Emig, C. C., D. F. Boesch and S. Rainer, 1977. Phoronida from Australia. *Records of the Australian Museum* 30(16): 455–474. [31 December 1977].

doi:10.3853/j.0067-1975.30.1977.191

ISSN 0067-1975

Published by the Australian Museum, Sydney

PHORONIDA FROM AUSTRALIA

CHRISTIAN C. EMIG
Station Marine d'Endoume, Marseille, France

DONALD F. BOESCH
Virginia Institute of Marine Science, Gloucester Point, Virginia, U.S.A.

and

SEBASTIAN RAINER[1]
Fisheries and Wildlife Division, Melbourne, Victoria, Australia

SUMMARY

Five species of Phoronida[2] have been recorded in Australian waters, from the vicinities of Brisbane, Sydney and Melbourne: *Phoronis pallida, P. psammophila, P. australis, Phoronopsis albomaculata* and *Phoronopsis harmeri*. A diagnosis for each species is given, together with notes on their taxonomy and ecology. The descriptions of three species, *Phoronis pallida, P. psammophila* and *Phoronopsis albomaculata,* have been expanded or modified. *Phoronopsis albomaculata* possesses nephridia with a single funnel, not two, and sometimes has a spiral lophophore. A new key to the species of Phoronida is provided, modifying the key established by Emig (1971).

INTRODUCTION

The earliest records of Phoronida in Australian waters were by Haswell (1883, 1885, 1893), from Port Jackson. *Phoronis australis* Haswell, 1883 was described burrowing in the tube wall of cerianthids (Coelenterata: Anthozoa), while a second species, considered to be probably *Phoronis psammophila* Cori, 1889 was recorded growing over empty mussel shells (Haswell, 1893). Other records of Phoronida have been of *P. australis,* from Port Jackson (Benham, 1889) and from Moreton Bay (Ponder, 1971).

An examination of material from recent survey work has increased the number of species of Phoronida known from Australia to five[2]. *Phoronis psammophila* has been definitely identified, and Australian records are now available for *Phoronis pallida* (Schneider, 1862), *Phoronopsis albomaculata* Gilchrist, 1907, and *Phoronopsis harmeri* Pixell, 1912. The occurrences of the five species in Australian waters are discussed below, together with brief descriptions, and a key to the species is provided. Records from Port Phillip Bay, in south-eastern Australia, are given with the station designations used previously (MMBW and FWD, 1973).

1 Present address: Division of Fisheries and Oceanography, Box 21, Cronulla, N.S.W. 2230, Australia.
2 Recently a sixth species, *Phoronis muelleri,* has been discovered from Moreton Bay, Queensland.

Records of The Australian Museum, 1977, **Vol. 30 No. 16,** 455-474, Figures 1-6

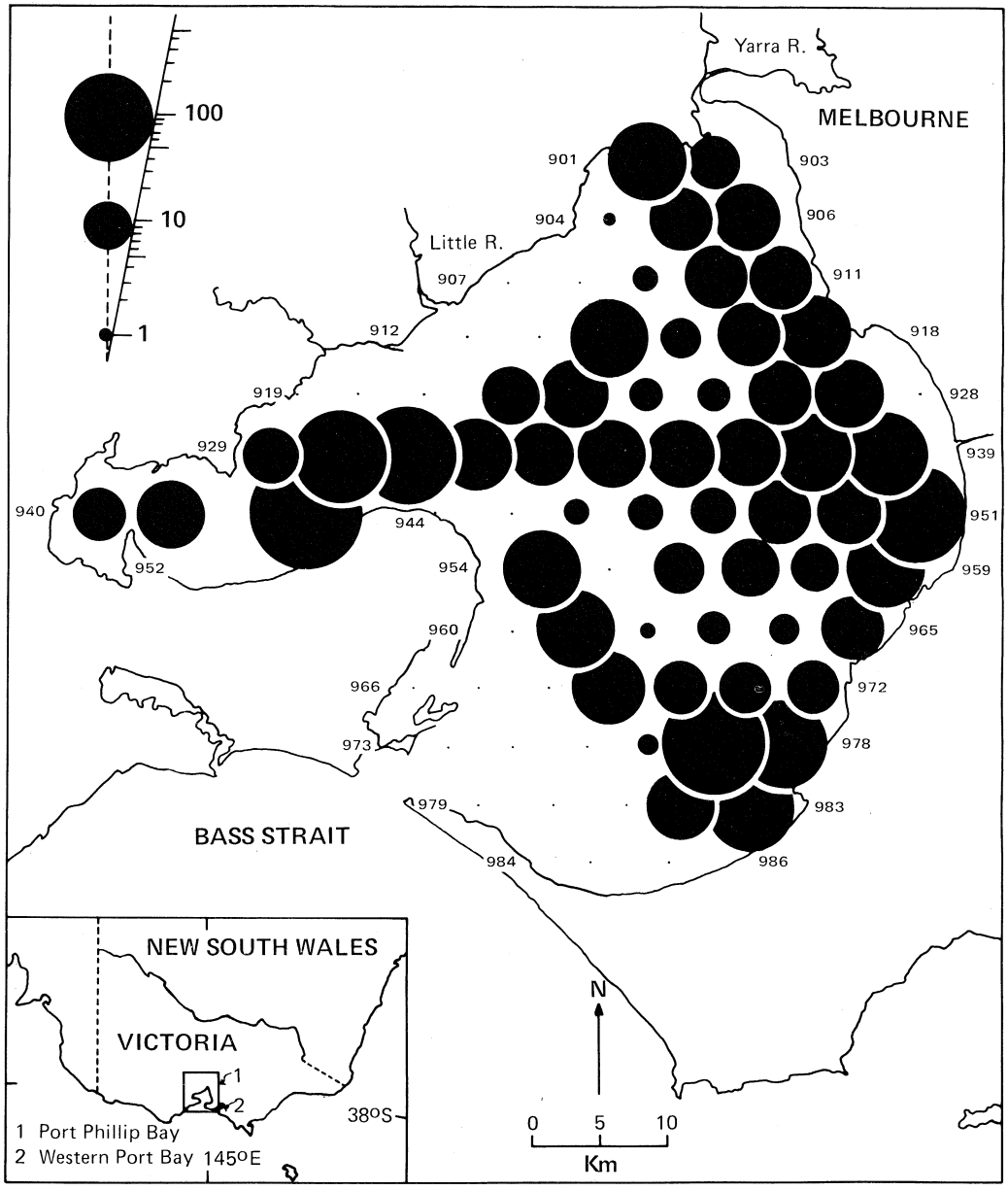

Fig. 1. *Phoronis pallida:* distribution and abundance (nos/m^2) in Port Phillip Bay, Victoria.

SYSTEMATICS

Genus **Phoronis** Wright, 1856

Phoronis pallida (Schneider, 1862) Silén, 1952

Figs 1, 2, 7a-f

Phoronis pallida. — Emig, 1969: 1531-1535, figs 2-7.

MATERIAL: Port Phillip Bay (Vict.), — 2515 specimens, from series 0900 between 17 October, 1969, and 11 October, 1971, by Smith-McIntyre grab and diver-operated suction dredge, mainly in fine sediments; — 4 spec., stn 1214, 2 km SE of Yarra River mouth, coll. 9 March, 1971, by grab from silty sediment, 4 m (Australian Museum W6551); — 6 spec., stn 1221, 3.5 km W of stn 1223, coll. 9 March, 1971, by grab from very fine sand, 8 m (Aust. Mus. W6552); — 35 spec., stn 1223, 2 km S of stn 1214, off Yarra River mouth, coll. 9 March, 1971, by grab from very fine sand, 8 m (Aust. Mus. W6553); — 3 spec., stn 1269, 10 km SSW of Werribee River, coll. 11 March, 1971, by grab from fine sand, 8 m (Aust. Mus. W6554).

DIAGNOSIS: Length — up to 140 mm, diameter 0.3-1 mm. Colour — in life, yellowish-pink. Lophophore — horseshoe-shaped (fig. 7a). Tentacles — 50-140, length 2-2.5 mm. Nephridia — with 2 funnels each, anal slightly larger than oral; descending branch nearly as long as ascending branch; nephridiopore on anal papilla, opening at or immediately below level of anus (fig. 7b, d). Giant nerve fibre — on left side only, diameter 10-20 µm (fig. 7f). Longitudinal muscle formula — range [17-19] = $\frac{5\text{-}6 \mid 5}{4 \mid 3\text{-}4}$, mean 18 = $\frac{5 \mid 5}{4 \mid 4}$. Gonads — hermaphrodite (fig. 7e); lophophoral organs large, glandular, nidamental glands absent (fig. 7a, c); no brooding. Larval form — *Actinotrocha pallida*. Other characters — unusual musculature arrangement (fig. 7f, fig. 2); circular muscles present three strong sphincters, longitudinal muscles divide into six zones.

REMARKS: The body length of our fixed specimens of *P. pallida* is 10-30 mm; their extended length should thus reach 100 mm (Emig, 1969a). This compares with lengths of up to 140 mm estimated elsewhere (Emig, 1969b). The tentacles number 80-120 and are about 2 mm long.

The nephridia are typical, with two funnels and the descending branch nearly as long as the ascending branch (Emig, 1969b, 1971). The upper part of the ascending branch is often prominent (fig. 7b, d). The nephridiopore sometimes opens immediately below the anus (fig. 7b).

The diameter of the giant nerve fibre (fig. 7f) ranges from 10 to 18 µm.

Longitudinal muscle bundle formulae were obtained for 104 specimens; the values are as follows, using the conventional formula of Selys-Longchamps (1907): 17 = $\frac{5 \mid 5}{4 \mid 3}$ in 1 specimen; 19 = $\frac{6 \mid 5}{4 \mid 4}$ in 3 specimens; 18 = $\frac{5 \mid 5}{4 \mid 4}$ in all other specimens (fig. 7f). A general muscle formula for *Phoronis pallida* may be given as: [17-19] = $\frac{5\text{-}6 \mid 5}{4 \mid 3\text{-}4}$. The arrangement of longitudinal and circular muscles (fig. 2) is unusual in this species (Silén, 1952; Emig, 1971).

P. pallida is hermaphrodite. A well-developed ovary and testis were present in all specimens examined (fig. 7e). The ovary lies on the dorsal side of the lateral vessel, the testis on the ventral side; the reverse situation found by Silén (1952) and Emig (1969b) was not observed, but the two gonads are often not firmly fixed in relation to each other.

All features examined in our animals agree generally with those specified by Silén (1952) and Emig (1969b, 1971), although the diameter of the giant fibre and the longitudinal muscle bundle numbers have been modified from the diagnosis established by Emig (1974).

In Port Phillip Bay *Phoronis pallida* was found in sediments ranging from fine sand to clayey-silt, occurring in numbers of up to 598 individuals/m² in fine sand with an admixture of silt. The tubes built by *P. pallida* tended to reflect the predominant sediment fraction

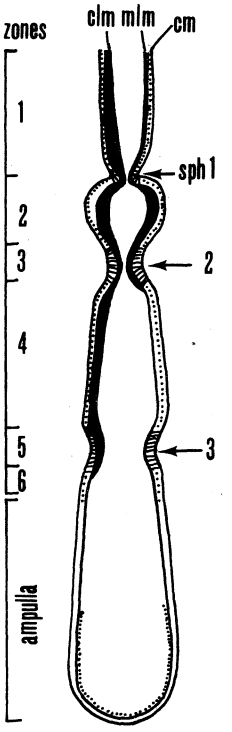

Fig. 2. Arrangement of muscles in *Phoronis pallida* (after Silen, 1952). *clm:* central longitudinal muscles; *cm:* circular muscle; *mlm:* marginal longitudinal muscle; *sph:* sphincter.

present, the walls being covered with fine sand grains and comparatively inflexible in regions of sandy sediment. In all instances, the tube ends immediately below the ampulla in a clear, flexible, membranous bulb free of attached sediment.

Salinities at the bottom in Port Phillip Bay generally range between 34‰ and 36‰. Recorded salinities in 1970-71 for areas where *P. pallida* occurred were 34.1-36.6‰. Lower salinities occur periodically near the mouth of the Yarra R., in the north, at times of flood. A strong salt wedge is usually present in this area, and the occurrence of *P. pallida* near the Yarra mouth may not signify tolerance of salinities markedly below 34‰. Temperatures at the bottom range from 10° to 24°.

No strong relationship with any faunal association is apparent. In general, the distribution of *P. pallida* follows that of surface-deposit feeding molluscs in Port Phillip Bay (Poore and Rainer, 1974).

DISTRIBUTION: Australia — Port Phillip Bay (Vict.); Wider distribution — Pacific and Atlantic oceans (Emig, 1973b).

Figs 7-9.

Abbreviations: *A* ascending branch, *af* anal funnel, *ap* anal papilla, *cf* collar fold, *D* descending branch, *d* diaphragm, e embryos, *ep* epistome, *f* funnel, *i* intestine, *lgf* left giant nerve fibre, *llm* left lateral mesentery, *lo* lophophore, *lv* lateral vessel, *mv* median vessel, *n* nephridiopore, *ng* nidamental glands, *np* nephridial papilla, *o* ovary, *oes* oesophagus, *of* oral funnel, *ol* lophophoral organs, *pst* prestomach, *rgf* right giant nerve fibre, *rlm* right lateral mesentery, *slv* secondary lateral vessel, *st* stomach, *t* testis.

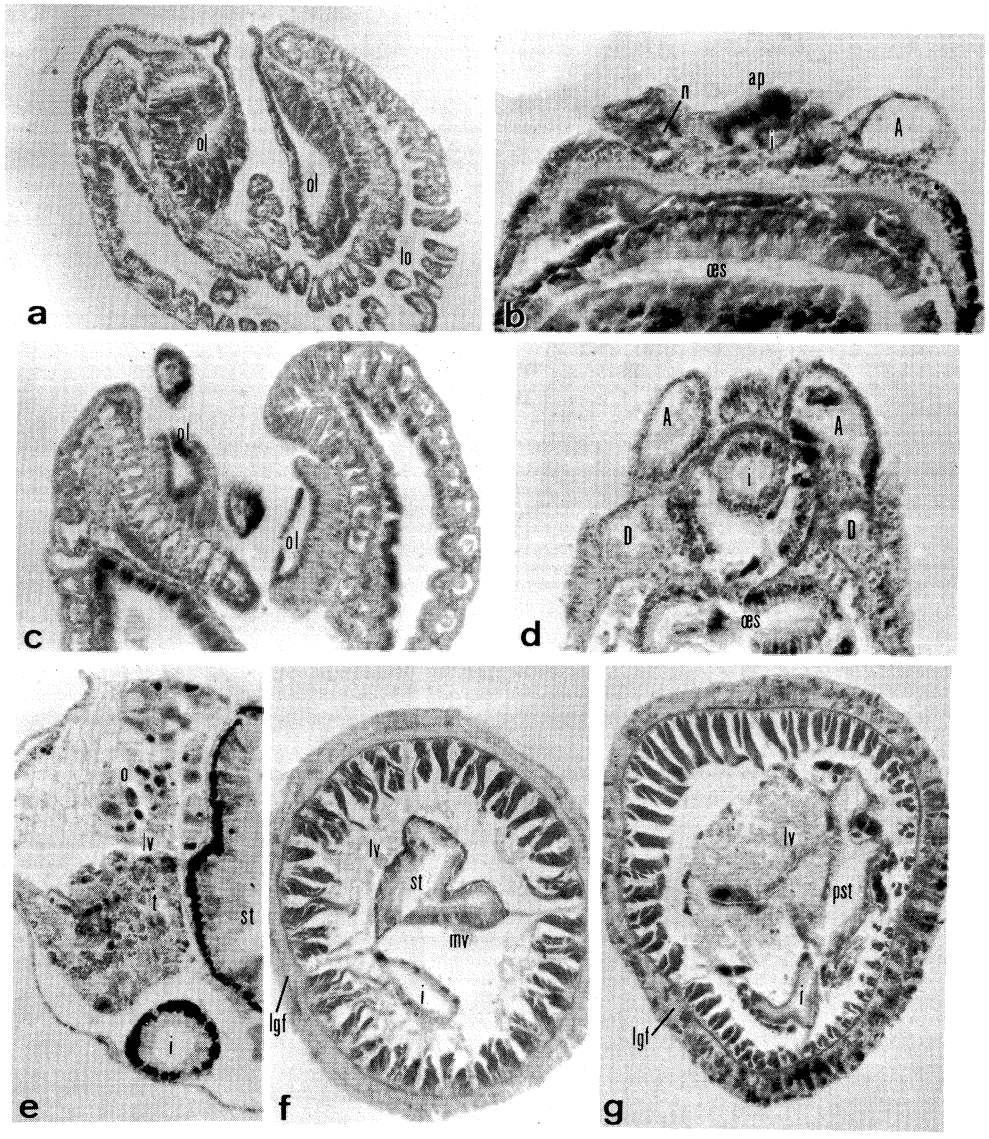

Fig. 7. *Phoronis pallida*. (a) and (c) cross section of the lophophore at the level of the lophophoral organs; (b) cross section of the anal papilla and nephridia; (d) cross section at descending branch of nephridia; (e) cross section of the ampulla through the gonads (testis and ovary); (f) cross section of the muscular region, zone 4. *Phoronis psammophila*. (g) cross section of the muscular region.

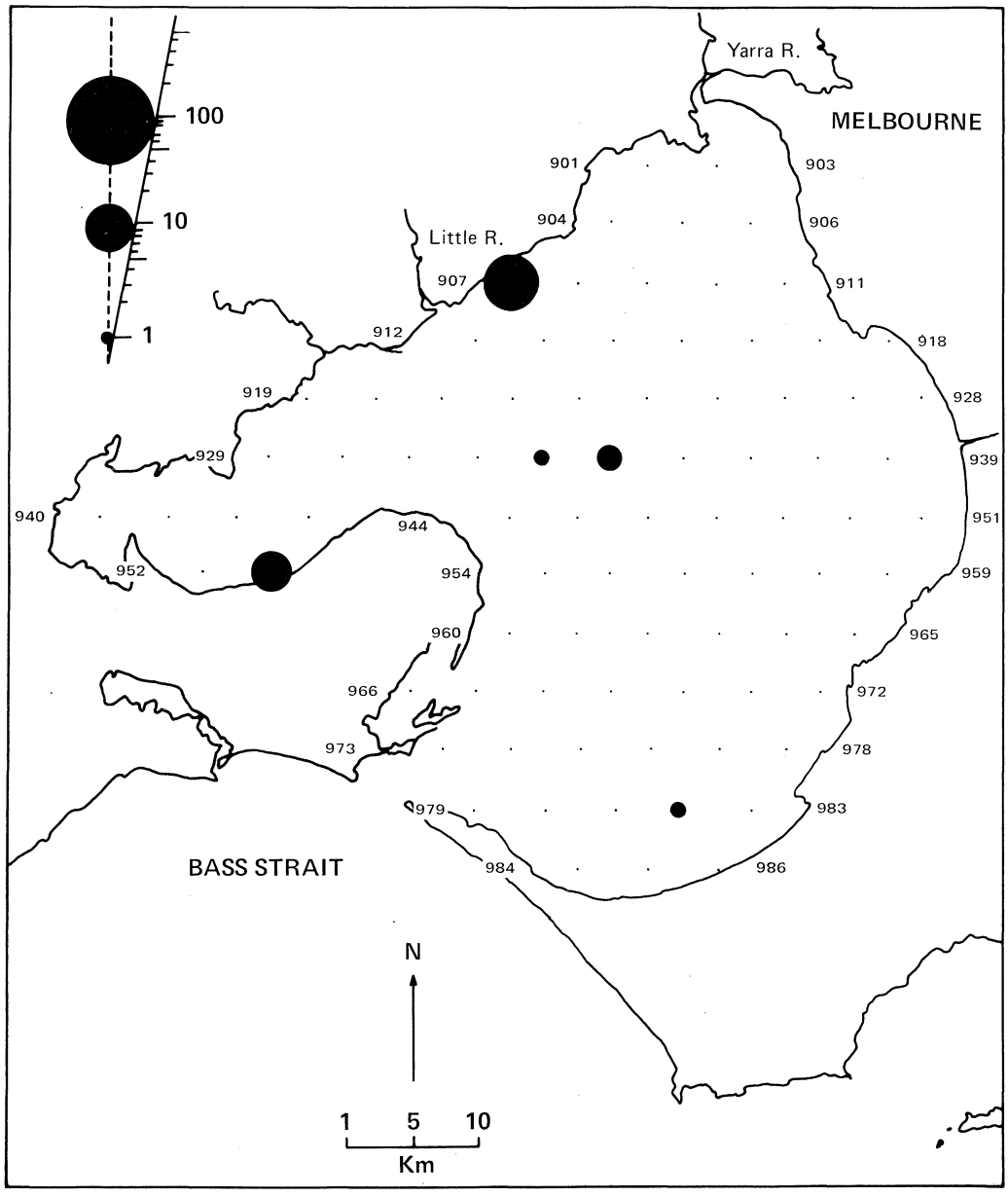

Fig. 3. *Phoronis psammophila*: distribution and abundance (nos/m²) in Port Phillip Bay, Victoria.

Phoronis psammophila Cori, 1889
Figs 3, 7g

Phoronis psammophila. — Emig, 1969a: 312-323 (in part), figs 2-9

Phoronis sabatieri Roule, 1889: 195-196.

Phoronis architecta Andrews, 1890: 445-449, fig. 1.

MATERIAL: Port Phillip Bay (Vict.), — 42 specimens, from series 0900 stations (fig. 3) of Port Phillip Bay Environmental Study, collected between 13 February, 1970, and 3 February, 1972, by Smith-McIntyre grab (S-M) from fine sand or silty sand, 2-25 m; — 6 spec., stn 953, coll. 11 June, 1971, by S-M grab from medium sand, 3 m (Aust. Mus. W6555).

Western Port (Vict.), — 1 specimen, stn 51S, lat. 38°21'22"S, long. 145°13'58"E, coll. 25 March, 1965, by S-M grab from coarse sand, 17 m; — 2 spec., stn M2, lat. 38°22'30"S, long. 145°14'16"E, coll. 7 January, 1974, by S-M grab from coarse sand-gravel sediment, 2 m.

DIAGNOSIS: Length — 60-190 mm, diameter 0.5-2 mm. Colour in life — lophophore transparent with white pigment spots, or occasionally lophophore yellow, red or green; body pink. Lophophore — horseshoe-shaped with ends turned medially. Tentacles — 60-130, length 1.5-2.5 mm. Nephridia — with one funnel each; descending branch short; nephridiopore on anal papilla, opening below anus. Giant nerve fibre — on left side only, diameter 7-27 µm (fig. 1g); rarely, very thin nerve fibre present on right side. Longitudinal muscle formula — range [25-53] = $\frac{7\text{-}19}{4\text{-}11}\,\frac{7\text{-}17}{4\text{-}11}$, mean 34 = $\frac{11}{6}\,\frac{11}{6}$. Gonads — dioecious; lophophoral organs large, glandular; nidamental glands of type 2c (after Zimmer, 1964); embryos in one or two masses in lophophore (except probably *P. architecta*); no brooding pattern observed. Larva unknown. Asexual propagation by transverse fission.

REMARKS: The specimens examined agree with the diagnosis of *Phoronis psammophila* given by Emig (1974). Muscle bundle formulae for the Australian material are as follows:

$\frac{11}{6}\,\frac{11}{6}$ = 34; $\frac{11}{7}\,\frac{12}{6}$ = 36; $\frac{13}{7}\,\frac{13}{6}$ = 39; $\frac{14}{7}\,\frac{13}{6}$ = 40; $\frac{13}{8}\,\frac{12}{7}$ = 40; $\frac{13}{7}\,\frac{14}{7}$ = 41; $\frac{13}{8}\,\frac{13}{7}$ = 41;

$\frac{15}{7}\,\frac{13}{6}$ = 41; $\frac{15}{7}\,\frac{13}{7}$ = 42; $\frac{14}{8}\,\frac{12}{8}$ = 42; $\frac{15}{7}\,\frac{15}{7}$ = 44; $\frac{15}{9}\,\frac{15}{6}$ = 45; $\frac{13}{9}\,\frac{15}{8}$ = 45; $\frac{13}{10}\,\frac{14}{8}$ = 45;

$\frac{13}{8}\,\frac{16}{8}$ = 45; $\frac{17}{7}\,\frac{16}{7}$ = 47; $\frac{15}{8}\,\frac{15}{9}$ = 47; $\frac{16}{8}\,\frac{16}{8}$ = 48; $\frac{15}{9}\,\frac{15}{9}$ = 48; $\frac{15}{11}\,\frac{15}{7}$ = 48; $\frac{15}{11}\,\frac{15}{8}$ = 49;

$\frac{16}{9}\,\frac{17}{7}$ = 49; $\frac{15}{9}\,\frac{17}{9}$ = 50; $\frac{16}{9}\,\frac{16}{9}$ = 50 in 4 specimens; $\frac{16}{9}\,\frac{17}{9}$ = 51; $\frac{16}{10}\,\frac{15}{10}$ = 51; $\frac{15}{10}\,\frac{17}{9}$ = 51;

$\frac{15}{11}\,\frac{16}{10}$ = 52; $\frac{17}{10}\,\frac{16}{9}$ = 52; $\frac{18}{10}\,\frac{16}{8}$ = 52; $\frac{15}{10}\,\frac{17}{10}$ = 52; $\frac{17}{9}\,\frac{17}{9}$ = 52; $\frac{15}{11}\,\frac{16}{11}$ = 53; $\frac{19}{7}\,\frac{17}{10}$ = 53.

The general and mean formulae of *Phoronis psammophila* from different localities are compared in Table 1. Significant variations in the mean formula occur from place to place, as previously noted by Emig (1971, 1972), and the present data confirm this. The high upper limit to the number of longitudinal muscle bundles in the Australian material indicates that it belongs to a separate population, as does material from Florida and the Azores (Emig, 1972). The formula given in the diagnosis above represents the limits of variation for the three populations.

The distribution of *P. psammophila* overlapped that of *Phoronis pallida* (figs 1, 3) although the former species generally occurs in shallower water and coarser sediments. The character of the tube wall varied with sediment in the same way as in *P. pallida*. Salinity and temperature values at the stations where *P. psammophila* occurred are generally similar to those given for *P. pallida*.

A close relationship exists between the distribution of *P. psammophila* and that of *Phoronopsis albomaculata,* at least in Port Phillip Bay (figs 3, 4).

DISTRIBUTION: Australia — Port Phillip Bay, Western Port (Vict.); Wider distribution — cosmopolitan (Emig, 1973b).

Table 1. Comparison of longitudinal muscle bundle formulae of *Phoronis psammophila* in different localities; (a) data published by Emig in other works.

Locality	Number of specimens	Mean formula	General formula
Port Phillip Bay (Australia)	37	$47 = \frac{15}{9}\,\frac{15}{8}$	$\frac{11\text{-}19}{6\text{-}11}\,\frac{11\text{-}17}{6\text{-}11} = [34\text{-}53]$
Azores (a)	76	$42 = \frac{14}{7}\,\frac{14}{7}$	$\frac{12\text{-}19}{5\text{-}9}\,\frac{11\text{-}17}{5\text{-}9} = [36\text{-}50]$
Florida (U.S.A.) (a)	38	$40 = \frac{13}{7}\,\frac{13}{7}$	$\frac{11\text{-}15}{5\text{-}8}\,\frac{11\text{-}17}{5\text{-}9} = [34\text{-}44]$
Concarneau (France) (a)	18	$37 = \frac{12}{7}\,\frac{12}{6}$	$\frac{8\text{-}17}{5\text{-}11}\,\frac{9\text{-}15}{4\text{-}9} = [26\text{-}46]$
Solomon Islands	4	$37 = \frac{11}{7}\,\frac{12}{7}$	$\frac{10\text{-}12}{7\text{-}8}\,\frac{11\text{-}12}{6\text{-}9} = [35\text{-}38]$
Chesapeake Bay (U.S.A.)	20	$36 = \frac{12}{6}\,\frac{12}{6}$	$\frac{10\text{-}14}{5\text{-}8}\,\frac{10\text{-}15}{5\text{-}7} = [32\text{-}42]$
Dinard (France) (a)	30	$36 = \frac{12}{6}\,\frac{12}{6}$	$\frac{9\text{-}14}{4\text{-}8}\,\frac{9\text{-}15}{4\text{-}8} = [26\text{-}42]$
Nosy-Bé (Malagasy) (a)	9	$35 = \frac{12}{6}\,\frac{11}{6}$	$\frac{10\text{-}13}{5\text{-}7}\,\frac{10\text{-}12}{5\text{-}6} = [32\text{-}38]$
Gulf of Marseilles (France) (a)	1934	$34 = \frac{11}{6}\,\frac{11}{6}$	$\frac{8\text{-}16}{4\text{-}9}\,\frac{8\text{-}16}{4\text{-}9} = [26\text{-}46]$
Ivory Coast	5	$34 = \frac{11}{6}\,\frac{11}{6}$	$\frac{10\text{-}12}{5\text{-}6}\,\frac{11}{6} = [32\text{-}35]$
Etang de Berre (France) (a)	117	$31 = \frac{10}{6}\,\frac{10}{5}$	$\frac{8\text{-}13}{4\text{-}7}\,\frac{8\text{-}12}{4\text{-}7} = [25\text{-}38]$
Etang de Thau (France) (a)	100	$28 = \frac{9}{5}\,\frac{9}{5}$	$\frac{8\text{-}14}{4\text{-}7}\,\frac{7\text{-}12}{4\text{-}7} = [25\text{-}39]$
Calanque de Port-Miou (France) (a)	29	$29 = \frac{10}{5}\,\frac{9}{5}$	$\frac{8\text{-}11}{4\text{-}6}\,\frac{7\text{-}11}{4\text{-}6} = [25\text{-}33]$
Mean of all localities	2417	$34 = \frac{11}{6}\,\frac{11}{6}$	$\frac{7\text{-}19}{4\text{-}11}\,\frac{7\text{-}17}{4\text{-}11} = [25\text{-}53]$

Phoronis australis Haswell, 1883
Fig. 9d-f.

Phoronis australis. — Emig and Marche-Marchad, 1969: 1244-1250, figs. 2-11.

MATERIAL: Wreck Bay (N.S.W.), lat. 34°60'S, long. 150°E (Aust. Mus. W6016). Camp Cove, Port Jackson (N.S.W.), lat. 33°50'S, long. 151°17'E (Aust. Mus. W6017).

DIAGNOSIS: Biotope — burrowing into tube-wall of cerianthid; an obligate inquiline of cerianthids. Length — 50-200 mm; diameter 2-6 mm. Colour in life — anterior body part black, deep reddish or pink. Lophophore — spiral, with 2.5-3.5 coils on each side (fig. 9d).

Tentacles — 600-1600, length 5-16 mm, tentacles united basally for about one third or one quarter of total length. Nephridia — with 2 funnels each, anal larger than oral, small; no descending branch; nephridiopore on nephridial papilla, opening at or above level of anus (fig. 9e). Giant nerve fibres — paired, diameter of left one 5-13 μm, diameter of right one 3-13 μm (fig. 9f). Longitudinal muscle formula — range [43-87] = $\frac{17\text{-}29 \mid 14\text{-}27}{4\text{-}17 \mid 5\text{-}17}$, mean 66 = $\frac{23 \mid 22}{12 \mid 9}$. Gonads — hermaphrodite; lophophoral organs small; nidamental, of type 2b; embryos brooded on mucous cords. Larva unknown. Asexual propagation by transverse fission.

REMARKS: Some of the material examined was collected near the type locality for the species (Balls Hd, Port Jackson). The Australian specimens generally agree with the description given by Emig and Marche-Marchad (1969), Emig et al. (1972) and Emig (1973a).

The length of the lophophore averages 7-9 mm, somewhat less than the 12-15 mm described by Haswell (1883) and Benham (1889), and the number of tentacles reaches 1600. Two giant fibres are present at all levels, the right slightly smaller than the left, commonly with diameters of 11 and 13 μm respectively. The longitudinal muscle bundle numbers in the Australian specimens are slightly higher than in the formulae established for other localities by Emig (1971, 1973a). The formulae obtained in 21 specimens are as follows:

$\frac{20 \mid 20}{8 \mid 12} = 60$; $\frac{20 \mid 19}{14 \mid 8} = 61$; $\frac{23 \mid 24}{10 \mid 9} = 66$; $\frac{23 \mid 24}{11 \mid 10} = 68$; $\frac{23 \mid 24}{10 \mid 11} = 68$; $\frac{24 \mid 23}{13 \mid 12} = 72$;

$\frac{24 \mid 25}{14 \mid 9} = 72$; $\frac{23 \mid 26}{13 \mid 10} = 72$; $\frac{24 \mid 24}{14 \mid 10} = 72$; $\frac{26 \mid 26}{14 \mid 7} = 73$; $\frac{27 \mid 23}{14 \mid 9} = 73$; $\frac{25 \mid 23}{15 \mid 10} = 73$;

$\frac{23 \mid 24}{14 \mid 12} = 73$; $\frac{25 \mid 22}{17 \mid 9} = 73$; $\frac{24 \mid 25}{14 \mid 11} = 74$; $\frac{27 \mid 22}{13 \mid 13} = 75$; $\frac{25 \mid 27}{13 \mid 11} = 76$; $\frac{27 \mid 23}{14 \mid 12} = 76$;

$\frac{28 \mid 25}{15 \mid 11} = 79$; $\frac{28 \mid 27}{12 \mid 13} = 80$; $\frac{28 \mid 27}{15 \mid 17} = 87$.

The general formula for these specimens is [60-87] = $\frac{20\text{-}28 \mid 19\text{-}27}{8\text{-}17 \mid 7\text{-}17}$ and the mean formula 73 = $\frac{25 \mid 24}{13 \mid 11}$. The different values reported previously by Emig (1971, 1973a) indicate that considerable regional variation exists. The mean and general formulae given in the diagnosis encompass the range of variation so far encountered.

Mature gonads were found in specimens collected at one locality (Camp Cove), in March 1974.

The burrowing habit of *Phoronis australis* is characteristic. Individuals occur in numbers of up to 100 per tube in the tube-wall of *Cerianthus* sp. The material in the present study was collected from mud and muddy sand from 7-13 m deep; the recorded depth range is 0-30 m. Emig et al. (1972) regard the cerianthid tubes as a hard substrate in which *P. australis* burrows, with the ampulla extending into the fourth layer of the cerianthid tube-wall and the lophopore spreading out on the outer surface of the tube. Our present observations agree with this, in contrast to statements made by Ikeda (1903) and Ponder (1971) that the lophophore emerges on the inner surface of the cerianthid tube.

The association between *Phoronis australis* and a cerianthid has been defined by Emig et al. (1972) as an inquilinism.

DISTRIBUTION: Australia — Sydney area, Wreck Bay (N.S.W.), Moreton Bay (Qld.); Wider distribution — Pacific and Atlantic oceans (Emig, 1974).

Genus **Phoronopsis** Gilchrist, 1907
Phoronopsis albomaculata Gilchrist, 1907
Figs 4-6, 8a-g.

Phoronopsis albomaculata. — Emig and Thomassin, 1969: 901-907, figs 2-8.

MATERIAL: Port Thillip Bay (Vict.), — 135 specimens, from series 0900 stations (fig. 4) of Port Phillip Bay Environmental Study, collected between 17 October, 1969, and 3 February, 1972, by Smith-McIntyre grab from fine sand or silty sand, 2-25 m; — 2 spec., stn 1221, 3.5 km W of stn 1223, coll. 9 March, 1971, by S-M grab from very fine sand, 8 m (Aust. Mus. W6556) — 3 spec., stn 1223, 4 km SSE of Yarra R. mouth, coll. 9 March, 1971, by S-M grab from very fine sand, 8 m (Aust. Mus. W6557); — 3 spec., stn 1224, 1.5 km SE of stn 1223, coll. 9 March, 1971, by S-M grab from fine sand, 8 m (Aust. Mus. W6558); — 1 spec., stn 1266, 5 km SE of Werribee R., coll. 11 March, 1971, by S-M grab from fine sand, 8 m (Aust. Mus. W6559).

Western Port (Vict.), — 1 spec., stn 22N, lat. 38°20'36"S, long. 145°13'12"E, coll. 18 March 1965 by S-M grab from shelly sand, 13 m.

Brisbane River (Qld), fig. 5 (Aust. Mus. W6024).

DIAGNOSIS: Length — 80-150 mm, diameter, 0.5-2 mm. Colour in life — lophophore pigmented with white spots; body yellowish. Lophophore — horseshoe-shaped or spiral, with a single coil on each side (fig. 8a, c). Tentacles — 70-160, length 2-3 mm. Nephridia — with one funnel each; descending branch short; epithelium thick; nephridiopore on anal papilla, opening below level of anus, on collar fold within invagination (figs. 6, 8b, d, g). Giant nerve fibre — paired, left fibre only present below nephridial level, left fibre diameter 15-35 µm (fig. 8e). Longitudinal muscle formula — range [46-102] $\frac{4\text{-}33 \mid 15\text{-}33}{7\text{-}20 \mid 7\text{-}16}$, mean 71 = $\frac{23 \mid 22}{14 \mid 12}$. Gonads — dioecious; lophophoral organs more or less glandular; no nidamental glands observed (fig. 8c). Larva unknown. Asexual propagation by transverse fission. Invagination — about 0.1 mm deep, often not distinct on oral side (fig. 8b, d, g).

REMARKS: The present material is distinct in a number of features considered diagnostic by Emig (1972, 1974).

The lophophore is horseshoe-shaped, with the ends turned inwards to form a single-coiled spiral on each side (fig. 8a). The number of tentacles reaches 160.

The nephridia possess only a single funnel (fig. 6, 8b, d, g), not two as suggested by Emig and Thomassin (1969) and Emig (1971). They are very similar to the nephridia of *Phoronis psammophila*, differing only in the larger size of the nephridial branches and in the position of the nephridiopore on the collar fold within the invagination in *Phoronopsis albomaculata* (fig. 7b, d). In both species the lateral mesenteries are lacking between the nephridial funnel and the diaphragm (fig. 8b, d, g). Accordingly, using the phoronid nephridial types established by Emig (1971, 1974), the nephridia of *Phoronopsis albomaculata* do not belong to category 5, but rather to category 2, and have the characteristics given in the diagnosis.

The diameter of the left giant nerve fibre averages 20-35 µm (fig. 8e).

Longitudinal muscle formulae were obtained for 14 specimens from Port Phillip Bay and 18 specimens from Brisbane River.

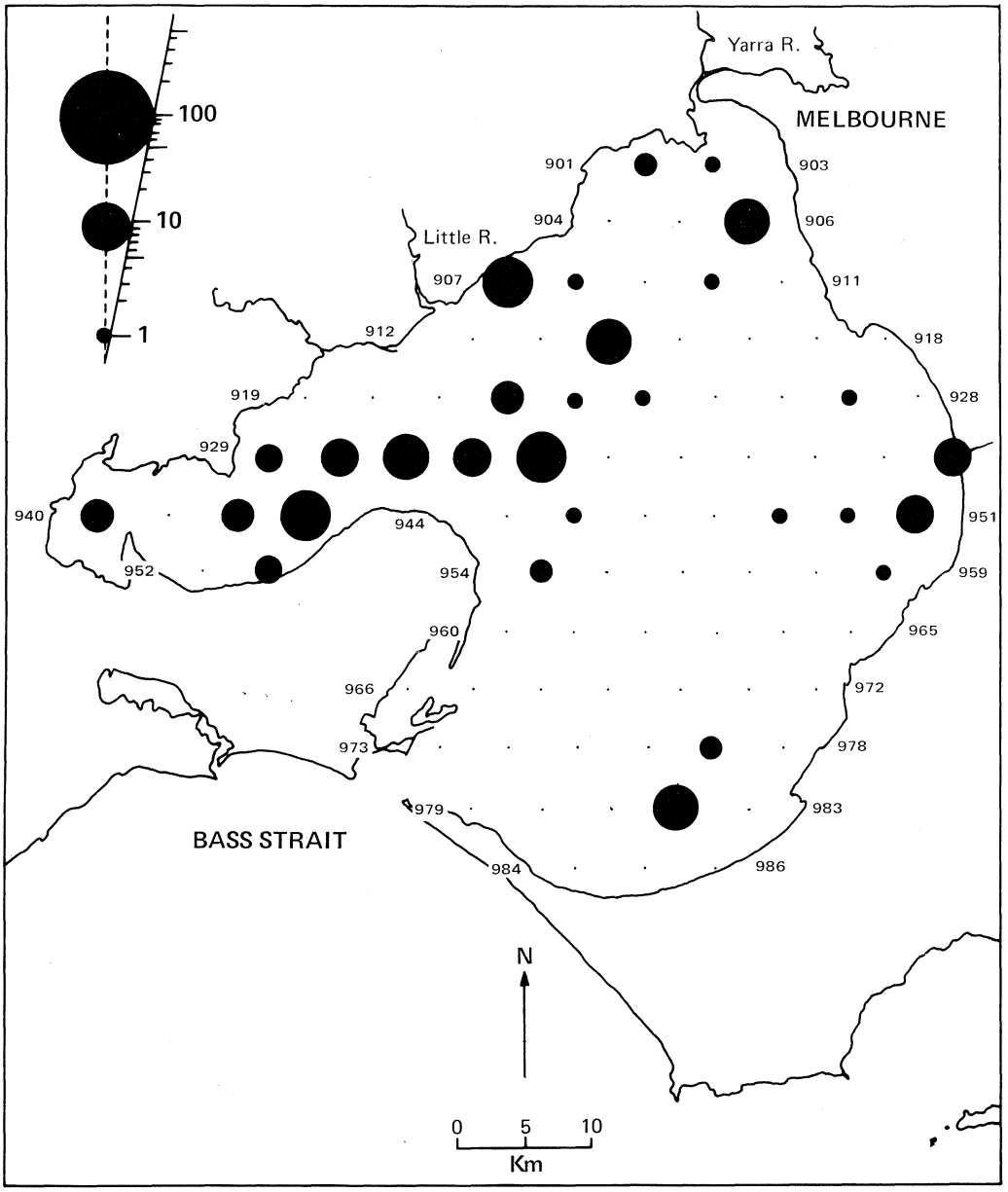

Fig. 4. *Phoronopsis albomaculata*: distribution and abundance (nos/m²) in Port Phillip Bay, Victoria.

Port Phillip Bay: $\frac{14}{8}\frac{15}{9}$ = 46; $\frac{18}{7}\frac{18}{8}$ = 51; $\frac{17}{10}\frac{18}{7}$ = 52; $\frac{17}{11}\frac{18}{8}$ = 54; $\frac{19}{10}\frac{18}{11}$ = 58; $\frac{19}{10}\frac{20}{10}$ = 59; $\frac{19}{11}\frac{20}{9}$ = 59; $\frac{19}{11}\frac{20}{10}$ = 60; $\frac{23}{10}\frac{19}{10}$ = 62; $\frac{22}{11}\frac{20}{10}$ = 63; $\frac{21}{11}\frac{21}{10}$ = 63; $\frac{21}{13}\frac{21}{9}$ = 64; $\frac{22}{11}\frac{23}{11}$ = 67; $\frac{20}{11}\frac{24}{13}$ = 68.

Brisbane R.: $\frac{19}{12}\frac{19}{12}$ = 62; $\frac{21}{14}\frac{20}{12}$ = 67; $\frac{21}{14}\frac{21}{13}$ = 69; $\frac{22}{14}\frac{20}{13}$ = 69; $\frac{25}{14}\frac{22}{12}$ = 73; $\frac{24}{16}\frac{21}{15}$ = 76; $\frac{25}{15}\frac{23}{13}$ = 76; $\frac{26}{15}\frac{24}{13}$ = 78; $\frac{25}{16}\frac{23}{14}$ = 78; $\frac{28}{16}\frac{24}{15}$ = 83; $\frac{27}{15}\frac{28}{13}$ = 83; $\frac{28}{17}\frac{25}{15}$ = 85; $\frac{28}{16}\frac{27}{14}$ = 85; $\frac{26}{17}\frac{26}{16}$ = 85; $\frac{30}{14}\frac{26}{16}$ = 86; $\frac{31}{17}\frac{27}{13}$ = 88; $\frac{31}{16}\frac{28}{14}$ = 89; $\frac{33}{20}\frac{33}{16}$ = 102.

Table 2. Comparison of longitudinal muscle bundle formulae of *Phoronopsis albomaculata* in different localities; (a): see Emig (1973a).

Locality	Number of specimens	Mean formula	General formula
Brisbane River (Australia)	18	79 = $\frac{26}{15}\frac{24}{14}$	$\frac{19\text{-}33}{12\text{-}20}\frac{19\text{-}33}{12\text{-}16}$ = [62-102]
Tulear (Malagasy) (a)	18	74 = $\frac{23}{14}\frac{24}{13}$	$\frac{20\text{-}30}{11\text{-}18}\frac{21\text{-}27}{10\text{-}15}$ = [67-82]
Nosy-Mitsio (Malagasy) (a)	10	69 = $\frac{22}{14}\frac{21}{12}$	$\frac{20\text{-}25}{11\text{-}17}\frac{19\text{-}24}{10\text{-}14}$ = [61-79]
Nosy-Bé (Malagasy) (a)	5	67 = $\frac{21}{14}\frac{20}{12}$	$\frac{18\text{-}23}{12\text{-}15}\frac{17\text{-}22}{11\text{-}13}$ = [59-73]
Ivory Coast (a)	1	66 = $\frac{21}{12}\frac{19}{14}$	$\frac{21}{12}\frac{19}{14}$ = [66]
Port Phillip Bay (Australia)	14	61 = $\frac{20}{11}\frac{20}{10}$	$\frac{14\text{-}23}{7\text{-}13}\frac{15\text{-}24}{7\text{-}13}$ = [46-68]
Mean of all localities	66	71 = $\frac{23}{14}\frac{22}{12}$	$\frac{14\text{-}33}{7\text{-}20}\frac{15\text{-}24}{7\text{-}16}$ = [46-102]

General and mean formulae extend the range of values reported previously for *Phoronopsis albomaculata* (Table 2), and the diagnostic muscle formulae take the new values into account.

Previous observations (Emig, 1973a) that *Phoronopsis albomaculata* is dioecious, has large and more-or-less glandular lophophoral organs (fig. 8c), and seems to lack nidamental glands, are confirmed on the Brisbane R. material (the Port Phillip Bay specimens were not in breeding condition). The absence of nidamental glands suggests that brooding does not occur. As in *Phoronopsis californica* and sometimes in *Phoronis psammophila* (Emig, 1973a), the testis occurs both along the lateral vessel in the left oral cavity of the trunk coelom and along the secondary lateral vessel in the right oral cavity (fig. 8f).

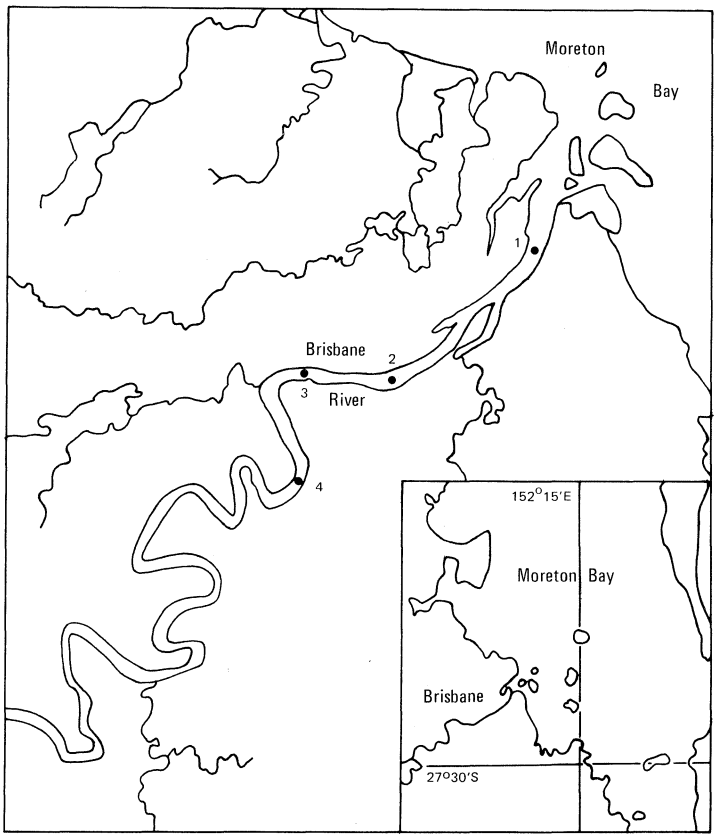

Fig. 5. Brisbane River and Moreton Bay: localities at which *Phoronopsis albomaculata* and *Phoronis australis* (Ponder, 1971) have been found. (1. Quarantine Station; 2. Meeandah; 3. Bulimba; 4. New Farm Park.)

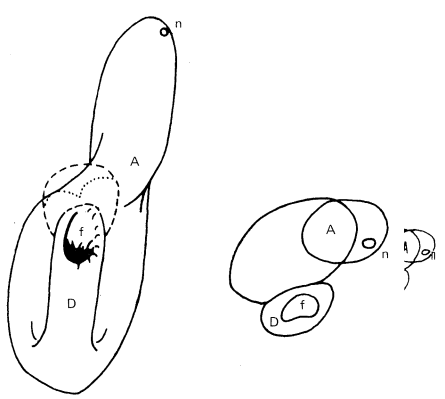

Fig. 6. Diagram of a nephridium of *Phoronopsis albomaculata*. The dotted line indicates the possible extent of funnel development that may occur, especially during gonad maturation (cf. Emig, 1971). Abbreviations, see figs 7-9.

In Port Phillip Bay *Phoronopsis albomaculata* has a distribution very similar to that of *Phoronis psammophila,* although more extensive (fig. 4), occurring in a density of up to 30 individuals/m^2 in silty-sand. It is subject to the same range of water temperature and salinity, and has the same depth range (2-25 m). The tube is similar to that of *P. psammophila.*

Some difficulty was experienced in differentiating *Phoronopsis albomaculata* from *Phoronis psammophila,* due to their similar general morphology and overlapping longitudinal muscle formulae. The invagination diagnostic of the genus *Phoronopsis* is often imperfectly developed in specimens that have recently undergone asexual propagation, or are regenerating the lophophore for any other reason. Such specimens were found at most stations, but any misidentification that may have occurred would not influence the general pattern of distribution as illustrated in figure 4.

In the estuary of the Brisbane River (fig. 5), *Phoronopsis albomaculata* was found subtidally as far upstream as New Farm Park, 22 km from the mouth, but was most abundant (up to 272/m^2) at the Quarantine Station site, 7 km from the mouth. Sediments at these sites ranged from muddy-sand at Quarantine Station to very soft mud at Bulimba and New Farm Park. Salinity at Quarantine Station is about 34‰ during much of the year, but dropped to 27‰ in December, 1971, and to 10‰ in February, 1972, following a flood caused by passage of a cyclone. At New Farm Park salinity is about 30‰ during low-flow conditions, but became near 0‰ in February, 1972. No *Phoronopsis albomaculata* were found above Quarantine Station just after the flood. The annual temperature range in the Brisbane River is approximately 16-28°. Benthic invertebrates associated with *Phoronopsis albomaculata* in the Brisbane River include the polychaetes *Prionospio* sp., *Heteromastus filiformis, Notomastus* sp., *Owenia fusiformis* and *Potamilla* sp; the bivalve *Notospisula parva,* the tanaid *Apseudes estuarius* and the amphipod *Eriopisa australiensis.*

DISTRIBUTION: Australia — Port Phillip Bay, Western Port (Vict.), Brisbane River (Qld); Indian and Atlantic oceans (Emig, 1973b).

Phoronopsis harmeri Pixell, 1912
Fig. 9a-c.

Phoronopsis harmeri. — Emig, 1967: 984-989, figs 1-4

Phoronis pacifica Torrey, 1901: 283-288, figs 1-5.

Phoronopsis viridis Hilton, 1930: 33-34, figs 1-4.

Phoronopsis striata Hilton, 1930: 34-35, figs 5-9.

MATERIAL: Careel Bay, Pittwater (N.S.W.), north of Sydney, lat. 151°20'E, long. 33°38'S (Aust. Mus. W6018, W6019, W6020, W6021, W6022, W6023).

Wallis Lake (N.S.W.), north of Port Stephens, lat. 152°35'E, long. 32°15'S (Aust. Mus. W4332).

DIAGNOSIS: Length — 40-220 mm, diameter 0.6-4 mm. Colour in life — greenish with white-pigmented tentacles. Lophophore — spiral, with 1.5-2 coils on each side. Tentacles — 100-400, length 2-5 mm. Nephridia — with two funnels each, anal smaller than oral (fig. 3b); long descending branch; nephridiopore opening on collar fold in invagination, below level of anus (fig. 3a). Giant nerve fibres — paired, diameter of left one 20-60 µm (fig. 3c); right giant nerve fibre present above level of right nephridium, atrophied below. Longitudinal muscle formulae — range [75-138] = $\frac{20\text{-}48}{12\text{-}27}\left|\frac{23\text{-}55}{11\text{-}26}\right.$, mean 111 = $\frac{37}{20}\left|\frac{36}{18}\right.$. Gonads — dioecious; lophophoral organs large, membranous; nidamental glands absent; no brooding pattern. Larval form — *Actinotrocha A* (Zimmer, 1964). Invagination — very distinct (fig. 9a, b).

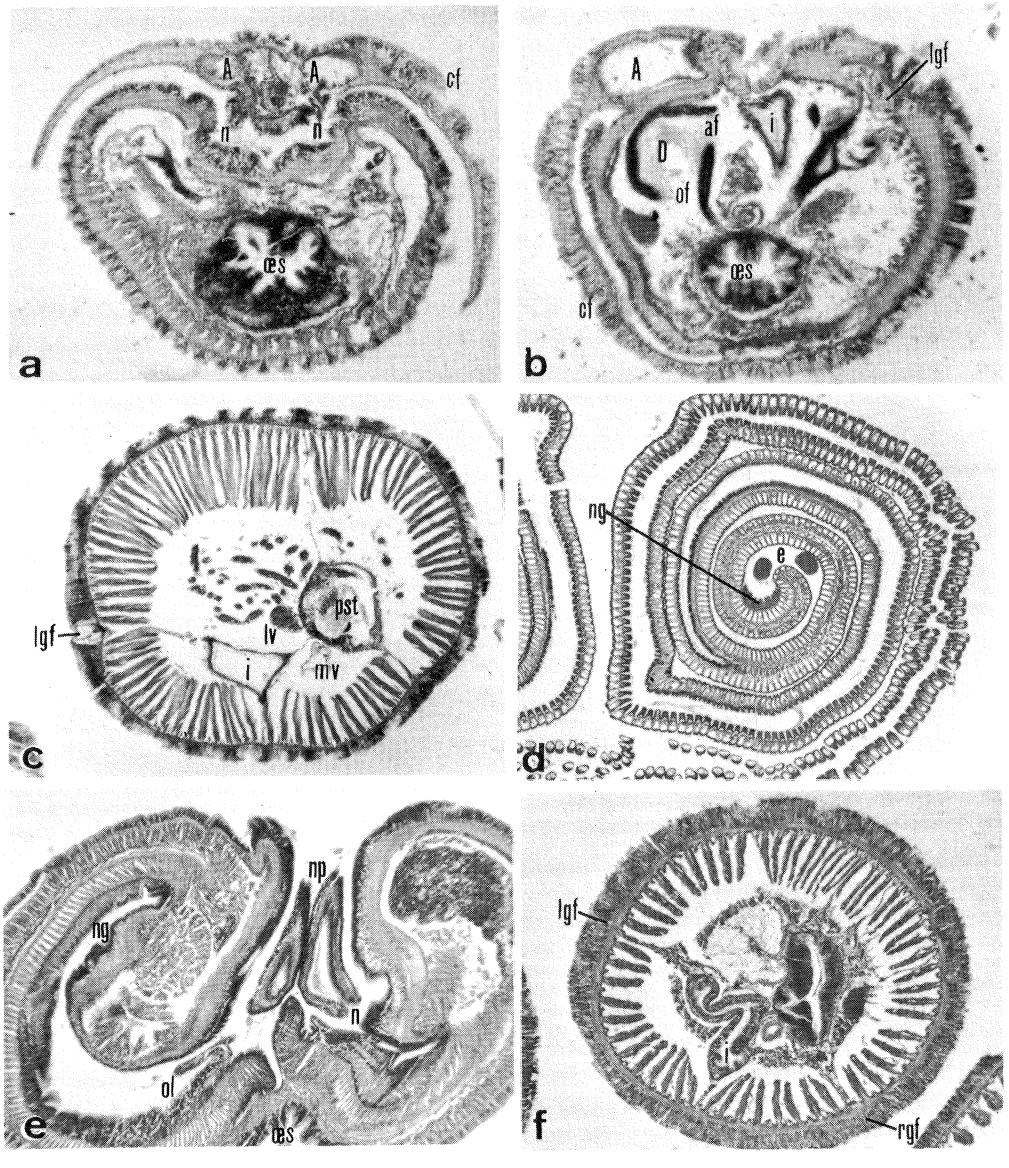

Fig. 9. *Phoronopsis harmeri.* (a) cross section of the collar fold, through the anal papilla and the nephridiopore; (b) cross section (below a) of the descending branch and two funnels of the right nephridium; (c) cross section of the muscular region. *Phoronis australis.* (d) cross section of the lophophore (left spiral only), showing the anterior part of the nidamental gland; (e) cross section of the nephridial papilla, with accessory sex glands in the lophophoral concavity; (f) cross section of the muscular region.

REMARKS: The material examined agrees well with the specific characteristics of *Phoronopsis harmeri*. The collar fold is very distinct, with the invagination much stronger than in *Phoronopsis albomaculata* (fig. 8b, d, g; fig. 9a, b).

The longitudinal muscle bundle formula was determined in six specimens:

$\frac{28 \mid 29}{18 \mid 13} = 88$; $\frac{30 \mid 29}{18 \mid 13} = 90$; $\frac{33 \mid 28}{18 \mid 20} = 99$; $\frac{31 \mid 30}{21 \mid 18} = 100$; $\frac{32 \mid 31}{21 \mid 16} = 100$; $\frac{42 \mid 33}{20 \mid 19} = 114$.

The Australian specimens, along with those recently described from the Cook Islands (Emig, 1973b) and from Marovo Lagoon (New Georgia Group, Solomon Islands: unpublished data), are smaller than *Phoronopsis harmeri* so far collected from the Pacific coast of North America. No gonads or other reproductive features were present in the local specimens, which may be juveniles.

At Careel Bay *P. harmeri* was found in *Zostera* beds in fine mud near low tide and at Wallis Lake this species occurs in muddy sand at 6-8 m depth.

DISTRIBUTION: Australia, Careel Bay, Wallis Lake (N.S.W.); Wider distribution — Pacific and Atlantic oceans (Emig, 1973b).

KEY TO SPECIES OF PHORONIDA

The results of the present study and the observations of Stancyk et al. (in press) and Emig (unpublished) concerning the nephridia and lophophore of *Phoronopsis albomaculata* and of *Phoronis ijimai* Oka have been incorporated in the key established by Emig (1971). Only the main taxonomic characters of the species are used, but all characters must be verified for the determination of a phoronid species.

1. Lophophore oval or horseshoe-shaped 2
— Lophophore spiral or helicoidal 8

2. Lophophore oval; nephridia with one funnel, descending branch absent; no lateral mesentery; burrowing habit ..... *Phoronis ovalis*
— Lophophore horseshoe-shaped 3

3. Nephridia with one funnel, descending branch present; usually only left giant nerve fibre present 4
— Nephridia with two funnels, anal larger than oral; no invagination at base of lophophore; hermaphrodite 6

4. Invagination present at base of lophophore, although often not distinct on oral side; nephridiopore opening on collar fold below anus ..... *Phoronopsis albomaculata*
— Invagination not present 5

5. All mesenteries present; nephridiopore below anus ..... *Phoronis psammophila*
— Left lateral mesentery absent in muscular region; nephridiopore at level of anus; prebuccal and postbuccal tentacles of same length, lateral tentacles longer ..... *Phoronis muelleri*

6. Descending branch of nephridia nearly as long as ascending branch; left giant nerve fibre only; circular muscles (three sphincters) and longitudinal muscles (six zones) unusual ..... *Phoronis pallida*
— Descending branch of nephridia absent; nephridial papilla present; two giant nerve fibres; burrowing or encrusting habit 7

7. Ascending branch of nephridia in two horizontal chambers; longitudinal muscle bundles number 24-43 ..... *Phoronis hippocrepia*
— Ascending branch of nephridia curved; longitudinal muscle bundle numbers 37-69 ..... *Phoronis ijimai*

8. Lophophore spiral 9
— Lophophore helicoidal; nephridia with two funnels and descending branch; invagination present at base of lophophore, deep ..... *Phoronopsis californica*

9. Invagination present at base of lophophore; right giant nerve fibre absent in muscular region; nephridia with descending branch 10
— Invagination not present; nephridia with two funnels, anal larger than oral; nephridia without descending branch; two giant nerve fibres 11

10. Nephridia with one funnel ..... *Phoronopsis albomaculata*
— Nephridia with two funnels, anal smaller than oral; invagination very distinct ..... *Phoronopsis harmeri*

11. Burrowing or encrusting species ..... *Phoronis ijimai*
— Inhabitating cerianthid tube-wall; lophophore multispiral ... *Phoronis australis*

ACKNOWLEDGEMENTS

We wish to thank N. Coleman and P. Hutchings, Australian Museum, for their assistance in collecting material from Wreck Bay (N.C.), and from Wallis Lake, Careel Bay and Camp Cove (P.H.). We are also grateful to G. Poore and R. Spies, Victorian Fisheries and Wildlife Division, for material from Port Phillip Bay.

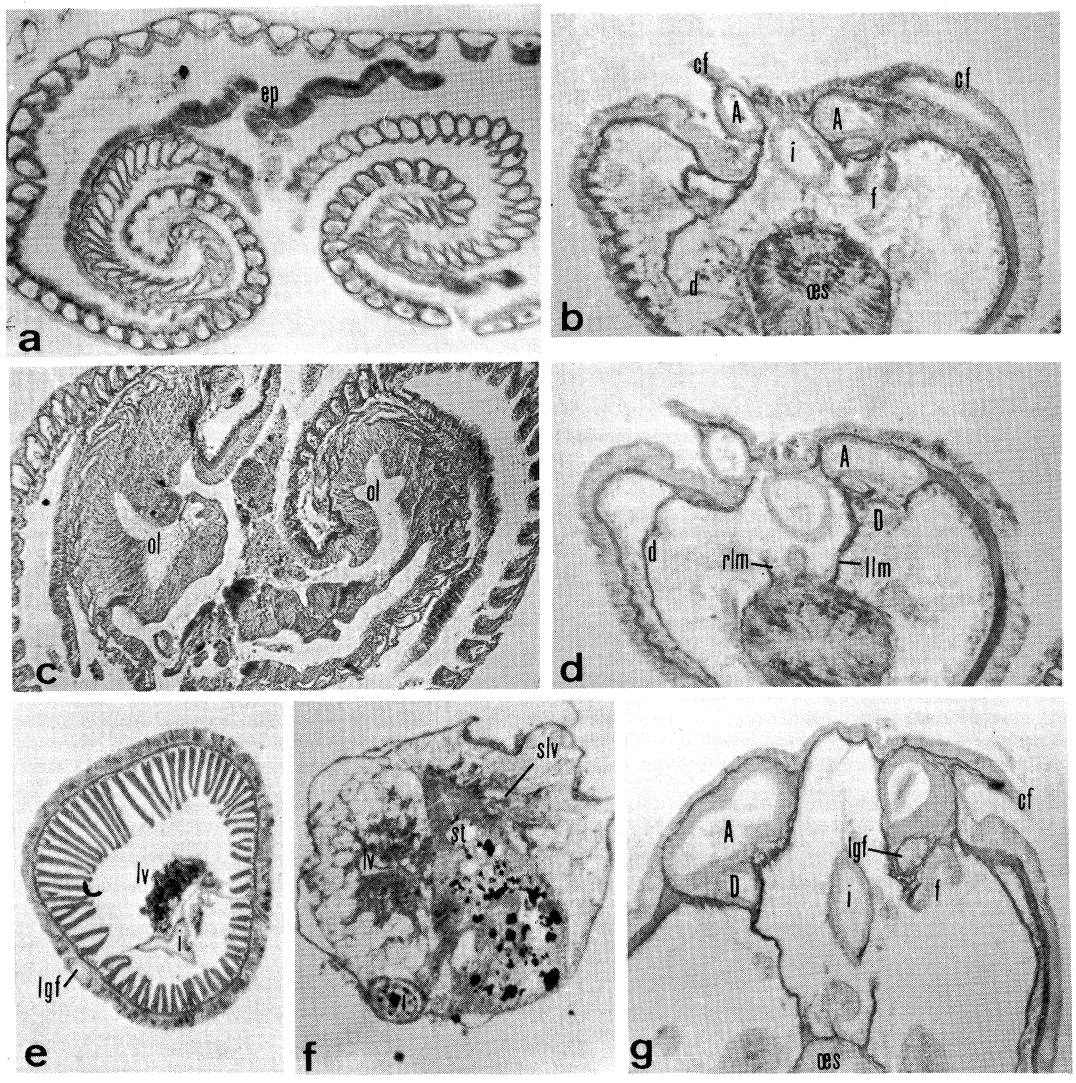

Fig. 8. *Phoronopsis albomaculata*. (a) cross section of the lophophore, without accessory sex glands; (b) cross section, slightly oblique, through the funnel; (c) cross section of the lophophore through the lophophoral organs; (d) cross section (below b) of the nephridia; (e) cross section of the muscular region; (f) cross section of the ampulla, showing testis in the two oral cavities; (g) cross section of the nephridia.

REFERENCES

Andrews, E. A., 1890. On a new American species of the remarkable animal *Phoronis*. *Ann. Mag. nat. Hist.* 5: 445-449.

Benham, W. B., 1889. The anatomy of *Phoronis australis*. *Q. Jl microsc. Sci.* 30: 125-158.

Emig, C. C., 1969a. Considérations sur la systématique des Phoronidiens. III. *Phoronis psammophila* Cori, 1889, et *Phoronis architecta* Andrews, 1890. *Bull. Mus. Hist. nat. Paris* 41: 312-327.

——— 1969b. Considérations sur la systématique des Phoronidiens. VIII. *Phoronis pallida* (Schneider) Silen, 1952. IX. *Phoronis ovalis* Wright, 1856. *Bull. Mus. Hist. nat. Paris* 41: 1531-1542.

——— 1971. Taxonomie et systématique des Phoronidiens. *Bull. Mus. Hist. nat. Paris* (Zool.) 8 (3): 469-568.

——— 1972. Phoronidiens récoltés lors de la campagne "Biaçores" du N/O Jean Charcot. *Téthys, Fr.* 4: 423-428.

——— 1973a. Phoronidiens de Madagascar. *Téthys, Fr.*, suppl. 5: 9-24.

——— 1973b. Ecologie des Phoronidiens. *Bull. Ecol.* 4 (4): 339-364.

——— 1974. The systematics and evolution of the phylum Phoronida. *Z. zool. Syst. Forsch.-Evol.* 12 (2): 128-151.

——— C. Herberts and B. A. Thomassin, 1972. Association de *Phoronis australis* (Phoronida) avec *Cerianthus maua* (Ceriantharia) dans les zones récifales de Madagascar. *Mar. Biol.* 15: 304-315.

——— and I. Marche-Marchad, 1969. Considérations sur la systématique des Phoronidiens. VII. *Phoronis australis* Haswell, 1883. *Bull. Mus. Hist. nat. Paris* 41: 1244-1251.

——— and B. Thomassin, 1969. Considérations sur la systématique des Phoronidiens. VI. *Phoronopsis albomaculata* Gilchrist, 1907. *Bull. Mus. Hist. nat. Paris* 41: 901-908.

Haswell, W. A., 1883. Preliminary note on an Australian species of *Phoronis* (*Gephyrea Tubicola*). *Proc. Linn. Soc. N.S.W.* 7: 606-608.

——— 1885. On a new instance of symbiosis. *Proc. Linn. Soc. N.S.W.* 9: 1019-1021.

——— 1893. The occurrence of a second species of *Phoronis* in Port Jackson. *Proc. Linn. Soc. N.S.W.* (2) 7: 340-341.

Hilton, A. W., 1930. Phoronidea from the coast of southern California. *J. Ent. Zool.* 22: 33-35.

Ikeda, I., 1903. On the occurrence of *Phoronis australis* Haswell near Misaki. *Ann. Zool. Japan.* 4: 115-118.

MMBW and FWD, 1973. Environmental study of Port Phillip Bay, report on phase one, 1968-1971. Melbourne and Metropolitan Board of Works and Fisheries and Wildlife Department of Victoria, Melbourne, 372 pp.

Ponder, W. F., 1971. "Montacutona ceriantha" n. sp., a commensal leptonid bivalve living with "Cerianthus". *J. Conch. Paris* 109: 15-25.

Poore, G. C. B., and S. F. Rainer, 1974. Distribution and abundance of soft-bottom molluscs in Port Phillip Bay, Victoria, Australia. *Aust. J. mar. Freshwat. Res.* 25 (3): 371-411.

Roule, L., 1889. Sur une nouvelle espèce méditerranéenne du genre *Phoronis*. *C. r. hebd. Séanc. Acad. Sci., Paris* 109: 195-196.

Selys-Longchamps, M. De., 1907. *Phoronis*. Fauna Flora, Golf Neapel, 30: 1-280.

Silén, L., 1952. Research on Phoronidea of the Gullmar Fiord area (west coast of Sweden). *Ark. Zool.* 4 (4): 95-140.

Stancyk, S. E., F. J. S. Maturo and R. W. Heard, 1976 Phoronids from the east coast of the United States. *Bull. mar. Sci.* 26(4): 576-584.

Torrey, H. B., 1901. On *Phoronis pacifica* sp. nov. *Biol. Bull. mar. biol. Lab., Woods Hole* 2: 283-288.

Zimmer, R. L., 1964. Reproductive biology and development of Phoronida. Univ. Microfilm, Ann Arbor, 416pp.

APPENDIX

Recently, *P. australis, Phoronopsis harmeri, Phoronopsis albomaculata,* and a species new to Australian waters, *Phoronis muelleri* have been discovered near Peel Island and Middle Banks (Moreton Bay). Data on these specimens will be published later.

Manuscript accepted for publication 1 July, 1974