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RHIZOCEPHALAN PARASITES OF THE CRAB *PUGETTIA BREVIROSTRIS*, WITH NOTES ON *SACCOLINA GRACILIS*

by

H. BOSCHMA

The present paper deals with two parasites of the crab *Pugettia brevirostris*, the one representing the new species *Sacculina reinhardi*, the other identified with *Sacculina muricata*. The excrescences of the external cuticle of *Sacculina reinhardi* are similar to those of *Sacculina gracilis*. For a comparison of *S. gracilis* with *S. reinhardi* some additional data of previously described specimens of *S. gracilis* are here noted and figured, to show that certain characters of this species are constantly different from the corresponding peculiarities in the only available specimen of *S. reinhardi*.

***Sacculina reinhardi* nov. spec. 1)**

U. S. Bureau of Fisheries, Northwestern Pacific Cruise, 1906, in entrance of Uraga Strait, Gulf of Tokyo, Japan, 70 fms., October 26, 1906, 1 specimen on *Pugettia brevirostris* (Doflein), U. S. National Museum, catalogue number 49552.

Specific characters. Male organs in the posterior part of the body, outside the visceral mass, forming straight thick-walled canals slightly increasing in size towards the dorsal region; transition of vas deferens into testis indicated by short chitinous tube only. Colleteric glands flat, their tubes nearly all in one row parallel to the surface, 15 to 17 tubes in longitudinal sections of the regions of maximum division. External cuticle with hyaline excrescences consisting of a basal part and a varying number of spines; diameter of excrescences 8 to 23 μ , height (including the spines) 8 to 27 μ . Retinacula unknown.

The specimen is oval to rectangular (fig. 1 a), the mantle opening lies at the top of a papilla at the anterior surface, slightly protruding above its

1) Named after Dr. Edward G. Reinhard, Catholic University of America, the author of several important papers on Rhizocephala.

surroundings, the stalk extends from a pronounced concavity in the posterior region. The mantle is somewhat wrinkled on account of numerous shallow grooves; moreover, a large part of the mantle shows minute furrows of a parallel course, especially in the anterior, the dorsal, and the ventral regions, often running perpendicular to the larger grooves. The dorso-ventral diameter is 7 mm, the antero-posterior diameter 5 mm, the thickness about 2 mm.

Longitudinal sections show that the male organs are contained in the posterior part of the body, outside the visceral mass (fig. 2 *g*). They form straight tubes which in their course towards the dorsal region gradually but only slightly increase in size. Their external shape does not furnish any indication concerning the region of transition of the vasa deferentia into the testes, this region is to be determined only by the fact that each of

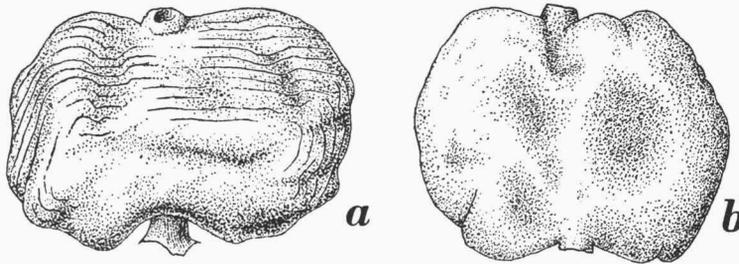


Fig. 1. *a*, *Sacculina reinhardi* nov. spec., type specimen, left side; *b*, *Sacculina muricata* Boschma, specimen on *Pugettia brevirostris* (Doflein), left side. *a*, $\times 6\frac{1}{2}$, *b*, $\times 3\frac{1}{2}$.

the vasa deferentia in its extreme dorsal part is internally covered by a distinct layer of chitin (fig. 2 *c*, right vas deferens; fig. 2 *d* and *g*, left vas deferens, these two figures representing parts of the same region). The vasa deferentia have a thick wall and a very narrow lumen (fig. 2 *a-d*); the testes gradually obtain a wider lumen but remain distinctly thick-walled (fig. 2 *d-f*). Towards the dorsal region the male organs gradually approach each other in the median plane, though remaining completely separated.

The colleteric glands form flat masses which do not protrude above the surface of the visceral mass. In their peripheral region they contain a single row of tubes arranged parallel to the surface (fig. 2 *h*), towards the central part a few tubes appear next to this single row (fig. 2 *i*). The two figured sections are from the region in which the system of tubes reaches its maximum division, the number of tubes being 15 and 17.

The external cuticle of the mantle is of varying thickness, in the parts of the cuticle represented in fig. 3 the thickness of the cuticle exclusive

of the excrescences amounts to 21 (*a*), 30 (*b*), 27 (*c*), 23 (*d*), 23 (*f*), 30 (*g*), 32 (*h*), 23 (*i*), 18 (*j*), and 26 μ (*k*).

The excrescences of the external cuticle consist of a hyaline kind of chitin, different from that of the main layers. In many parts of the cuticle the excrescences are composed of a number of spines united on a thin common basal part (fig. 3 *b*, *d*), the spines having a length of 5 to 16 μ . In other regions of the cuticle the basal parts become thicker, leading to a more solid appearance of the excrescences (fig. 3 *k*). Further development

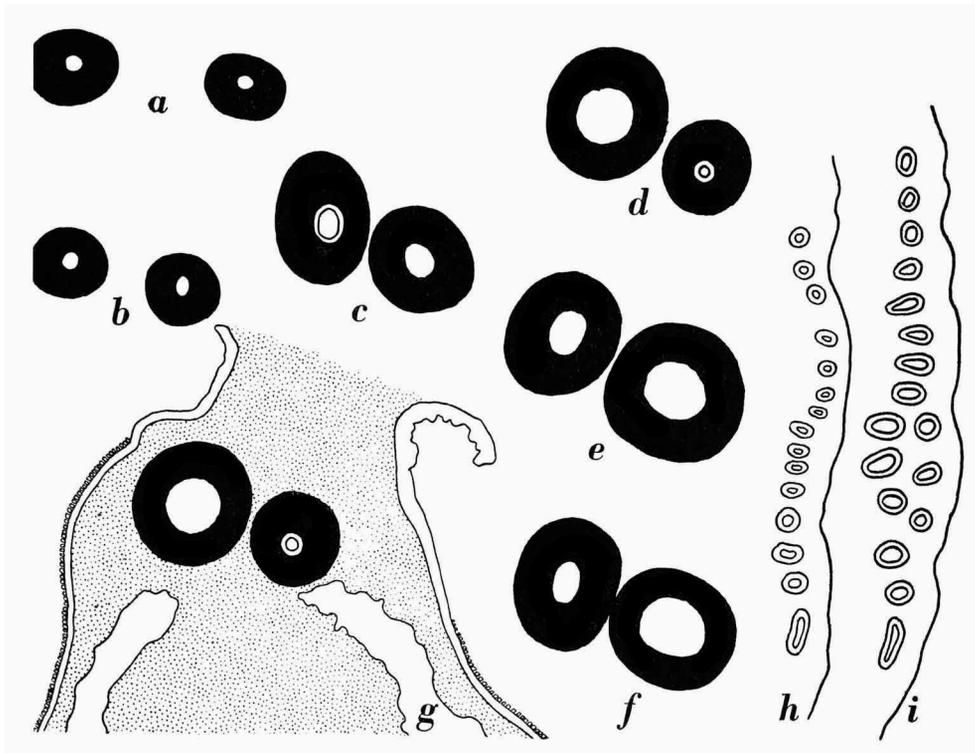


Fig. 2. *Sacculina reinhardi* nov. spec., type specimen. *a-f*, transverse sections of the male genital organs, *a* of the ventral parts of the vasa deferentia, each following section farther towards the dorsal region; *g*, posterior part of a longitudinal section from the region of the stalk; *h*, *i*, longitudinal sections of one of the colleteric glands, *i* nearer to the centre than *h*. *a-g*, $\times 45$; *h*, *i*, $\times 80$.

of the basal part gives rise to excrescences in which the spines are of the same height as the basal parts (fig. 3 *g*, *j*) or even smaller than the latter (fig. 3 *a*, *c*, *f*, *i*); exceptionally the spines are extremely small, as if abraded (fig. 3 *h*). The figures give an idea of the excessive variation in the shape

of the excrescences in various parts of the mantle. The height of the excrescences including the spines is from 8 to 27 μ . When seen in surface view the spines appear to occur all over the topmost parts of the excrescences (fig. 3 *e*) which have a diameter of 8 to 23 μ , and are rather crowdedly covering the upper part of the external cuticle.

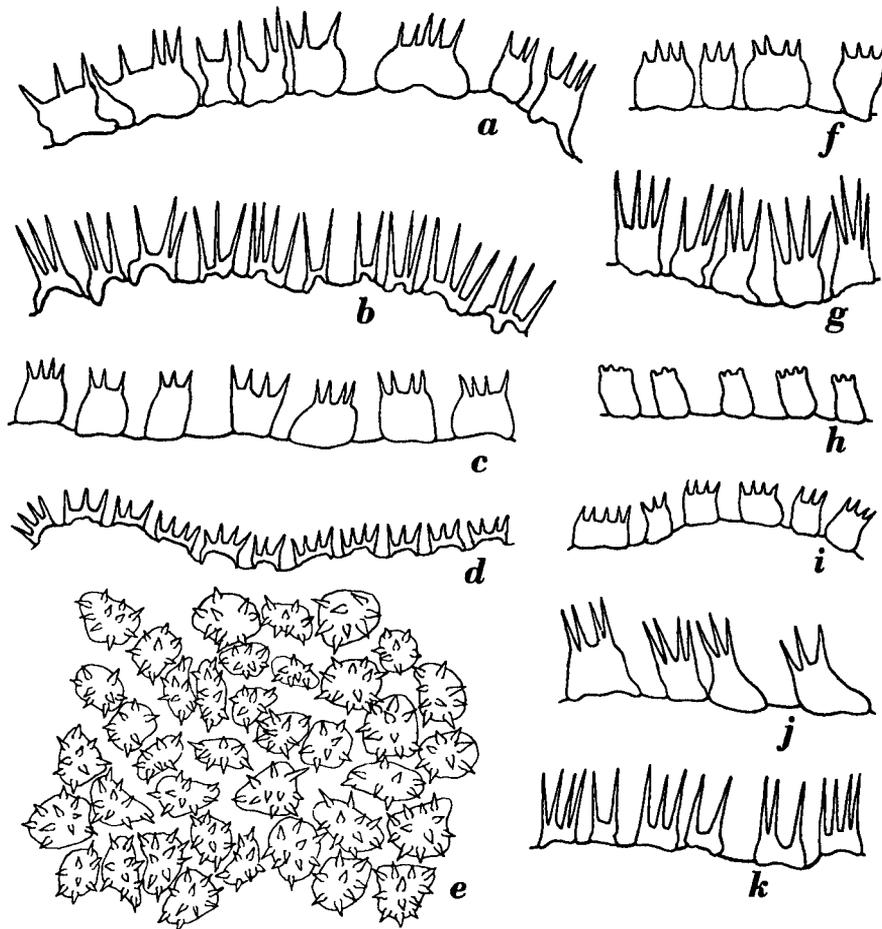


Fig. 3. *Sacculina reinhardi* nov. spec., type specimen. *a-d, f-k*, upper parts of sections of the external cuticle; *e*, excrescences of the external cuticle in surface view. $\times 530$.

Retinacula were not found on the parts of the internal cuticle examined, in all probability they do not occur in the species.

The excrescences of the external cuticle of *Sacculina reinhardi* bear a strong resemblance to those of *Sacculina gracilis*. The two species differ,

however, in their internal structure. Up to now nine specimens of *S. gracilis* have become known; these show constant characters in the structure of the male organs, in which there is a distinct region of transition of the vasa deferentia into the testes, in contradistinction to *S. reinhardi*. Moreover in *S. gracilis* the vasa deferentia invariably have a wide cavity, altogether different from the extremely narrow lumen in the vasa deferentia of *S. reinhardi*. As far as the colleteric glands are concerned, which principally are not unlike in the two species, the number of tubes is distinctly different, because in *S. gracilis* there are 6 to 10 tubes in a longitudinal section of the region of maximum division, while in *S. reinhardi* this number is 15 to 17, about twice the number in the other species. To emphasize the difference of the two species a few particulars are here added concerning hitherto unpublished data of certain specimens of *S. gracilis*.

Sacculina gracilis Boschma

The following list contains the localities and the hosts of the various described specimens of *Sacculina gracilis*, with the figures (in previous publications as well as in the present paper). The list shows that the structure of the colleteric glands of all the specimens is known. The structure of the male organs is accurately known in seven of the nine specimens; in the parasite on *Thalamita sima* from Singapore and in the parasite on *Thalamita* spec. from the Siboga Expedition the posterior parts of the body are rather severely damaged, so that not a complete series of transverse sections of the male organs is available; some sections, however, still contain parts of the male organs, proving that these conform to those in undamaged specimens.

Koh Kahdat (Thailand), 7-9 m, February 15-18, 1900, Dr. Th. Mortensen, 1 specimen on *Portunus* spec. (probably *Portunus (Hellenus) longispinosus* Dana var. *obtusidentata* Miers) (type specimen of *Sacculina gracilis* Boschma, 1931 a, p. 329). Figures: Boschma, 1931 a, fig. 7 h (external shape), fig. 23 (longitudinal section), fig. 24 a-e (external cuticle); present paper, fig. 4 a-d (male organs), fig. 6 e, f (colleteric gland). Measurements: $5 \times 2\frac{1}{2} \times 1\frac{1}{2}$ mm.

Koh Kam (Thailand), 15 m, February 6, 1900, Dr. Th. Mortensen, 1 specimen on *Thalamita sima* H. Milne Edwards (*Sacculina gracilis* Boschma, 1931 a, p. 330). Figures: Boschma, 1931 a, fig. 24 f-h (external cuticle); present paper, fig. 4 e-h (male organs), fig. 6 a, b (colleteric gland). Measurements: $4 \times 2\frac{1}{2} \times 1\frac{1}{2}$ mm.

Siboga Expedition, Sta. 240, Banda, reef, November 22—December 1, 1899, 1 specimen on *Lithocheira setosa* (A. Milne Edwards) (type specimen of *Sacculina formosa* Boschma, 1931 b, p. 34). Figures: Boschma, 1931 b, fig. 5 h (external shape), fig. 20 (longitudinal section), fig. 21 (external cuticle); present paper, fig. 5 e-h (male organs), fig. 6 c, d (colleteric gland). Measurements: $4 \times 2 \times 1$ mm.

Snellius Expedition, Island Sissie near Misool, shore or reef, October 6, 1929, 1 specimen on *Thalamita investigatoris* Alcock (young crab, therefore identification

not absolutely certain) (*Sacculina gracilis* Boschma, 1951 a, p. 10). Figures: Boschma 1951 a, fig. 1 a (external shape), fig. 2 (external cuticle), fig. 6 (male organs), fig. 7 a-c (colleteric gland). Measurements: $6 \times 4 \times 1\frac{1}{2}$ mm.

Siglap, Singapore, 1933, M. W. F. Tweedie leg. 1 specimen on *Thalamita simpsoni* A. Milne Edwards (*Sacculina gracilis* Boschma, 1951 a, p. 10). Figures: Boschma, 1951 a, fig. 1 b (external shape), fig. 3 (external cuticle), fig. 7 d (colleteric gland); present paper, fig. 5 a-d (male organs). Measurements: $6\frac{1}{2} \times 4 \times 2\frac{1}{2}$ mm.

Siglap, Singapore, July 1934, M. W. F. Tweedie leg., 1 specimen on *Thalamita sima*

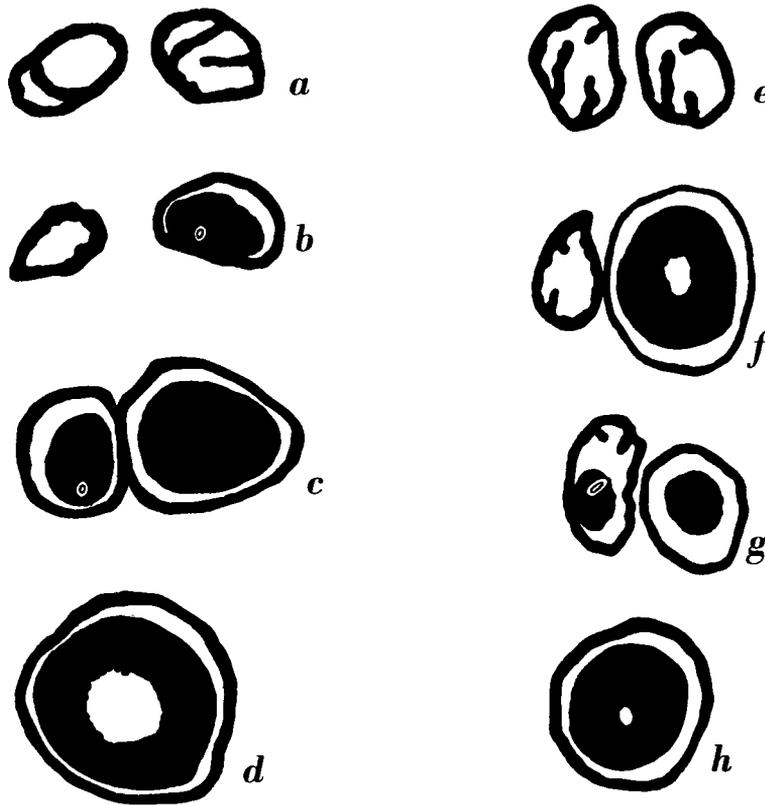


Fig. 4. *Sacculina gracilis* Boschma, transverse sections of the male organs of two specimens, from ventral to dorsal region. a-d, type specimen on *Portunus longispinosus* Dana; e-h, specimen on *Thalamita sima* H. Milne Edwards from Thailand. $\times 80$.

H. Milne Edwards (*Sacculina gracilis* Boschma 1951 a, p. 10). Figures: Boschma, 1951 a, fig. 1 c (external shape), fig. 4 (external cuticle), fig. 7 f (colleteric gland). Measurements: $8 \times 4 \times 1\frac{1}{2}$ mm.

Siboga Expedition, Sta. 164, south of Salawati, $1^{\circ} 42'.5$ S, $130^{\circ} 47'.5$ E, 20 m, August 20, 1899, 1 specimen on *Thalamita* spec. (*Sacculina gracilis* Boschma, 1951 a, p. 10). Figures: Boschma, 1951 a, fig. 1 d (external shape), fig. 5 (external cuticle), fig. 7 e (colleteric gland). Measurements: $6 \times 4 \times 2\frac{1}{2}$ mm.

China, 1 specimen on *Ser fukiensis* Rathbun, S. F. Light coll. (United States National Museum, acc. no. 83534) (*Sacculina gracilis* Boschma, 1951 b, p. 111). Figures: Boschma,

1951 b, fig. 1 *a* (external shape), fig. 2 *a-c* (male organs), fig. 3 *a-c* (colleteric gland), fig. 4 (external cuticle). Measurements: $12\frac{1}{2} \times 8 \times 4\frac{1}{2}$ mm.

"Albatross", Sta. 5159, Tawi Tawi Group, Sulu Archipelago, 18-21 m, February 21, 1908, 1 specimen on *Notonyx vitreus* Alcock (United States National Museum, acc. no. 53256) (*Sacculina gracilis* Boschma, 1951 b, p. 111). Figures: Boschma, 1951 b, fig. 1 *b* (external shape), fig. 2 *d-g* (male organs), fig. 3 *d, e* (colleteric gland), fig. 5 (external cuticle). Measurements: $4 \times 3 \times 2$ mm.

The figured transverse sections of the male organs of four specimens (figs. 4 and 5) show that these organs are of a more or less uniform

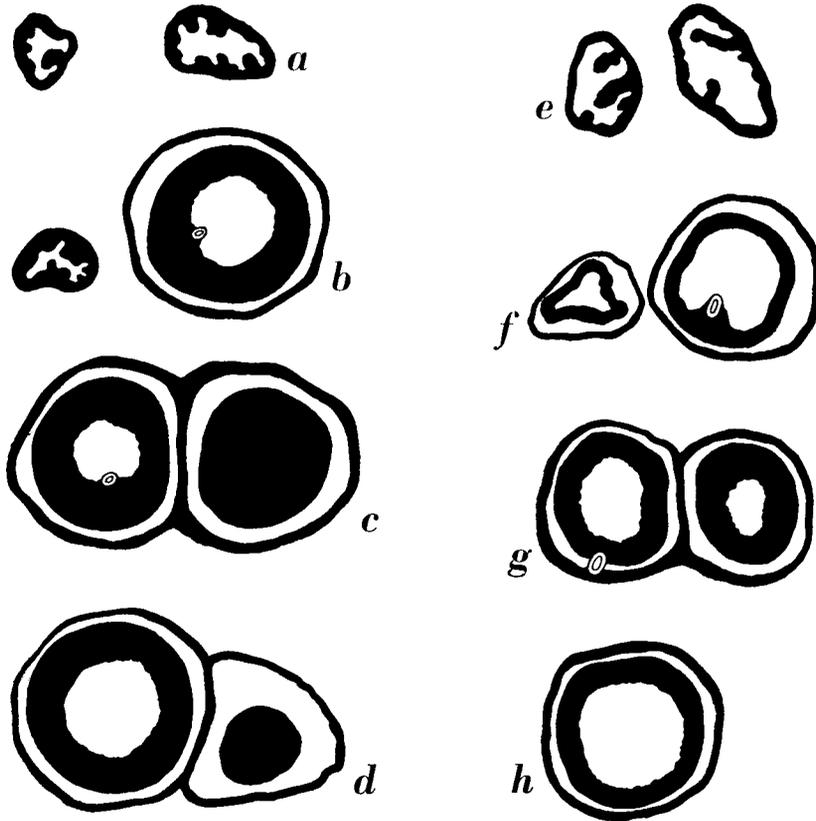


Fig. 5. *Sacculina gracilis* Boschma, transverse sections of the male organs of two specimens, from ventral to dorsal region. *a-d*, specimen on *Thalamita simpsoni* A. Milne Edwards; *e-h*, specimen on *Lithocheira setosa* (A. Milne Edwards). $\times 64$.

structure. Invariably the vasa deferentia are comparatively wide, while their inner walls have some ridges extending into the cavities (figs. 4 *a, e*, 5 *a, e*). Each vas deferens is connected with its testis by a narrow chitinous tube (figs. 4 *b, c, g*, 5 *b, c, f, g*). The testes are distinctly wider than the vasa deferentia, and as a rule have wide cavities (figs. 4 *d, h*, 5 *d, h*).

Generally the male organs of the two sides of the body have an approximately similar shape and size. The figures need no further comment because they closely correspond with those of previously described specimens of *Sacculina gracilis*.

Fig. 6 shows the tubes of the colleteric glands of three specimens, the chitinous products of the glands in the first and in the third specimen, the epithelium producing the chitinous structures (represented as black contours of the tubes) in the second specimen, in which at the time of preservation of the parasite the tubes had not yet produced chitin. The colleteric glands of the three specimens correspond in having a very small number

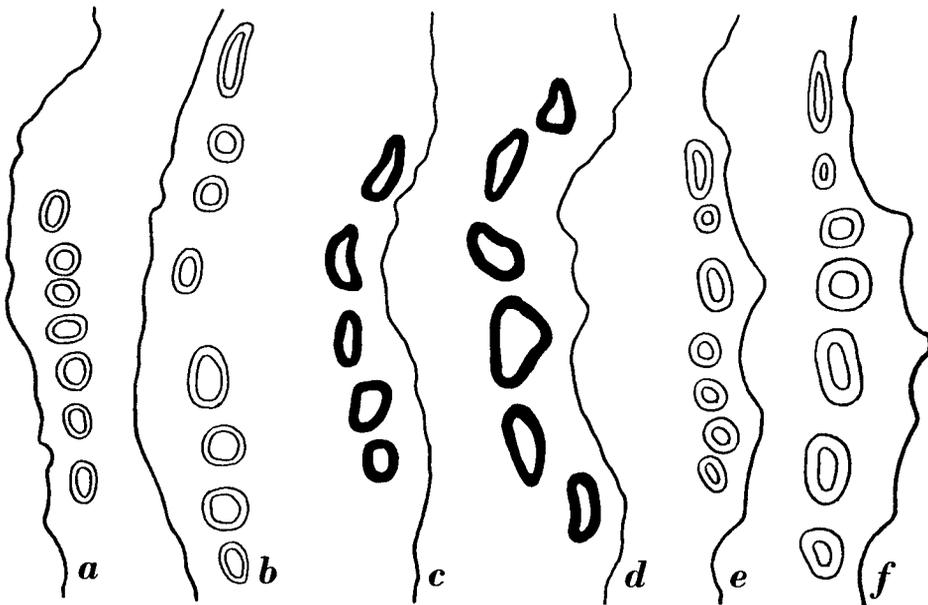


Fig. 6. *Sacculina gracilis* Boschma, longitudinal sections of colleteric glands of three specimens. *a, b*, specimen on *Thalamita sima* H. Milne Edwards from Thailand; *c, d*, specimen on *Lithocheira setosa* (A. Milne Edwards); *e, f*, specimen on *Portunus longispinosus* Dana. $\times 190$.

of tubes, arranged in a single row along the surface of the gland, the maximum number of tubes in a section being 8 (fig. 6 *b*), 6 (fig. 6 *d*), and 7 (fig. 6 *e, f*), respectively. In the colleteric glands of the other specimens of *S. gracilis*, described in previous papers, the maximum number of tubes in a longitudinal section of the region of strongest division is 9 (specimen on *Thalamita investigatoris*), 10 (specimen on *Th. stimpsoni*), 8 (specimen from Singapore on *Th. sima*), 7 (specimen on *Thalamita spec.*),

10 (specimen on *Ser fukiensis*), and 8 (specimen on *Notonyx vitreus*), respectively.

The characters of the male organs and those of the colleteric glands, therefore, are fairly constant, even when the peculiarities of specimens infesting widely different hosts are compared. The same holds true for the variation of the excrescences of the external cuticle. *Sacculina reinhardi*, which has cuticular structures like those of *S. gracilis*, must be considered a distinct species on account of the peculiarities of its internal organs, the male organs of *S. reinhardi* being fundamentally unlike the corresponding parts of *S. gracilis*, and the colleteric glands having a much larger number of tubes.

Not too much importance should be attached to the number of tubes in the colleteric glands, for in many species of Sacculinidae it is a well known fact that this number increases in correlation with the size of the specimens. In this connexion, however, it is interesting that in the largest known specimen of *Sacculina gracilis* (the parasite of *Ser fukiensis*), with a larger diameter of 12½ mm, the maximum number of tubes in a longitudinal section is 10. The number of 17 tubes in a section of the colleteric glands of the type specimen of *S. reinhardi*, the larger diameter of which is 7 mm, indicates that in this instance in all probability the different number of tubes indeed is a specific character.

Sacculina muricata Boschma

U. S. Bureau of Fisheries, "Albatross" Sta. 3698, off Honshu Island, Japan, 153 fms., May 5, 1900, 1 specimen on *Pugettia brevirostris* (Doflein), U. S. National Museum, catalogue number 49556.

The shape of the specimen is irregularly hexagonal (fig. 1 *b*), its dimensions are: dorso-ventral diameter 12 mm, antero-posterior diameter 9 mm, and thickness 5 mm. The surface of the mantle has a few wrinkles and grooves among which especially one in the median line of the right side is pronounced, being caused by pressure of the ventral ridge of the abdomen of the host against the parasite. The mantle opening lies at the top of a short tube, in the middle of the anterior region.

Longitudinal sections show that the male organs lie in the visceral mass, commencing in the region next to the stalk (fig. 7 *a*) and continuing their course towards the dorsal region along the mesentery (fig. 7 *b-d*). The vasa deferentia are thick-walled canals with rather narrow cavities (fig. 7 *a, b*); gradually they pass into the testes, which have a wider cavity (fig. 7 *c, d*). The exact region of transition of the vasa deferentia into the testes is not to be determined because there are no chitinous structures on the inner walls

of the ventral parts of the vasa deferentia. The testes are surrounded by a well developed muscular layer which does not continue ventrally around the vasa deferentia, this layer does not end abruptly around the ventral extremities of the testes, but gradually diminishes in the region of transition of the two parts of the male organs. For the whole of their extent the male organs remain completely separated.

The colleteric glands contain a rather compact mass of tubes, 73 are to be counted in a longitudinal section of the most strongly divided region (fig. 7 *e*). In the here described specimen the tubes do not contain chitin, so that the epithelium of the tubes has been drawn.

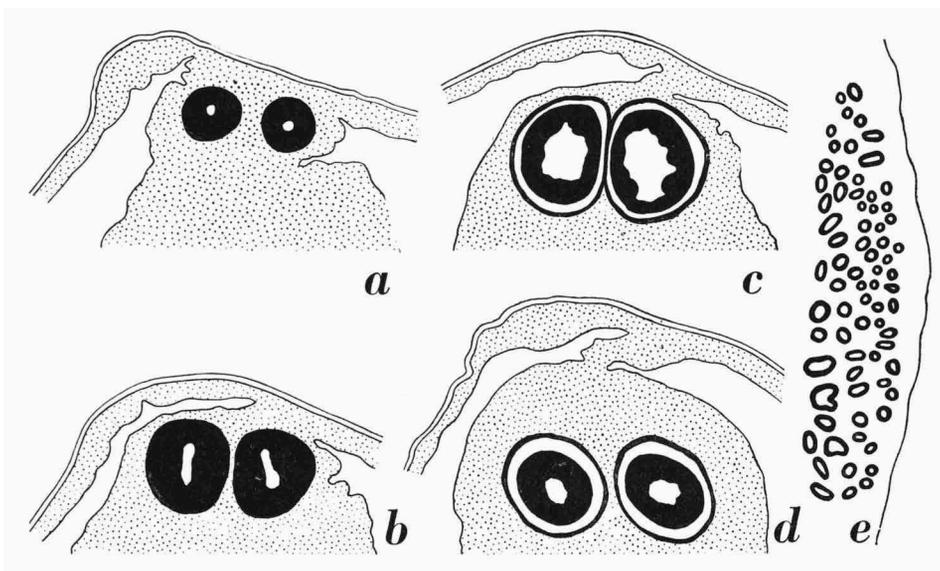


Fig. 7. *Sacculina muricata* Boschma, specimen on *Pugettia brevis* (Doflein). *a-d*, posterior parts of longitudinal sections, *a* containing the ventral parts of the vasa deferentia, each following section farther towards the dorsal region; *e*, longitudinal section of one of the colleteric glands, *a-d*, $\times 30$; *e*, $\times 53$.

The external cuticle of the mantle is of variable thickness, generally from 16 to 35 μ . Its surface bears pointed papillae in rather thick masses (fig. 8 *a-c*); the papillae do not bear lateral hairs, they have a length of 7 to 12 μ .

The internal cuticle of the mantle bears numerous retinacula in fairly regular distribution (fig. 8 *d*). Each retinaculum consists of a circular basal part and 8 to 14 spindles (fig. 8 *e*). The spindles have a length of 12 to 18 μ , they do not show distinct barbs.

The parasite of *Pugettia brevis* (Doflein) described above is iden-

tified with *Sacculina muricata* Boschma, though in certain respects it differs from the type specimen, a parasite of *Sphenocarcinus simpsoni* Miers (*Oxypleurodon simpsoni*). The hosts both belong to the family Majidae. The specimen on *Pugettia brevirostris* was collected off Honshu (or Hondo) Island at a depth of 280 m, the type specimen came from the Sagami Sea, adjoining Honshu Island, from a depth of 720 m.

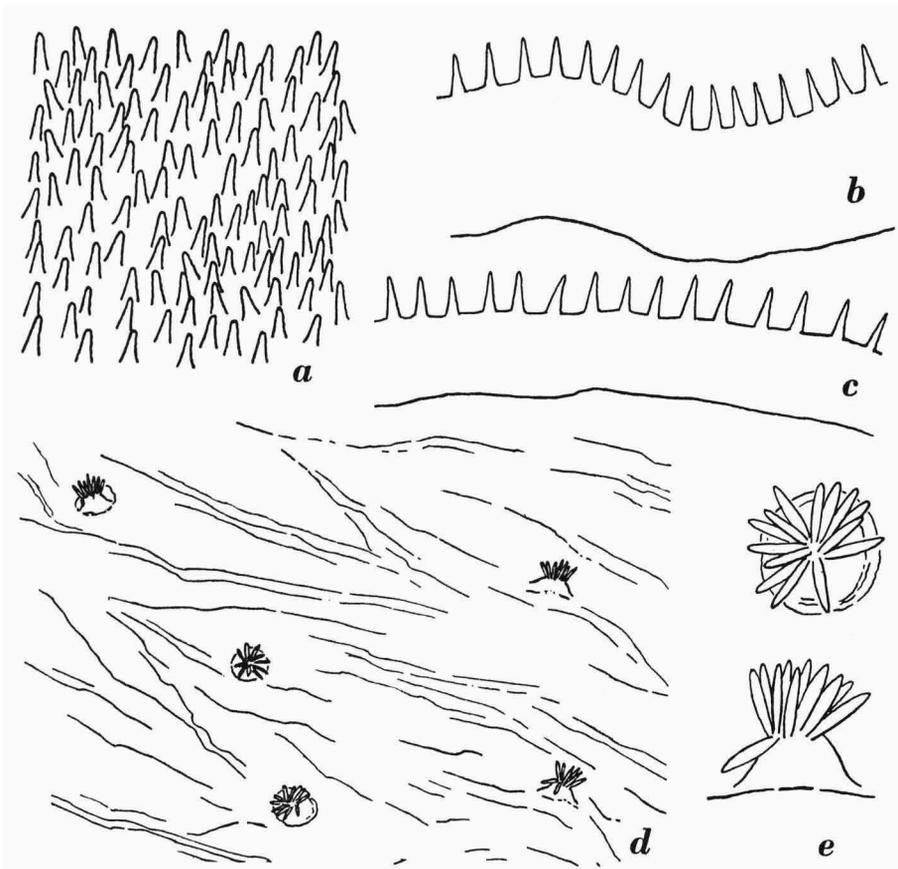


Fig. 8. *Sacculina muricata* Boschma, specimen on *Pugettia brevirostris* (Doflein). *a*, excrescences of the external cuticle in surface view; *b*, *c*, sections of the external cuticle; *d*, internal cuticle with retinacula; *e*, two retinacula. *a-c*, *e*, $\times 530$; *d*, $\times 170$.

The dimensions of the type specimen are $6\frac{1}{2} \times 4\frac{1}{2} \times 4$ mm, those of the here described specimen $12 \times 9 \times 5$ mm, showing that the latter is nearly twice as large as the former, which may account for some of the differences between the two specimens.

In their external appearance the two specimens are not strikingly dif-

ferent, though the type specimen (Boschma, 1931 a, fig. 7 *f*) has a smooth surface not presenting the wrinkles and grooves of the specimen of fig. 1 *b* of the present paper.

The chief differences of the two specimens are those of the male genital organs. In the type specimen (Boschma, 1937, fig. 64) the vasa deferentia have comparatively wide cavities, while in parts of the testes there are insignificant ridges extending into the cavities, the male organs in the whole of their length having thinner walls than in the specimen of fig. 7 of the present paper. Moreover, in the type specimen the muscular sheath of each of the testes is comparatively wide, not so closely joining the testes as in the other specimen.

The colleteric glands of the two specimens have a corresponding structure. In the specimen on *Spenocarcinus* there are up to 57 tubes in a longitudinal section (Boschma, 1937, fig. 65), in the specimen on *Pugettia* up to 73 (fig. 7 *e* in the present paper). This difference to all appearances is directly correlated with the size of the two specimens. The situation of the colleteric glands in the visceral mass is, however, different in the two specimens: in the parasite of *Pugettia* the glands occur approximately in the centres of the lateral surfaces of the visceral mass, while in the specimen on *Sphenocarcinus* they lie in the anterior part.

The excrescences of the external cuticle are entirely similar in the two specimens, having approximately the same length, 7 to 12 μ (Boschma, 1931a, fig. 11 *a, b*; fig. 8 *a-c* in the present paper).

The retacula of the type specimen have 5 to 8 or more spindles of a length of 10 to 14 μ (Boschma, 1931 a, fig. 11 *c, d*), those of the other specimen have 8 to 14 spindles of a length of 12 to 18 μ . The general structure is similar, so that the differences may be due to individual variation.

Notwithstanding certain differences the two specimens at least provisionally may be regarded as conspecific, the question may become definitely settled if additional material of parasites of the two crabs becomes available.

Among the specimens dealt with in the present paper there are two parasites of the crab *Pugettia brevirostris* (Doflein) from Japanese waters, belonging to two different species. It is interesting that in one locality, Seto, the crab *Pugettia quadridens* (De Haan) was found to be infested by two species of Sacculinidae, *Sacculina pilosella* Van Kampen and Boschma and *S. pugettiae* Shiino (cf. Shiino, 1943, pp. 11 and 23). The differences between the four species are at once apparent by examination of the external cuticle, which is devoid of excrescences in *S. pugettiae*, bears distinct

papillae in *S. muricata*, and has hyaline excrescences in *S. pilosella* and in *S. reinhardi*, those of *S. reinhardi* having a length of 8 to 23 μ , those of *S. pilosella* measuring 33 to 50 μ (cf. Shiino, 1943, fig. 7 C).

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