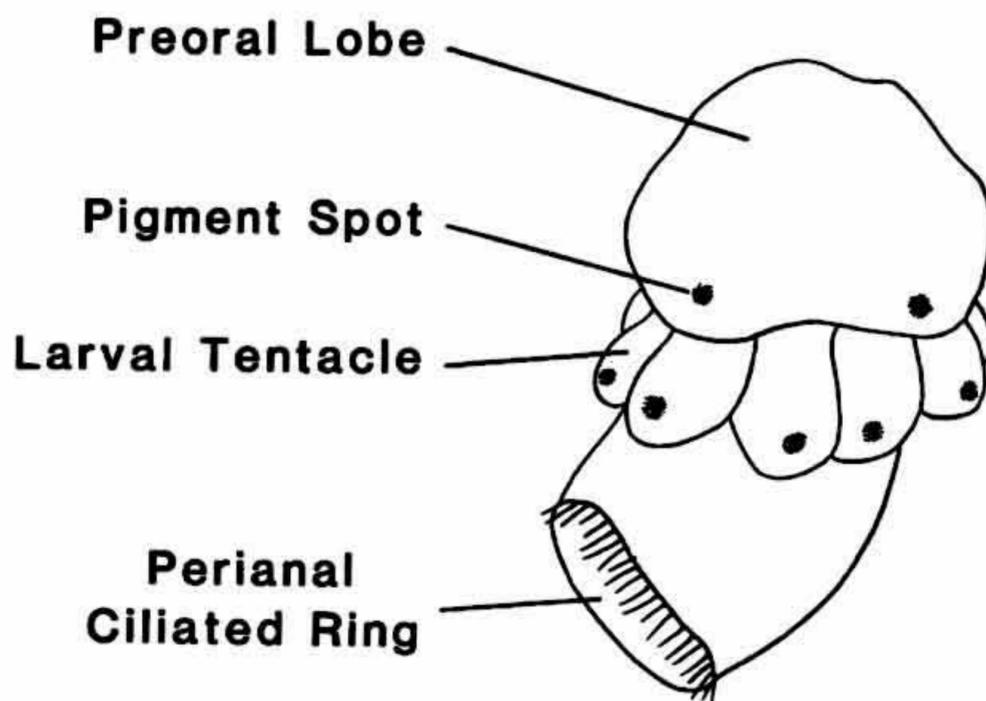


Figure 2.VI.7.—*Phoronis hippocrepeia* larva: lateral view (from Silén 1954).

$$[24-43] = \begin{array}{c|c} 7-15 & 7-16 \\ \hline 3-7 & 3-10 \end{array}$$

Phoronis hippocrepeia is hermaphroditic, and its embryos are brooded as paired masses in the lophophore. The larva, which was described by Silén (1954) as *Actinotrocha hippocrepeia* (Fig. 2.VI.7), is characterized by an opaque body covered with patches of pigment. The larva also has 2 ventral blood masses that fuse in older larvae and 10 larval tentacles.

In Kaneohe Bay, *P. hippocrepeia* burrows into coral rock, and into oyster shells and barnacles (Fig. 2.VI.5a) attached to harbor pilings to depths of 30 cm below mean tide level. The animal secretes a membranous tube that lines the burrow and that usually branches and ramifies through the carbonate matrix. Clusters of translucent white lophophores are readily visible in areas protected from excessive water motion. This species is known from the North Atlantic, North Sea, Mediterranean, southern Africa, and Brazil (Emig 1973). In the Pacific this species has been recorded only from the Hawaiian Islands (Emig 1977).

Phoronis ovalis Wright, 1856

This is the smallest known phoronid species. It is generally 2 to 6 mm long, with an oval-shaped lophophore (composed of 11 to 28 short tentacles). Specimens are usually transparent or semitransparent and some have a band of brown pigmentation where the lophophore joins the trunk (Forneris 1959). The ampulla is well developed (Fig. 2.VI.8), serving to anchor the animal within the burrow. Nephridia have a straight ascending tube and a single, small coelomic funnel (Fig. 2.VI.6b). The nervous system lacks (not visible) giant nerve fibers, and both lateral mesenteries are absent from the trunk. In addition to the typical circulatory system, an "accessory" blood vessel and a second lateral longitudinal vessel exist. There are 14 to 39 longitudinal muscles, of which 7 to 21 are in the left cavity and 7 to 19 in the right one. (There is no conventional formula for this species because of the absence of lateral mesenteries in the trunk). *Phoronis ovalis* is probably dioecious. It lacks nidamental glands (accessory sex glands) but is

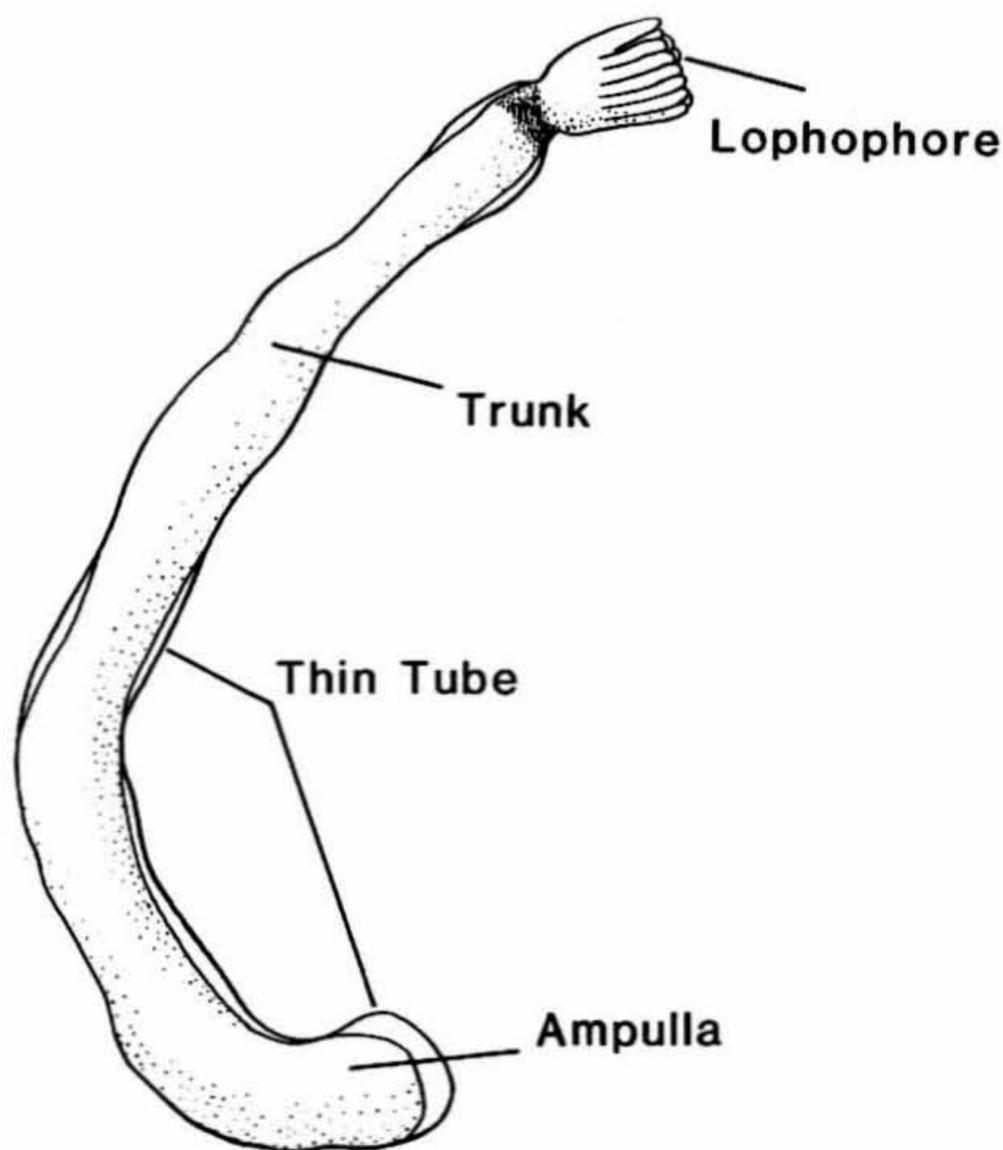


Figure 2.VI.8.—*Phoronis ovalis*: whole animal (contracted).

known to brood embryos within the parental tube (Silén 1954). In Hawaii, *P. ovalis* is found on shallow reef flats in burrows in coral rubble, where it attains estimated densities of 12,000/m² in Kaneohe Bay, Oahu. However, individuals are difficult to find because of their small size and cryptic habitat. This species is known from the North and South Atlantic, North Sea, Mediterranean, Chile, New Zealand, Vancouver, and the Hawaiian Islands (Emig 1973, 1977).

Phoronis psammophila Cori, 1889

Adult specimens are flesh-colored and from 15 to 40 mm long when contracted (Fig. 2.VI.9). The lophophore is horseshoe-shaped and composed of as many as 130 tentacles, which are speckled with white spots that remain after preservation. The nephridia have a descending branch opening by a single coelomic funnel and an ascending branch (Fig. 2.VI.6c). There is a single giant nerve fiber on the left side measuring 5 to 27 μ m in diameter. The longitudinal muscles are of the feathery type and the formula is:

$$[25-53] = \frac{7-19 \quad | \quad 7-17}{4-11 \quad | \quad 4-11}$$

Specimens from Kaneohe Bay, Oahu, had the following muscle band formulae:

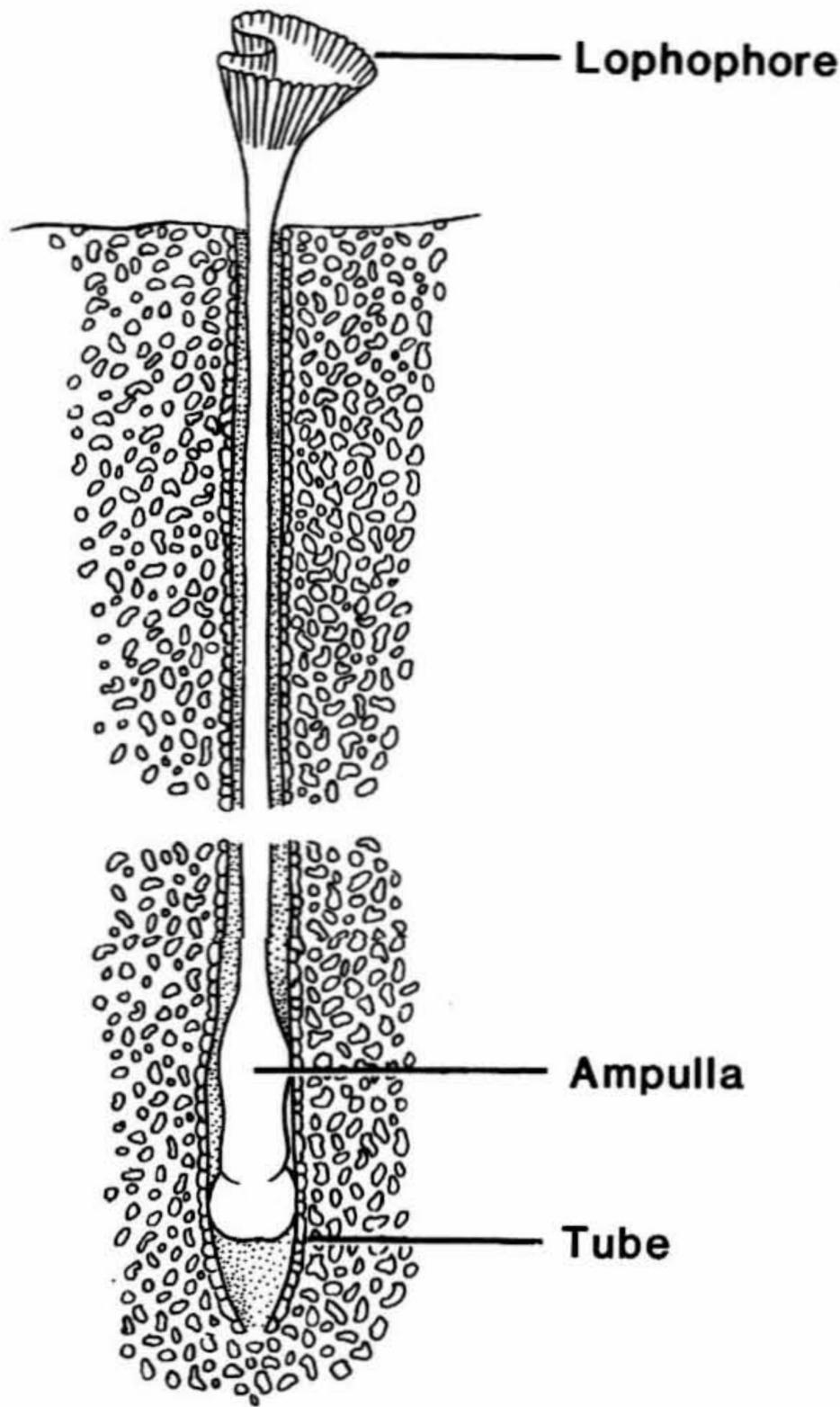


Figure 2.VI.9.—*Phoronis psammophila*: whole animal in normal position in its tube embedded in sand.

$$33 = \frac{11}{6} \mid \frac{10}{6} \text{ or } 34 = \frac{10}{7} \mid \frac{10}{7} .$$

Phoronis psammophila is dioecious; the females brood their embryos in a single mass in the lophophoral cavity. The pelagic larva is known as *Actinotrocha sabatieri* and was discovered by Roule (1896). The larva (Herrmann 1979) is transparent and has 3 blood masses, 1 on each side of the esophagus and the third on the ventral midline just above the tentacles. There are up to 12 larval tentacles, and presumptive adult tentacles are represented by thickenings of the larval tentacles (Fig. 2.VI.3).

Phoronis psammophila has been found subtidally to a depth of 3.5 m in an area of fine sand and coral rubble in Kaneohe Bay, Oahu. These specimens have

the characteristic straight tube covered with sand grains arranged vertically in the sediment (Fig. 2.VI.9). *Phoronis psammophila* is known from cool temperate and tropical regions of world oceans; in the tropical Pacific it has been found in the Solomon Islands, Panama, and in the Hawaiian Islands (Emig 1973, 1979).

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NOTE

1. Annotated diagrams of morphology and internal anatomy of adult and larval phoronids can also be found in Emig (1975, 1979, 1982).

GLOSSARY (PHORONIDA)¹

basiepithelial: In the lower part of the epithelium.

capillary caecum: Small blood vessel arising from the lateral blood vessel.

epistome: Epidermal flap of tissue bordering the inner tentacle row and overlapping the mouth that contains a fluid-filled cavity, the protocoel, and is surrounded by the lophophore.

ganglion: Group of nerve cell bodies.

lecithotrophic larvae: Larvae containing stored food reserves as yolk, usually with a short pelagic phase.

lophophore: Oval or horseshoe-shaped (sometimes more complex) feeding, respiratory, and protective structure composed of 2 rows of ciliated tentacles that surround the mouth and contain extensions of the mesocoel. The lophophore contains important components of the nervous and vascular systems.

muscle formula (Fig. 2.VI.2): The number of longitudinal body-wall muscles in each quadrant of the trunk.

preoral lobe or hood: Anterior hood in the actinotroch larva that projects ventrally above the entrance to the mouth and contains the protocoel.

prestomach: Part of the descending branch of the digestive system between the esophagus and the stomach, with a ciliary groove for conveying food materials to the stomach. Not present in the larva.

stomacal blood plexus: Blood-filled sinus surrounding the stomach of the phoronid into which the lateral blood vessels flow. Blood then enters the median vessel and is transported anteriorly.

trunk: The adult phoronid is divided into 2 major body regions based on external morphological features, the lophophore anteriorly and the rest of the body (or trunk) posteriorly. The trunk contains most or all of the main organs and systems, and the swollen posterior end is referred to as the ampulla.

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