THE OCCURRENCE IN AUSTRALIA OF THREE SPECIES OF PHORONDIDA (LOPHOPHORATA) AND THEIR DISTRIBUTION IN THE PACIFIC AREA

CHRISTIAN C. EMIG & CARMEN RÓLDAN

Summary

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Of the ten known species of Phoronida, all have representative populations in the Pacific Ocean and seven have been recorded in Australian waters (Emig *et al.* 1977; Emig 1982a, b). Recent benthic surveys of Spencer Gulf and Nouméa lagoon have resulted in the first records of *Phoronis psammophila* and *Phoronopsis albomaculata* from South Australia and New Caledonia; the new material is listed below, together with details of the collecting stations. Previously unidentified material from New Zealand in the collection of Portobello Marine Laboratory proves upon reexamination to be the first New Zealand record of *Phoronopsis albomaculata*. In addition, examination of material of *Phoronis australis* in the South Australian Museum led to additional locality records of this species in Western Australia and Queensland. The Pacific occurrence of all three species is discussed below, and a brief diagnosis given of each.

Phoronis australis Haswell

Phoronis australis Haswell, 1883: 606.
Phoronis buskii McIntosh, 1888: 1.

Distribution in the Pacific Ocean (Fig. 1).

Japan : 3. Misaki (Ikeda 1902, 1903); 4. Kyushyu (Ishihawa 1977), Kii Peninsula (Uchida 1979). *China* : 6. Amoy, Qingdao (Wu & Ruiping 1980; Emig 1982a b). *Philippines* : 7. (McIntosh 1888; Cori 1939). *Vietnam* : 8. Nhatrang Bay (Kasyanov & Radashevsky 1987). *Australia* : 17. Waterman Bay, W. Aust., (coll. South Australian Museum; Fig. 1); 10. Southport, Queensland (coll. South Australian Museum; Fig. 1), Moreton Bay, Queensland (Emig 1977); 18. Houtman Abrolhos Is., W. Aust. (Emig 1982b); 12. Sydney, N.S.W. (Haswell 1883; Ponder 1971; Emig *et al.* 1977).

Diagnosis

Burrowing in tube-wall of cerianthids, generally of the genus *Cerianthus*. From the intertidal zone to 36 m depth.

Length in extension up to 200 mm, 2-5 mm in diameter. Colour in life: body pink; anterior body part and lophophore transparent or purple to black. Lophophore spiral with 2.5 to 3.5 coils on each side, 5-16 mm in length, 600-1 000 tentacles. Nephridia with two funnels (anal large, oral small), an ascendant branch only, nephridiopore opening on nephridial ridge at level of anus. Two giant nerve fibres (left one 5-13 μm in diameter; right one 3-13 μm in diameter). Longitudinal muscle bundles of bushy type; arrangement of longitudinal muscle bundles relative to four sub-divisions of metacoelom formed by mesenteries (i.e. clockwise left oral, right oral, right anal, left anal sub-divisions) represented by conventional formula of Selys-Longchamps (1907); the general formula is:

$$[43\text{-}87]\ \frac{14\text{-}29 \mid 13\text{-}27}{4\text{-}17 \mid 5\text{-}17}$$ and the mean formula is

$$64 = \frac{22 \mid 22}{11 \mid 9}.$$

Sexual reproduction hermaphroditic; embryos brooded in lophophoral cavity on mucous cord secreted by nidamental glands of type B (*i.e.* restricted to floor of lophophoral concavity with an extension along coils of lophophore on inner surface of tentacles and associated with two embryo masses); lophophoral organs small. Asexual reproduction by transverse fission.

Larva: unknown.

Remarks

The burrowing habits of *P. australis* are characteristic. The species lives in the tube-wall of cerianthid species, mainly of *Cerianthus*. No ecological data were available on the individuals. The specimens collected in Australian waters appear to have a higher number of longitudinal muscle bundles than those examined in Atlantic and Indian waters (Table 1).

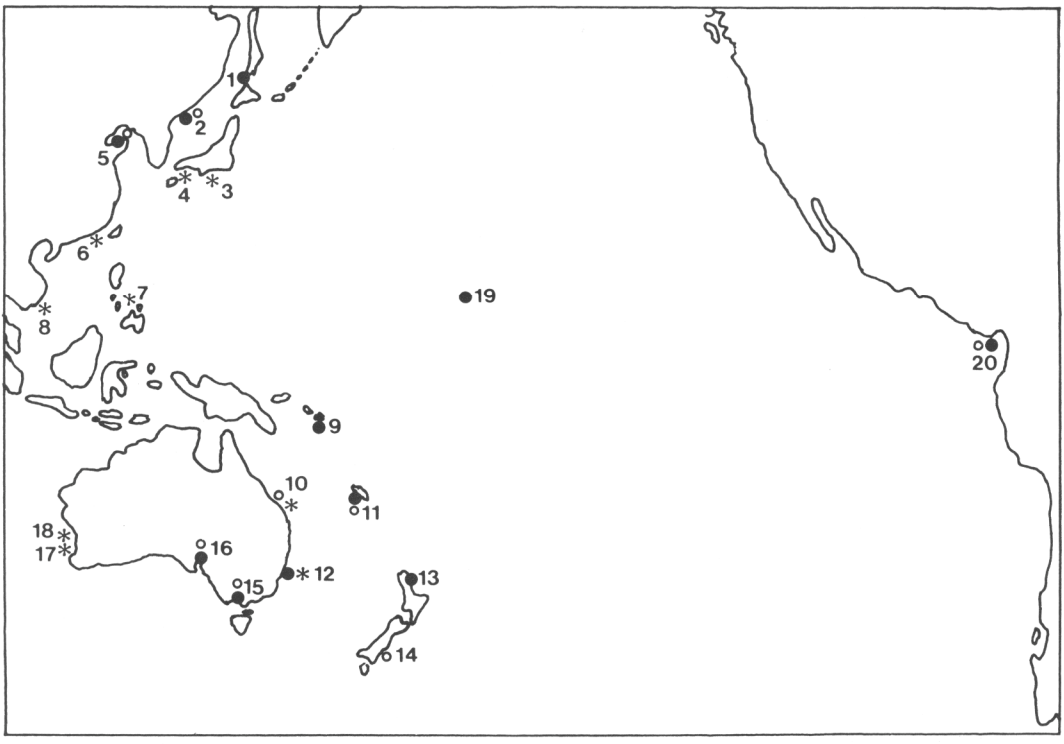

FIGURE 1. Occurrences of *Phoronis australis*, *P. psammophila* and *Phoronopsis albomaculata* in the Pacific Ocean (see explanation in text for location numbers and Tables 1, 4 and 5).

TABLE 1. Longitudinal muscle formulae of *Phoronis australis* recorded in Australian locations (see Fig. 1 for locations). N = number of specimens examined.

Locality	N	Mean		General Formula	
10. Southport	5	78	$= \frac{27 \mid 26}{14 \mid 11}$	$\frac{23-30 \mid 22-27}{12-15 \mid 10-14}$	[68–84]
10. Moreton Bay	1	65	$= \frac{23 \mid 22}{13 \mid 7}$		
12. Sydney	21	73	$= \frac{25 \mid 24}{13 \mid 11}$	$\frac{20-28 \mid 19-27}{8-17 \mid 7-17}$	[60–87]
17. Waterman Bay	1	59	$= \frac{21 \mid 19}{11 \mid 8}$		
Total for species	94	66	$= \frac{23 \mid 22}{12 \mid 9}$	$\frac{17-35 \mid 14-27}{4-17 \mid 5-19}$	[43–87]

Phoronis psammophila Cori

Phoronis psammophila Cori, 1889: 1.
Phoronis sabatieri Roule, 1889: 195.
Phoronis architecta Andrews, 1890: 445.

Distribution in the Pacific Ocean (Fig. 1).

Russia Far East: 1. Sakhalin (Emig 1984; Emig & Golikov 1990); 2. Poss'yet Bay, Mordinov Gulf (Emig 1984; Emig & Golikov 1990). *China*: 5. Changshan Is., Dalni, Potonoman (Emig 1984). *Solomon Is.*: 9. (Emig 1977). *Australia*: 12. Cabbage Tree Basin, N.S.W. (Rainer & Fitzhardinge 1981); 15. Port Phillip Bay, Western Port, Victoria (Emig *et al.* 1977); 16. Spencer Gulf, S. Aust. (coll. South Australian Museum; Fig. 2). *New Caledonia*: 11. Nouméa lagoon (coll. Emig; Fig. 3). *New Zealand*: 13. Ranganna Bay, Doubtless Bay (coll. D. P. Gordon); 13. Howick, Whangateau Harbor, Waitemata, Jellicoe (Jillett 1971; Gordon & McKnight 1983; coll. D. Gordon). *USA-Hawaii*: 19. Oahu (Emig 1977; Emig & Bailey-Brock 1987); 19. Midway (Sorden 1983). *Panama*: 20. (Emig 1982a).

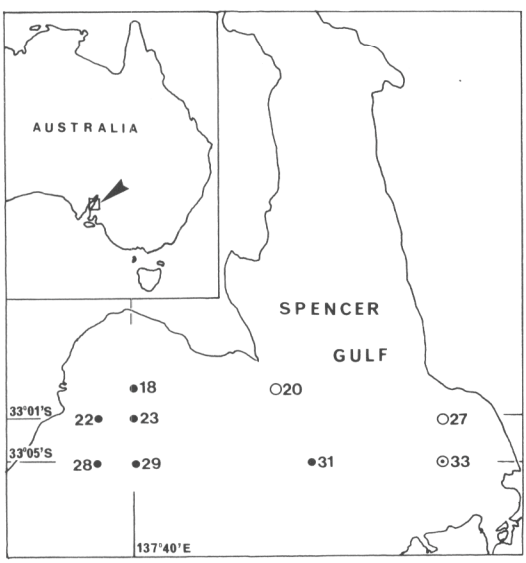

FIGURE 2. Map of the stations at which phoronid species have been recorded in Spencer Gulf (numbers correspond to station numbers of Table 2).

Diagnosis

Embedded vertically in soft sediments, generally sandy to muddy, or covered by seagrass beds. From the intertidal zone down to 52 m depth.

Length in extension up to 190 mm, diameter 0.5-2 mm. Colour in life: body pink; lophophore transparent with white (occasionally yellow, green or red) pigment spots. Lophophore horseshoe-shaped with ends turned medially. Tentacles up to 190, length 1.5-2.5 mm. Nephridia with single funnel, descending and ascending branch, nephridiopore on anal papilla opening below anus. Single giant nerve fibre, on left side, 7-27 μm in diameter, very thin nerve fibre rarely present on right side. Longitudinal muscle bundles of feathery type; general formula is:

$$[24\text{-}53]\ \frac{7\text{-}19 \mid 7\text{-}18}{4\text{-}11 \mid 4\text{-}11},\ \text{mean formula is } 35 = \frac{12 \mid 11}{6 \mid 6}.$$

Sexual reproduction dioecious; females brooding embryos in single mass in lophophoral cavity through nidamental glands of type C (*i.e.* formed by fusion of inner row of lophophore tentacles); males with large, glandular lophophoral organs. Asexual reproduction by transverse fission.

Larva: *Actinotrocha sabatieri* Roule, 1896.

Remarks

In South Australia during the benthic survey of Spencer Gulf, *P. psammophila* was recorded at seven stations, occurring with *Phoronopsis albomaculata* only at St. 33 (Fig. 2; Table 2), at which site its density reached about 40 individuals.m^{-2}. In Cabbage Tree Basin, NSW (Rainer & Fitzhardinge 1981) (Fig. 1), *P. psammophila* was found in three locations where the salinity varies between 27.8 and 36.2 % and the annual temperature range between 10.7 and 26.4 °C: in stable sand flat at 0.3 m (but presence appears rather uncommon in shallower sites in this basin); in a silty sand with patches of *Posidonia australis* at 2 m depth; and in silty sand with surface detritus at 5 m depth. This last location has a much lower concentration of dissolved oxygen, which confirms the ability of this species to live in waters containing small amounts of oxygen (Emig 1982b). The associated fauna is common in many estuaries along the south-east Australian coast.

In New Zealand, *Phoronis psammophila* has been collected in the northern part of North Island, in Howick (Auckland Harbour) in a *Zostera* patch in sandy mud and sporadically in Whangateau Harbor (D. P. Gordon, personal communication); in Ranganna Bay in fine sand at 21 m (34°50′38″S, 173°14′60″E); in Doubtless Bay in fine sand at 17 m (34°56′21″S, 173°24′43″E) and in sandy mud at 52 m (34°56′21″S, 173°24′43″E). The last location is the deepest record for *P. psammophila*. In the last two locations the specimens, collected with a Smith-McIntyre grab, are sparsely distributed (2-3 individuals per haul).

In the Nouméa lagoon, New Caledonia (Fig. 3; Table 3), *P. psammophila* occurs at low density in fine to coarse sands, generally covered with a rich epibiosis, and in seagrass beds of *Halodule minervis* with *Halimeda* (St.65, 119A, 119B); its density varied from 3 to 100 individuals.m^{-2}. This species occurred

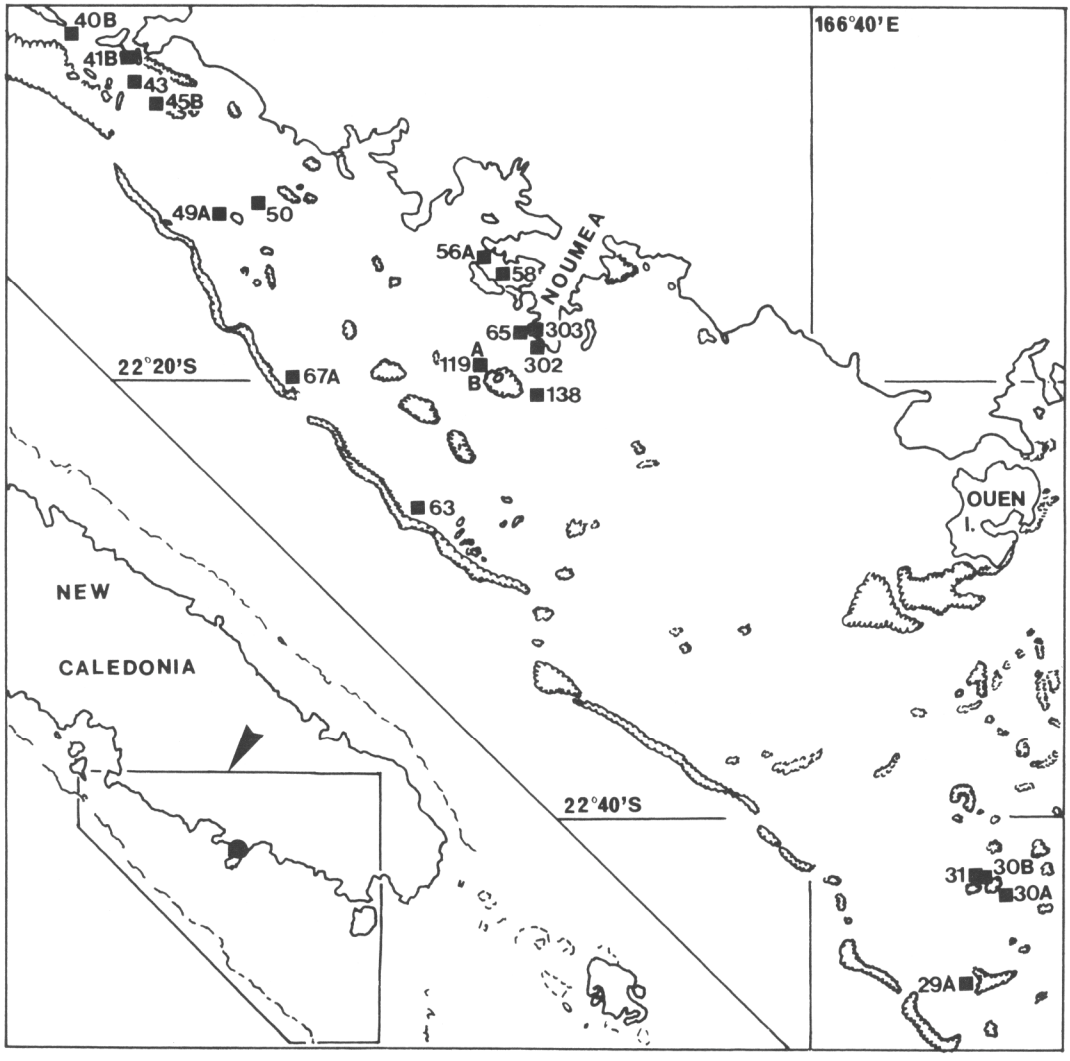

FIGURE 3. Map of the stations at which phoronid species have been recorded in the Nouméa lagoon (numbers correspond to station numbers of Table 3).

generally with one or two other phoronid species, *e.g. Phoronis muelleri* Selys-Longchamps, *Phoronopsis albomaculata* and/or *Phoronopsis harmeri* Pixell (Table 3). In the Anse Vata (0-2 m; St. 302) and in the Baie des Citrons (2-5m; St.303, 65), *Phoronis psammophila* occurs with *Phoronopsis harmeri* at very shallow depth.

The various populations of *Phoronis psammophila* cannot be characterized by the formulae of their longitudinal muscles (Table 4), for large variations occur within the populations, and within and between geographical areas. No relationship could be established with environmental factors.

Phoronopsis albomaculata Gilchrist

Phoronopsis albomaculata Gilchrist, 1907: 152.

Distribution in the Pacific Ocean (Fig. 1).

Russia: 2. Peter-the-Great Bay, Poss'yet Bay (Emig & Golikov 1990). *Australia:* 10. Moreton Bay, Queensland (Emig 1977; Emig *et al.* 1977); 15. Port Phillip Bay, Western Port, Victoria (Emig *et al.* 1977); 16. Spencer Gulf, S. Aust. (coll. South Australian Museum; Fig. 2). *New Caledonia*: 11. Nouméa lagoon (coll. C. C. Emig, B. A. Thomassin; Fig. 3). *New Zealand*: 14. Otago, Portobello (Rainer 1981; coll. Portobello Marine Laboratory). *Panama*: 20. (Emig 1982a).

TABLE 2. Records of *Phoronis psammophila* and *Phoronopsis albomaculata* in Spencer Gulf (see map in Fig. 2) and of *Phoronis australis* in Australian waters. Surface per grab haul is 0.1 m^2. SAM = South Australian Museum.

St.	Depth (in m)	Sand	Number of individuals per grab haul Nov. 85	Feb. 86	Aug. 86	Feb. 87	Sept. 87	Reg. No. SAM.L. . .
Phoronis psammophila								
18	10	fine					3	513
22	10	fine			1			503
23	12	fine			2		2 1	504, 514, 515
28	12	medium					1	516
29	13	fine					1	505
31	8	coarse					1	517
Phoronopsis albomaculata								
20	22	coarse					1	526
27	7	fine		6 7 6	1 2 1		2 4 4 11	521-525 527-530
Phoronis psammophila and *[Phoronopsis albomaculata]*								
33	5	very fine	2	2 1	1 4 1	1	1 3+[2]	506-512 518-520 [531]

Phoronis australis:
– Waterman Bay (W Australia, 31°51′S, 115°45′E), Coll. Noel Morrissy, Reg. No. SAM.TL 7294
– Southport (Queensland), Reg. No. SAM.TL 6605

TABLE 3. Records of Phoronida in the Nouméa lagoon (collected by B. A. Thomassin and C. C. Emig) (see map in Fig. 3); the data in italics represent individuals.m^{-2}. In St.119A, 119B, and 138, the percentage of organic carbon is 0.3-0.35 FF = fine fraction of the sediment (<63 μm). SAM = South Australian Museum.

St.	Depth (in m)	*Phoronis* *muelleri*	*psammophila*	*Phoronopis* *albomaculata*	*harmeri*	Sand	%FF	Reg. No. SAM.L. . .
29A	24	*5*	*5*					
30A	12			2				
30B	6		1					643
31	16		2					
40B	17				1	fine muddy		
41B	6	*3*		*9*	*3*			652 649 641
43	21	8	1			coarse	11	
45B	13			1				
49A	10		2	3		coarse	3	650 644
50	26	1	3		5	coarse	4	653 645 642
56A	15	*20*				fine muddy		
58	10	2				sandy mud		
63	11		*3*	*3*		fine	4	
65	5		2	6		coarse	5	651 646
67A	14	*5*				coarse fine		
119A	6		*40*		*50*	coarse		654 647
119B	6		*40*		*40*	coarse	6	655 648
138	24	*10*				fine muddy		
302	0.5–2		*50*		*300*	coarse		
303	2–5		*100*		*100*	fine		

TABLE 4. Longitudinal muscle formulae of *Phoronis psammophila* recorded in the Pacific Ocean and southern Australian waters (see Fig. 1 for locations). N = number of specimens examined.

Locality	N	Mean	General Formula
13. New Zealand	6	$26 = \frac{9 \mid 9}{4 \mid 4}$	$\frac{9-10 \mid 8-9}{4-5 \mid 4-5}$ [25–28]
16. Spencer Gulf	8	$33 = \frac{11 \mid 10}{6 \mid 6}$	$\frac{10-14 \mid 9-12}{5-6 \mid 5-8}$ [29–39]
20. Panama	33	$37 = \frac{13 \mid 12}{6 \mid 6}$	$\frac{9-16 \mid 9-14}{5-9 \mid 5-9}$ [28–48]
9. Solomon	4	$37 = \frac{11 \mid 12}{7 \mid 7}$	$\frac{10-12 \mid 11-12}{7-8 \mid 6-9}$ [35–38]
5. China	10	$38 = \frac{11 \mid 12}{8 \mid 7}$	$\frac{9-14 \mid 10-14}{7-9 \mid 6-9}$ [33–46]
2. Russia	11	$39 = \frac{12 \mid 12}{8 \mid 7}$	$\frac{10-14 \mid 10-15}{6-10 \mid 6-9}$ [32–46]
11. New Caledonia	22	$40 = \frac{13 \mid 12}{8 \mid 7}$	$\frac{9-17 \mid 8-18}{5-11 \mid 5-10}$ [29–53]
15. Melbourne	36	$47 = \frac{15 \mid 15}{9 \mid 8}$	$\frac{11-19 \mid 11-17}{6-11 \mid 6-11}$ [34–53]
19. Hawaii	2	$\frac{10 \mid 10}{7 \mid 7} = 34$ and	$\frac{11 \mid 10}{6 \mid 6} = 33$
Total for species	3 137	$35 = \frac{12 \mid 11}{6 \mid 6}$	$\frac{7-19 \mid 7-18}{4-11 \mid 4-11}$ [24–53]

Diagnosis

Embedded vertically in soft sediments, generally coarse sands. From 0 to 55 m depth.

Length in extension up to 150 mm, diameter 0.5-2 mm. Colour in life: body pink; lophophore transparent with pigment spots. Lophophore horseshoe-shaped with ends turned medially, up to one coil. Tentacles up to 160, length 2-3 mm. Nephridia with single funnel, descending and ascending branch, nephridiopore on anal papilla opening below anus on collar fold within invagination. Giant nerve fibre paired, left fibre only present below nephridial level on left side (15-35 μm in diameter). Longitudinal muscle bundles of feathery type; general formula is:

[44-102] $\frac{14\text{-}33 \mid 13\text{-}34}{7\text{-}20 \mid 6\text{-}20}$, mean formula is $68 = \frac{22 \mid 21}{13 \mid 12}$.

Sexual reproduction dioecious; females probably having brooding pattern; males with large glandular lophophoral organs. Asexual reproduction by transverse fission.

Larva: unknown.

Remarks

In South Australia, during the benthic survey of Spencer Gulf, *Phoronopsis albomaculata* was recorded at three stations, occurring with *Phoronis psammophila* at St.33 (Fig. 2; Table 2). Its density reached about 70 individuals.m^{-2} at St.27; a similar density (up to 75 individuals.m^{-2}) has been cited near Tuléar, Madagascar, by Thomassin & Emig (1983).

During a survey of the Nouméa lagoon (New Caledonia) (Fig. 3; Table 3), *Phoronopsis*

TABLE 5. Longitudinal muscle formulae of *Phoronis albomaculata* recorded in the Pacific Ocean and southern Australian waters (see Fig. 1 for locations). N = number of specimens examined.

Locality	N	Mean		General Formula	
20. Panama	22	54 =	18 | 18 / 9 | 9	16–21 | 15–23 / 8–12 | 8–12	[47– 67]
14. Portobello	4	56 =	18 | 19 / 10 | 9	18–19 | 18–19 / 8–13 | 8–10	[54– 59]
16. Spencer Gulf	34	56 =	19 | 18 / 10 | 9	15–22 | 13–21 / 8–12 | 7–11	[44– 63]
15. Melbourne	14	59 =	19 | 20 / 10 | 10	14–23 | 15–24 / 7–13 | 7–13	[46– 68]
11. New Caledonia	10	65 =	21 | 19 / 13 | 12	17–27 | 17–21 / 10–15 | 9–13	[53– 76]
2. Russia	31	67 =	21 | 21 / 13 | 12	14–27 | 16–28 / 9–17 | 6–17	[48– 80]
10. Moreton Bay	20	80 =	26 | 24 / 16 | 14	19–33 | 19–33 / 12–20 | 12–16	[62–102]
Total for species	240	68 =	22 | 21 / 13 | 12	14–33 | 13–34 / 7–20 | 6–20	[44–102]

albomaculata was collected by B. A. Thomassin at several stations characterized by coarse sand and fine sand at a low density of 3-9 individuals.m^{-2}.

In Otago (New Zealand) (Fig. 1), the species cited as *Phoronopsis* sp.1 by Rainer (1981: St.B10) has been identified by us as *Phoronopsis albomaculata* (material deposited in the Portobello Marine Laboratory): this species occurs at 4 m depth with a mean abundance of 9.7, in a sandy bottom (fraction 2-3 φ = 65.5%) with a large amount of coarse material and 14% organic detritus, under the influence of tidal currents. This record is from one of the coldest coastal locations in New Zealand, with water temperatures of 5-7°C in winter.

In the Russian Far East (Fig. 1) where the locations are under the influence of subtropical waters, *Phoronopsis albomaculata* has been recorded between 8 and 45 m depth with a density 8-20 individuals.m^{-2}, but up to 312 individuals.m^{-2} at 25 m in Poss'yet Bay (Emig & Golikov 1990).

As in *Phoronis psammophila*, no relationship could be established between geographical populations of *Phoronopsis albomaculata* on the basis of their muscle formulae (Table 5).

Conclusions

Phoronis psammophila is a cosmopolitan species and *Phoronopsis albomaculata*, previously considered as a tropical species, appears now as a tropical-temperate species according to its life conditions in New Zealand. The latter occurs in similar types of sandy bottoms to *Phoronis psammophila*, but in general in those with a higher amount of the coarse fraction under the influence of stronger near-bottom currents; *P. psammophila* has a higher density in well-sorted fine sands (Thomassin & Emig 1983). Such factors should explain the distribution of both species in Spencer Gulf and in the Nouméa lagoon and their co-occurrence in some locations.

The present data provide confirmation that, in Phoronida, low densities occur in tropical and subtropical waters (Emig 1982b; Thomassin & Emig 1983) in contrast to the higher densities which are cited at higher latitudes. For example, *P. psammophila*: 18000 individuals.m^{-2} in Marseille (South of France; Emig 1982b) and *Phoronopsis albomaculata*: 325 individuals per m^{-2} in the Poss'yet Bay (Russia Far East).

The taxonomic characters of *Phoronis australis*, *P. psammophila* and *Phoronopsis albomaculata* show strong similarities over the whole Pacific area, except for the muscle formulae, which vary widely within and between geographical locations.

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