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(Sarsiellidae)*

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ABSTRACT

Morphology, biology, and variability of a new genus with four new species are described from collections of deep-sea ostracods obtained by the Lamont Geological Observatory and Woods Hole Biological Laboratory in the Atlantic, Antarctic, and Indian Oceans. Adult females far outnumber males in collections, but juvenile males and females are present in equal numbers indicating that adult males are short lived. Microtome sections of male and female genitalia document that the male transfers sperm to the female in ovoid spermatophores which are attached externally. Examination of stomachs shows that members of the new genus are carnivores—feeding on copepods, ostracods, and nematodes. Apparently adult males do not eat. A key is presented for identification of early instar stages by means of examination of sixth and seventh limbs.

Introduction

Collections of deep-sea ostracods obtained by the Lamont Geological Observatory, Columbia University,

and the Woods Hole Marine Biological Laboratory contained a new genus belonging to the family Sarsiellidae in samples from five localities (Figure 1). Data concerning localities and collections follow:

Station	Latitude-Longitude	Ocean	Depth (meters)	Date	Number of specimens
V-14-24	56°37' S, 34°48' W	Antarctic	3500 *	7-8 March 1958	1
V-15-131	40°14.6' S, 55°24.7' W	South Atlantic	1475 *	3 April 1959	76
V-18-13	47°10' S, 61°02' W	South Atlantic	135 *	17 February 1962	1
V-16-15	45°00' S, 45°46' E	southern Indian	1622 *	8 January 1960	1
118A	32°19.2' N, 64°36.8' W	North Atlantic	1135-1153 ^b	18 August 1966	353

* Small bottom trawl.

^b Epibenthic trawl.

Since three of the samples contained only one specimen of the new genus and the specimens at the remaining stations showed great variation, it was difficult to determine whether differences between them were individual or specific. In order to establish a basis for such a judgment, a detailed analysis was made of the specimens from station 118A, which clearly belonged to a single species. Using the variation found in this species as a guide, it was determined that the collections contained four new species, which are described herein.

I wish to thank Dr. Horton H. Hobbs, Jr., for help in interpreting the anatomy of genital organs from both whole mounts and microtome sections, and Drs. Robert J. Menzies, Meredith L. Jones, Neil C. Hulings for supplying specimens upon which this study was based. The specimens were collected on vessels of the Lamont Geological Observatory, Columbia University, and the

Woods Hole Marine Biological Laboratory. Criticisms of parts of the manuscript by Drs. Thomas E. Bowman and Roger F. Cressey, Jr., are most appreciated. I also thank Mrs. Carolyn Bartlett Gast for final preparation of figures from my camera lucida pencil drawings and for entire preparation of Plates 1 and 6, and Mrs. Vernetta Williams for preparing stained sections.

Methods

IDENTIFICATION OF EARLY INSTAR STAGES.—The usual method for determining the number of instars in the ontogeny of a species of ostracod in a collection is to make a scattergram of carapace length versus carapace height on arithmetic graph paper. Normally, instars of the same developmental stage form a cluster of points sufficiently distant from clusters formed by other instar stages to be able to determine the number of stages in the sample. It is generally possible to rec-

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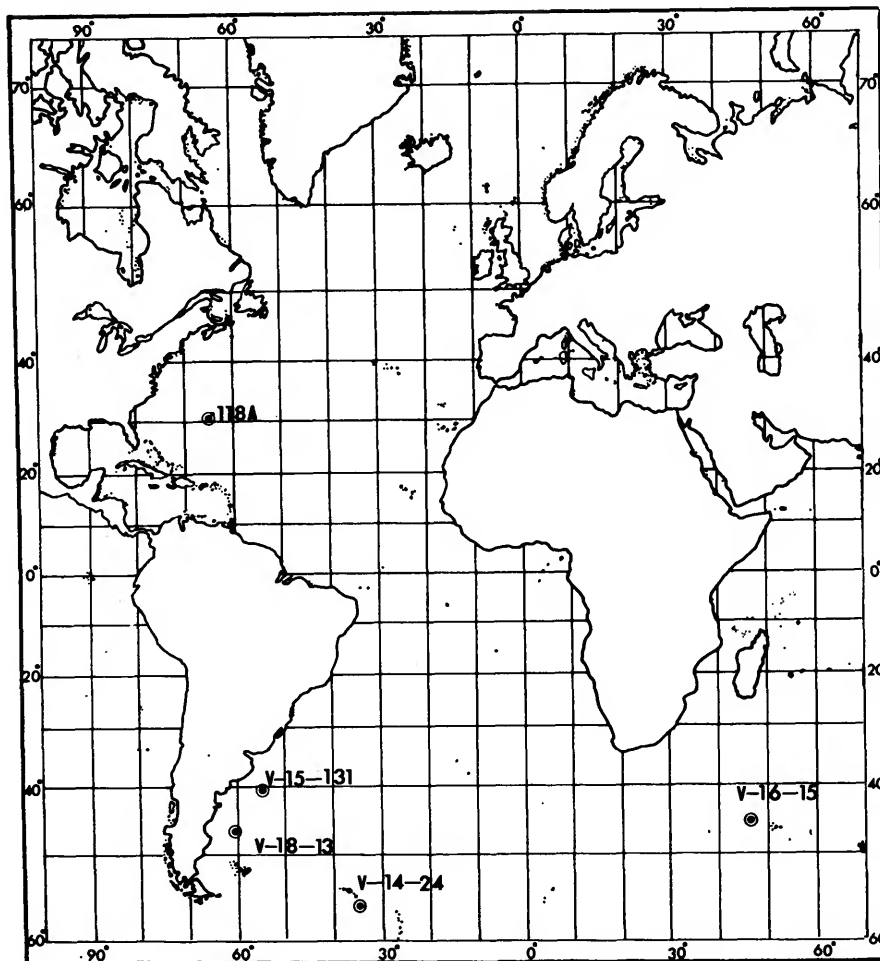


FIGURE 1.—Stations of research vessels *Vema* and *Atlantis II*, where ostracods reported herein were collected.

ognize that an instar is missing from a collection if the spacing between any two clusters is inordinately wide, compared to spacings between other clusters. On the other hand, it is very difficult to determine whether the population in nature contains earlier instar stages than those represented in the collection. This is a problem because the small size of the earlier instars often results in their being missed by the sampling device or overlooked in the picking operation.

If the number of instar stages of a species is known, it can be established whether all stages are present in a collection. This is not possible, however, in many

groups, including myodocopid ostracods, in which the number of instar stages seems to vary from species to species and is known with certainty for few species.

During a study of variation of morphology of instars of *S. sandersi*, it was observed that the morphology of the 6th and 7th limbs developed in a consistent and predictable manner while progressing from instar I to instar IV. A key was then constructed for use in identifying early instar stages. This key, when tested against other myodocopids reported in the literature, was found also to apply to them with three exceptions (to be discussed later). Use of the key, given below,

Key to Early Myodocopid Instars

1. 6th limb without bristles, 7th limb absent Instar I
6th limb with one or more bristles, 7th limb present 2
2. 6th limb with one bristle Instar II
6th limb with more than one bristle (usually many) 3
3. 7th limb without bristles * Instar III
7th limb with bristles Instar IV–Instar N

* In some genera of Sarsiellidae the males, which are relatively sparse, do not have bristles on the 7th limb during any developmental stage. For these forms it is necessary to use other criteria such as the morphology of the endopodite of the 2nd antenna to determine whether the specimen belongs to instar III or IV.

should save an investigator considerable time and effort by permitting him to identify the stage of development of specimens without having to resort to scattergrams.

Data from the literature presented in Table 1 strengthen the assumption that the above key may be applied to myodocopid genera other than *Spinacopia*. This table shows that *Cypridina pectinata*, *Philomedes globosus*, and *Sarsiella zostericola* apparently do not fit in the above key. Consideration of the evidence upon which the authors based their interpretation of the number of instars in these three species leads me to believe that they are in error and that the key does indeed also apply. For example, Skogsberg (1920) found his earliest stage of *P. globosus* within the brood chamber of a female, the next stage was not present in his collection and its presence is based on theoretical growth factors, and the following stage is according to Skogsberg (p. 139) “. . . the youngest freely living stage I found.” I believe that Skogsberg’s “earliest stage” is an embryo and not an instar in the sense used in the present paper, and the third stage, “youngest freely living stage,” is actually instar I (Skogsberg numbered his instars in reverse to the system used herein so that my instar I is his instar VII). Strong support for this interpretation comes from the work of Elofson (1941), who raised *Philomedes globosus* in aquaria and found only five juvenile instar stages. He stated (p. 369) that he did not find Skogsberg’s stages VIII–VI (the two earliest stages reported by Skogsberg). Certainly, the best method for determining instar stages is by raising ostracods in aquaria. Considerable weight must be given to the conclusion by Elofson that *Philomedes globosus* has five juvenile instar stages, which is the same number derived by using the above key.

The only argument to support my contention that the two earliest instars of *Cypridina pectinata* described by Skogsberg (1920) should both be included

in the instar I stage is that it seems unlikely that the 6th and 7th limbs would be identical in two early instars; some development should take place. Additional data for this species as well as other myodocopid species are needed to test the validity of the key.

The third species in Table 1 that does not fit the key is *Sarsiella zostericola*. Kornicker (1967) estimated that instars I and II were missing from his sample and described instars III, IV, and V, as well as the adult. According to the above key, only instar I was missing from the sample and his descriptions are of instars II, III, IV, and the adult. In order to estimate the number of growth stages missing from his sample, Kornicker divided the average shell length of the earliest stage in the sample by 1.26 (Przibram’s theoretical growth factor for a linear dimension). The resulting dimensions were concluded to be the approximate average length of the next earlier growth stage. This procedure was repeated until an instar length was obtained approaching the length of an embryo acquired from the brood chamber of a female. The method is in common usage and similar to that used by Skogsberg (1920) for determining early growth stages for *Philomedes globosus*. Concerning the estimate that instars I and II were missing from the sample, Kornicker (p. 7) stated, “The conclusion must be considered tentative because of the many factors that cause the growth rate to deviate from the theoretical (Tessier, 1960, p. 541).” The evidence now indicates that only instar I was missing from the sample. Additional support for this conclusion comes from Elofson (1941, p. 367) who listed the length of the egg (carried within the brood chamber) of *Philomedes globosus* as 0.49–0.56 mm and the length of the freshly hatched larva as 0.80 mm. By dividing larval length by the length of the smallest egg and then the largest egg, a “growth” factor range of 1.63–1.57 is obtained. If the estimated

TABLE 1.—Number of bristles on 6th and 7th limbs of juvenile instars

Juvenile instar stage	<i>Gigantocypris agassizi</i> ^a		<i>Gigantocypris muelleri</i> ^a		<i>Gigantocypris danae</i> ^a		<i>Macrocypridina castanea</i> ^a	
	6th limb	7th limb	6th limb	7th limb	6th limb	7th limb	6th limb	7th limb
I	0	limb absent	0	limb absent	0	limb absent	0	limb absent
II	instar missing		1	0	1	0	1	0
III	1+	0	1+	0	instar missing		1+	0
IV	1+	1+	1+	1+	1+	1+	1+	1+
V	1+	1+	1+	1+	1+	1+	1+	1+
VI	instar missing		1+	1+	instar missing			
VII								
Total estimated by original author		6		6		6		5
Total estimated herein		6		6		6		5

Juvenile instar stage	<i>Cypridina pectinata</i> ^b		<i>Philomedes globosus</i> ^b		<i>Sarsiella zostericola</i> ^c		<i>Spinacopia sandersi</i>		<i>Spinacopia variabilis</i>	
	6th limb	7th limb	6th limb	7th limb	6th limb	7th limb	6th limb	7th limb	6th limb	7th limb
I	0	limb absent	limb absent	limb absent ^d			0	limb absent	instar missing	
	0	absent	instar missing	absent	instar missing					
II	1	0	1	0	1	0	1	0	1	0
III	1+	0	1+	0	1+	0	1+	0	instar missing	
IV	1+	1+	1+	1+	1+	1+	1+	1+	1+	1+
V	1+	1+	1+	1+						
VI										
VII										
Total estimated by original author		6		7		5				
Total estimated herein		5		5		4		4		4

^a E. Poulsen, 1962.^b T. Skogsberg, 1920.^c L. S. Kornicker, 1967.^d Instar removed from brood chamber of female.

length of the missing instar I listed by Kornicker (1967, p. 7) is divided by the embryo length (obtained from within brood chamber of female) a "growth" factor of 1.09 is the result. The factor of 1.09 may be much too small. If the average "growth" factor (1.52) of *Philomedes globosus* is applied to the *S. zostericola* embryo, a dimension of 0.48 mm results, which is close to instar II (0.44 mm) of Kornicker (p. 7). It is, of course, hazardous to apply factors obtained from one species to another, but the data help to arrive at the

conclusion that only instar I was absent from the samples studied by Kornicker.

The data used herein indicate that the total number of juvenile instars in the myodocopa is four to six, with four instars in the Sarsiellidae (N=3 species), five in the Philomedinidae (N=1 species), and five or six in the Cypridinidae (N=5 species) (Table 2). It is suggested by the present study that the total number of instars in a species does not affect appendage morphology of the first three stages.

TABLE 2.—Number of juvenile stages

Taxon	Juvenile instars
Cypridinidae	
<i>Gigantocypris agassizi</i>	6
“ <i>muelleri</i>	6
“ <i>danae</i>	6
<i>Macrocypridina castanea</i>	5
<i>Cypridina pectinata</i>	5
Philomedinidae	
<i>Philomedes globosus</i>	5
Sarsiellidae	
<i>Sarsiella zostericola</i>	4
<i>Spinacopia sandersi</i>	4
“ <i>variabilis</i>	4

PREPARATION OF SPECIMENS.—Standard microtome sections stained with Mallory's triple stain were used in the study of genitalia. In these preparations the head of sperm stains yellow orange and the midpiece from which the flagellum arises stains light blue. Secretion in the seminal vesicle of the male and in the spermatophore attached to the female stains red. Smear preparations were made of testes, seminal vesicle, and spermatophores by mashing them in aceto-carmine under a cover glass. In these, the head of sperm stains pink and the midpiece is without color.

Biology

RELATIVE ABUNDANCE OF MALES AND FEMALES.—Adult males are generally sparse among the Sarsiellidae. Müller (1894) pointed out that the maxilla and 5th limb of the male are unsuitable for gathering food. Sample 118A contains 32 adult males and 123 adult females of *S. sandersi*; adult females outnumber males by 3.8 to 1. I examined the gut of three males and found them empty, thus supporting Müller's contention that adult males do not eat. If this is so, it seems likely that males are less abundant than females because of having a shorter life span. Probably, they die soon after fertilizing the female.

Data concerning the relative abundance of sexes among juvenile instars might be useful in establishing the reason for adult males being sparse in nature. For example, if males are also sparse in juvenile stages, as suggested by the few data presented by Kornicker (1967, p. 7) for *Sarsiella zostericola*, the sex-ratio pattern would have been established prior to the male's reaching the adult stage, and, therefore, length of the life of the male could not be a major reason for its being sparse. Data in the literature concerning the

distribution of sexes in juvenile instars of the Sarsiellidae are lacking, except for that of Kornicker and Wise (1962) and Kornicker (1967), in which samples were too small to have statistical value; therefore, the sex was determined herein for 35 specimens of *S. sandersi* at the instar IV stage of development.

In order to be able to treat the results statistically, seven subsamples of four to six specimens each were picked at random from the collection and the percent of males calculated (Table 3). The average percentage of males in all subsamples is 54.5. The percent of males in the population at 0.95 probability is within the range 40–68.

The presence of about the same number of males and females at the instar IV stage of development supports the hypothesis that adult males are short lived. An alternate hypothesis that adult males might live in a different locality than adult females is discounted because of the absence of records of collections of sarsiellids in which males are more abundant than females.

TABLE 3.—Distribution of sexes in instar IV

Subsample	Total specimens	Males	Females	Percent of males
1	6	4	2	66.7
2	4	3	1	75.0
3	5	2	3	40.0
4	5	2	3	40.0
5	5	2	3	40.0
6	5	2	3	40.0
7	5	4	1	80.0

Average percent of males (\bar{x}) = 54.5

N = 7

S. D. = 18.52

2 S. E. m = ± 14

Percent of males in population at 95% confidence = 40–68

REPRODUCTIVE SYSTEM (Figure 2).—Because the collections contain adult males only of *S. sandersi* the study of the reproductive system was made on this species. A similarity between the spermatophores attached to adult females of *S. sandersi* and the remaining three species studied indicates that the system described for *S. sandersi* probably also applies to the other species.

In brief, sperm is produced in two testes located on each side of the male above the penis. The sperm is transferred through a tubular vas deferens to a large bilobed seminal vesicle which also contains a secretion that stains red with Mallory's. A single penis with a

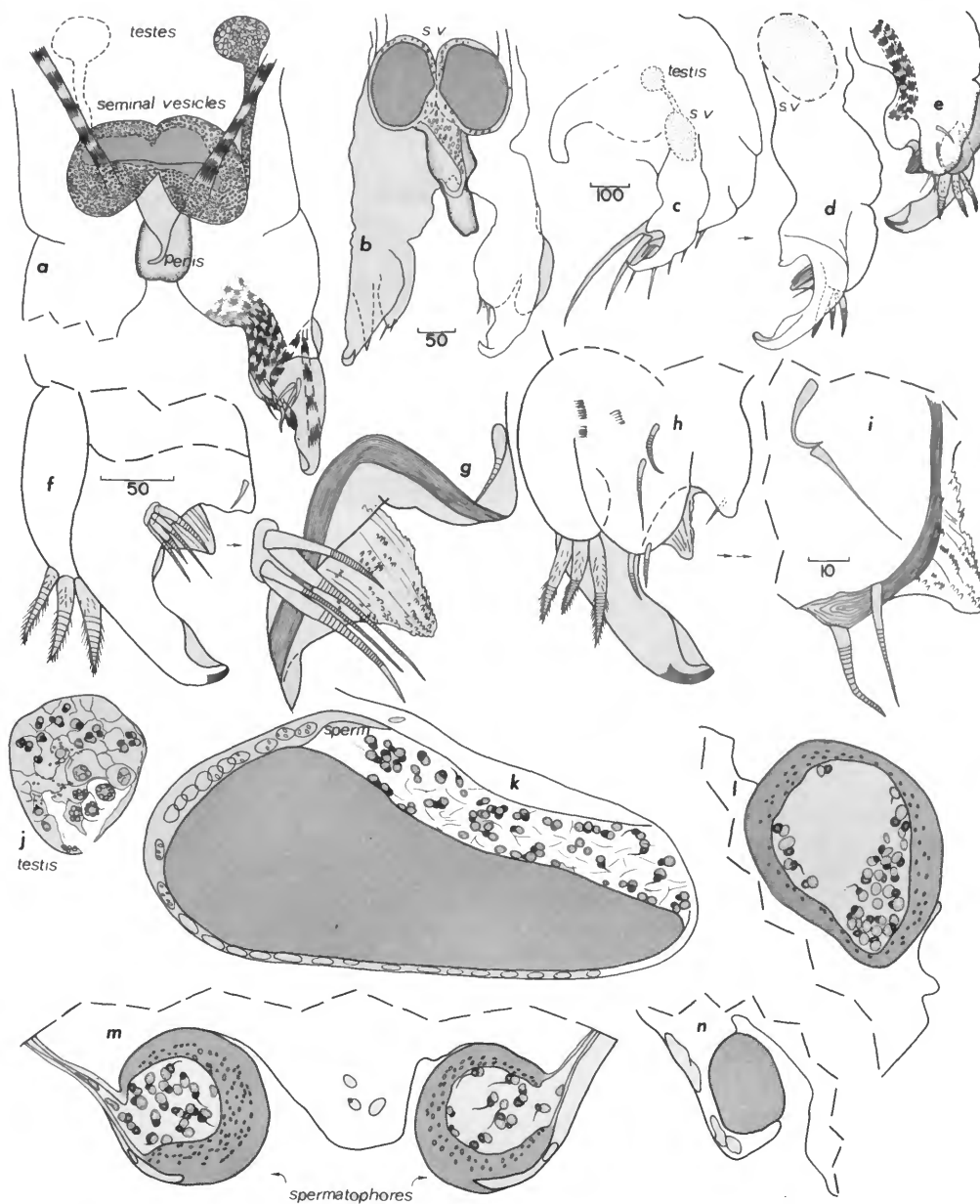


FIGURE 2.—*Spinacopia sandersi*, genitalia, adult ♂: a, copulation system, specimen 3; b, same, specimen 43; c, same, with furca, and outline of gut, specimen 3; d, detail of c; e, right copulatory organ, medial view, specimen 3; f, same, lateral view; g, detail of f; h, left copulatory organ, specimen 3, medial view; i, detail of h; j, section of right testis; k, section of seminal vesicle. Adult ♀, specimen 66, 4 eggs in marsupium: l, section through spermatophore; m, sections through specimen showing both spermatophores; n, section through end of spermatophore. (Same scale in microns: c; a, b, d, e; f, h; g, i-n.)

short curved ejaculatory duct hangs between the lobes of the seminal vesicle. On either side of the penis is a long complex clasping organ consisting of three lobes, one of which bears a terminal sclerotized hook and a triangular ridged tooth.

Two oval spermatophores each consisting of a sheath of secretion and containing sperm are found on most adult females; each is attached to a genital opening located on the left and right sides of the body above the furca. Presumably these have been extruded through the ejaculatory duct of the male and deposited on the female.

The spermatophores of *Spinacopia* resemble more closely spermatophores of *Cypridina mediterranea* described by Ramsch (1906) than the elongate spermatophores observed by Poulsen (1965, p. 116) entering the "receptaculum seminis" of *Eusarsiella longicornis* Poulsen.

The oviduct of the female of one specimen examined contained sperm only in the immediate vicinity of the spermatophore, suggesting that eggs are fertilized as they leave the oviduct. Additional studies are necessary to confirm this, however, because the proximal portion of the oviduct was not visible on the specimen, and the oviduct was obscure on several other specimens sectioned. The gravid females of *S. sandersi* contain up to four eggs in the marsupium, and some also have the same number in the ovaries. Females of *S. variabilis* contain as many as six eggs in the marsupium and seven in the ovaries. The single female of *S. menziesi* in the collection contains nine unextruded eggs in the ovaries. The single specimen of *S. bisetula* contains five eggs in the marsupium and four in the ovaries. Spermatophores are attached to females having eggs both in the marsupium and ovaries. This suggests that part of the genital opening is sufficiently free from the attached spermatophore to permit passage of eggs; however, it is also possible that new spermatophores are attached to the female after she deposits the first clutch of eggs in the marsupium.

A more detailed description of genitalia is presented in the description of males and females of *S. sandersi*.

FOOD AND DIGESTION.—Darby (1965) presented photographs of copepod remains in the gut of *Sarsiella greyi* Darby (1965, pl. 27: fig. 8). He also reported (1965, p. 35) several copepods in the stomach of *Sarsiella pilipollicus* Darby. Kornicker (1967, p. 32) reported a complete harpacticoid copepod in the gut of a juvenile female of *Sarsiella zostericola*, and the pres-

ence of a whole harpacticoid copepod, several arthropod appendages and a diatom in one specimen of *Sarsiella disparalis*, and two nematodes in another (p. 44).

Organisms found in the gut of several specimens of *Spinacopia* are shown on Plate 2 and are listed below:

Species	Stage	Sex	Gut content
<i>S. bisetula</i>	adult	♀	copepod fragments
<i>S. variabilis</i>	adult	♀	3 harpacticoid copepods, 1 nematode, 3 pellets
"	adult	♀	1 polycopid ostracod, copepod fragments
<i>S. sandersi</i>	adults (3 spec.)	♂	empty
"	instar I	?	1 polycopid ostracod, 3 copepods
"	instar II	?	1 copepod
"	"	?	1 podocopid ostracod
"	instar IV	♀	1 polycopid ostracod
"	"	♂	copepod remains

These data indicate that adult males of *Spinacopia* do not eat, and that juveniles of both sexes and adult females are extremely voracious. Their diet consists mainly of small arthropods (copepods, polycopid and podocopid ostracods) and worms (free living nematodes). The presence of foreign fecal pellets in the midgut and foregut region of a specimen suggests that *Spinacopia* swallows objects and organisms on the basis of size rather than type. The gut contains relatively little fine-grained material.

Apparently food is pushed into the mouth of *Spinacopia* by the coxale endite of the mandible and the spines and bristles of the maxilla. The size of organisms in the gut shows that the esophagus is capable of considerable dilation. Copepods, ostracods, and nematodes in the gut often are whole, indicating that *Spinacopia* does not have an internal mechanism for grinding food. Whole specimens in the gut appear to be cleaned of internal protoplasm, suggesting that digestive enzymes produced by *Spinacopia* do not affect the chitinous exoskeleton of arthropods or nematodes. The calcified shells of ingested ostracods remain brittle and do not seem to have been decalcified during the digestive process.

In one specimen a whole copepod was observed partway out the anus. Apparently, intact organisms with their viscera digested pass through the gut of *Spinacopia*. Finely divided material filled the rectal area of another specimen. This loose aggregation was roughly cylindrical but did not form a distinct pellet

such as that formed by *Cypridopsis vidua* (see Kesling, 1951, p. 7, fig. 3).

Although the data are few, they suggest that the Sarsiellidae are voracious carnivores that feed upon small benthic arthropods and worms. When sarsiellids are abundant—they are the dominant species in some localities—the effect of their voraciousness on the community must be considerable.

Family SARSIELLIDAE Brady and Norman, 1896

Spinacopia, new genus

TYPE-SPECIES.—*Spinacopia sandersi* Kornicker, described herein.

ETYMOLOGY.—The generic name "Spinacopia," from the Latin "spina" = thorn and "copia" = abundance. Gender: feminine.

DIAGNOSIS OF GENUS.—Shape: Carapace oval with greatest height near middle in female and posterior to middle in male; shallow incisur present on both male and female; rostrum of male more prominent than on female.

Ornamentation: Punctate or smooth and with abundant hairs and scattered normal pores.

Infold: Infold of female characterized by having 5 stout spinous bristles forming row in front of caudal process (6 bristles observed on single valve of 1 specimen); 3–8 smaller spinous bristles present below larger bristles; infold in front of caudal process of single male observed with only 4 large spinous bristles and 2 or 3 smaller bristles; both female and male with single bristle below rostrum.

Size: Length of mature females of 4 species ranges from 1.71 to 2.75 mm; height as percent of length ranges from 80.2 to 94.1. Male slightly smaller and much narrower than female; height as percent of length 69.4.

First antenna: Second joint with 1 dorsal bristle, 3rd joint with usual ventral and dorsal bristles; 4th joint with 1 dorsal and 2 or 3 ventral bristles; sensory bristle of 5th joint on both male and female normal for family; medial bristle of 6th joint of female minute and missing on some specimens, same bristle longer on male; bristles of joints 7 and 8 normal for family.

Second antenna: Protopodite without medial bristle; exopodite normal for family, with 2 bristles on 9th joint; endopodite of female 2-jointed with 2 or 3 bristles on 1st joint and 1 (rarely 2) long bristle on 2nd joint; endopodite of male (*S. sandersi*) 3-jointed with 3rd

joint recurved: 1st joint with 2 bristles, 2nd with 3, 4th with 2.

Mandible: Considerable sexual dimorphism usually present in family; coxale endite with bifurcate tip present in female, absent in male; ventral margin of coxale on female fringed with hairs; basale of female with 1 spine near middle of dorsal margin and 2 distally, ventral margin with total of 8 or 9 spines and bristles; exopodite of both male and female prominent and with bristle reaching one-fourth to one-third the length of 1st endopodite joint; basale of male (*S. sandersi*) with 3 bristles on dorsal margin and 7 short bristles and 1 extremely long bristle on ventral margin. Endopodite of male: 1st joint with 1 long and 2 short distoventral bristles; 2nd joint with 2 stout bristles near middle of dorsal margin and 1 long and 1 medium bristle on terminal end near ventral margin; 3rd joint with short a-bristle, stout clawlike b-bristle, short clawlike c-bristle, and long d-bristle. Endopodite of female: joints 1–3 with large claws normal for family; joint 1 with 2 medial spines at base of main claw and 1 disto-dorsal spine; joint 2 with 2 dorsal spines and 1 lateral spine at base of main claw; joint 3 with 2 ventral spines and 1 small spine medially near base of main claw.

Maxilla: Normal for family. Exopodite with 3 bristles.

Fifth limb: Endite with 1 bristle; 1st joint with 3 bristles; 2nd joint with 6 bristles; 3rd joint with 1 (rarely 2) bristle on outer lobe and 3 or 4 bristles on inner lobe; 4th and 5th joints with 4–6 bristles.

Sixth limb: All species in the genus with at least 3 distinct endites; in 3 species, *S. menziesi*, *S. variabilis*, and *S. bisetula*, 4 endites evident, but in *S. sandersi* the 4th endite not separated from end joint by indentation in margin. First endite with 1–3 bristles; 2nd endite with 2 or 3 bristles; 3rd endite with 3 or 4 bristles; 4th endite with 3–5 bristles; end joint with 2–4 (rarely 5) anterior bristles, 1 or 2 (rarely 3) middle bristles, and 1–3 hairs posterior bristles.

Seventh limb: Well developed in both male and female; proximal group with 4–10 bristles; distal group with 6 bristles, 3 on each side; each bristle spinous distally; terminus with opposing combs; each comb with 9–12 teeth in female and 2 or 3 in male.

Furca: Each lamella with 7 or 8 claws; claw 3 shorter than claw 4; claw 1 continuous with lamella.

Eyes: Lateral eyes absent. Medial eye large. (Lateral eyes are generally present in sarsiellids, most of which have been reported from shallow water.)

Rod-shaped organ: 1- or 2-jointed and with rounded or pointed tip.

Brush-like bristles: Consisting of 7 or 8 minute bristles above genitalia of female.

COMPARISONS.—Genera having only claw 1 continuous with the lamella are *Sarsiella* Norman, 1869, and *Parasarsiella* Poulsen, 1965. The claws of these two genera decrease gradually in length and strength proximally on the lamella, whereas on *Spinacopia* the 3rd claw is shorter and weaker than the 4th. Genera having species with weaker claws placed between

stronger claws are *Chelicopia* Kornicker, 1959, and *Muelleriella* Poulsen, 1965. These genera differ from *Spinacopia* in having more than one claw continuous with the lamella. The remaining genus in the family, *Scottiella* Poulsen, 1965, has more than one claw continuous with the lamella and does not have weak claws between stronger claws.

Of particular interest is the well-developed exopodite of the mandible on *Spinacopia*. The only species having a similar exopodite, but with a shorter bristle is *Muelleriella zealandica* Poulsen, 1965.

Key to Species of *Spinacopia*

1. Carapace longer than 2.50 mm; 4th joint of 1st antenna with 3 ventral bristles *S. menziesi*, new species
- Carapace shorter than 2.25 mm; 4th joint of 1st antenna with 2 (rarely 3) ventral bristles . . . 2
2. Carapace with large punctae *S. sandersi*, new species
- Carapace smooth 3
3. Endopodite of 2nd antenna of ♀ with 2 bristles on 1st joint and ridge-like hirsute ventral margin on posterodorsal bulge of carapace *S. bisetula*, new species
- Endopodite of 2nd antenna of ♀ with 3 bristles on first joint and without hirsute ridge on carapace *S. variabilis*, new species

Spinacopia menziesi, new species

FIGURES 3, 4; PLATES 1c, 3a-c

HOLOTYPE.—USNM 122086, ♀ with unextruded eggs, carapace length 2.75 mm; carapace and some appendages in alcohol, remaining appendages on slides.

TYPE-LOCALITY.—Antarctic Ocean, Lamont Geological Observatory No. 48, station V-14-24, 3500 meters, lat. 56°37'S, long. 34°48'W, Abyssal Hills, eastern Scotia Sea southeast of South Georgia Island, collected 7-8 March 1958 in small bottom trawl (SBT).

ETYMOLOGY.—The species is named in honor of Dr. Robert J. Menzies, who has collected many of the ostracods described herein and has contributed greatly to the knowledge of the abyssal fauna.

DESCRIPTION OF FEMALE.—Shape (Figures 3a, b; Plates 1c, 3a): Carapace oval in lateral view with greatest height near middle; anterior produced in area of rostrum and with shallow but distinct incisur; posterior with short caudal process below valve middle; carapace globose in dorsal view with greatest width posterior to middle; dorsoposterior part of shell inflated.

Ornamentation (Figures 3d, g, h): Surface smooth with abundant hairs, and scattered normal pores.

Infold (Figures 3c, e, f): Infold broad behind rostrum and in front of caudal process, narrower else-

where; infold below incisur with single bristle near inner margin; infold in front of caudal process with 5 spinous bristles forming row in middle near dorsal margin of process; 3 or 4 small spinous bristles present below the 5 larger bristles; about 14 minute bristles present along inner margin of infold in front of and dorsal to caudal process.

Selvae: Wide lamellar prolongation with smooth outer margin present along anterior, ventral, and posterior margins of both valves; prolongation continuous across incisur (Figure 3f).

Muscle scars (Figure 3i): Central muscle scars consisting of about 16 oval scars (not visible through shell; scars estimated by examining ends of muscles after removing shell).

Pore canals (Figures 3d-f): Normal pore canals scattered over valve surface. Radial pore canals numerous around anterior, ventral, and posterior margins.

Size: Holotype length 2.75 mm, height 2.29 mm (measurements include caudal process); height as percent of length 83.3.

First antenna (Figures 3j-l): Dorsal bristle of 2nd joint fairly long and with long spines near middle and short spines distally; lateral surface, ventral and dorsal margins of 2nd joint with clusters of short spines; ventral bristle of 3rd joint longer than spinous dorsal bristle, and with a few faint spines near middle; 4th

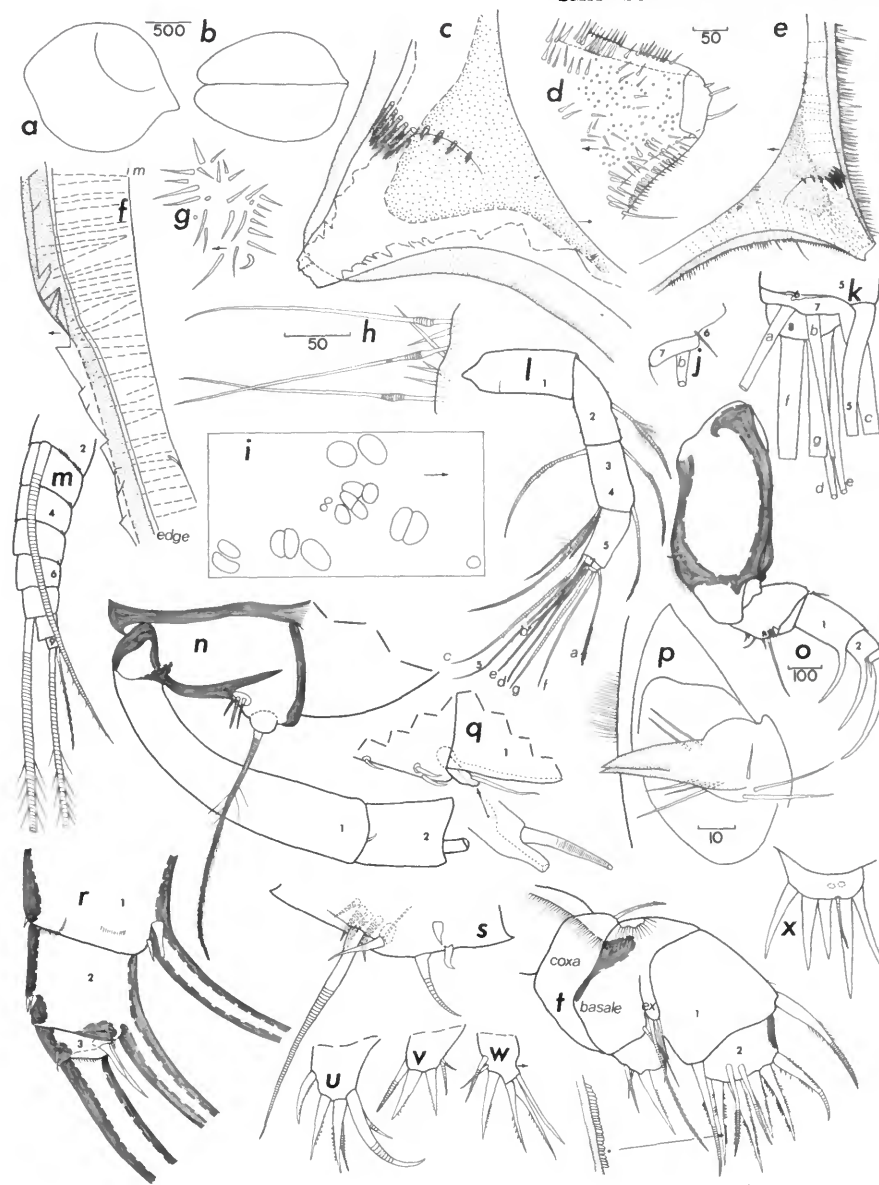


FIGURE 3.—*Spinacopia menziesi*, ♀ holotype, carapace: *a*, left lateral view; *b*, dorsal view, anterior to left. Caudal process left valve: *c*, medial view, *d*, lateral view. Caudal process right valve: *e*, medial view. Anterior margin right valve: *f*, medial view. Surface hairs: *g*, on left valve dorsal to central muscle scars. Hairs along rostral margin left valve: *h*, medial view. Muscle scars right valve: *i*, lateral view. First antenna: *j*, small bristle on 6th joint of left limb, medial view; *k*, bases of bristles on joints 5–8 of right limb, medial view; *l*, right limb, lateral view. Right 2nd antenna, medial view: *m*, joints 2–9 of exopodite (bristles shown only on joints 2, 7, 9); *n*, endopodite and joints 1, 2 of exopodite. Right mandible: *o*, lateral view; *p*, coxale endite, medial view; *q*, exopodite, medial view; *r*, joints 1–3 of endopodite, medial view; *s*, ventral bristles on basale, medial view. Right maxilla: *t*, lateral view (all bristles of endites not shown); *u–w*, 3 endites; *x*, medial view of 2nd joint of endopodite (marginal spines not shown on bristles). Same scale in microns: *a*, *b*; *l*, *o*; *c–g*, *i*, *m*, *n*, *t–x*; *h*, *j*, *k*, *q–a*.)

joint with 1 spinous dorsal bristle, ventral margin with 3 spinous bristles, 1 long, 1 medium, 1 short; sensory bristle of 5th joint with 2 short filaments; 6th joint with minute medial bristle on left limb, and without bristle, but with minute projection on medial distal margin of right limb where bristle is generally located; 7th joint with a-, b-, and c-bristles: a-bristle with spines distally and reaching more than one-half length of sensory bristle of 5th joint; b-bristle shorter than a-bristle and with 1 short filament near middle; c-bristle about same length as sensory bristle and with 3 short filaments; 4 bristles of 8th joint bare, similar in length, slightly shorter than c-bristle.

Second antenna (Figures 3*m*, *n*; Plate 3*b*): Proto-podite bare and without distomedial bristle. Endopodite weakly 2-jointed: 1st joint with 3 short bare bristles, 2nd joint with 1 long spinous terminal bristle. Exopodite 9-jointed: distal margin of joint 1 with short curved medial spine; bristle of joint 2 with few natatory hairs distally and without ventral spines; joint 9 with 1 short spinous bristle and 1 long bristle with sparse natatory hairs; bristles of joints 3–8 without marginal spines, and with sparse natatory hairs; distal margins of joint 2–4 or 2–5 with comb of short spines.

Mandible (Figures 3*o*–*s*): Ventral margin of coxale hairs; coxale endite with bifurcate tip and several spines near base. Basale: dorsal margin with 1 spine near middle and 2 distally; ventral margin with total of 8 or 9 spines and bristles, 3 in proximal group and 5 or 6 in distal group: proximal group with 2 short medial spines and 1 longer marginal bristle; distal group with 1 medial spine, 1 very long medial bristle and 3 or 4 shorter lateral bristles forming row; a U-shaped glandular? opening present on lateral side between proximal and distal groups. Exopodite large with blunt tip and ventral bristle about one-third length of 1st endopodite joint. Endopodite: 1st joint with short terminal spine on dorsal margin, 2 medial spines near base of main ventral claw, and short spines in 2 rows distally on medial surface; 2nd joint with 2 subterminal spines on dorsal margin and 1 lateral spine proximal to base of main ventral claw; 3rd joint with 1 dorsal and 2 ventral spines, and short spines in row at base of main claw.

Maxilla (Figures 3*t*–*x*): Coxale with anterior bristle with faint marginal spines distally; basale with 1 bare bristle near exopodite; exopodite with 2 short bare bristles and 1 long bristle with marginal spines distally; 1st and 3rd endites each with 6 bristles, 2nd endite

with 5; 1st endopodite joint with spinous alpha- and beta-bristles, and a few short spines distally on anterior margin; 2nd endopodite joint with 2 spinous a-bristles laterally, 1 bare c-bristle medially, and usually 5 pectinate terminal bristles; distal inner margin of posterior terminal bristle with closely spaced teeth in row.

Fifth limb (Figure 4*a*): Epipodial appendage with 45 or 46 hairs; single endite with 1 bare bristle. Exopodite: 1st joint with 3 spinous bristles, 2 long, 1 short; 2nd joint with 6 spinous bristles, 5 terminal and 1 proximal, latter bristle shorter than others; 3rd joint with 3 bristles on inner lobe and 1 on outer lobe; 4th and 5th joints with 4 spinous bristles; surface of exopodite joints hairs.

Sixth limb (Figures 4*b*, *c*): Four endites present: 1st endite with 1 bristle, 2nd with 2 or 3, 3rd with 4, 4th with 3, all bristles spinous. End joint with 4 spinous anterior bristles, 2 spinous bristles near middle, and 2 stout hairs posterior bristles; clusters of hairs present on medial surface of limb, and along margin of end joint on each side of posterior bristles.

Left 7th limb (Figure 4*d*): Proximal group with 8 bristles, 4 on each side; distal group with 6 bristles, 3 on each side; each bristle with 3–6 teeth, and with long marginal spines distally; terminus with opposing combs, each with about 9 faint teeth.

Right 7th limb: Similar to left limb except for having 10 bristles in proximal group, 6 on one side, 4 on other.

Furca (Figures 4*e*, *f*; Plate 3*c*): Each lamella with 8 claws: claw 1 continuous with lamella, remaining claws separated from lamella by suture; claw 3 more slender and shorter than claw 4, all claws slender and with pointed tip; most claws with teeth in row along posterior margin and short hairs along anterior margin; clusters of spines present along anterior margin of each lamella and at base of claw 1.

Eyes: Lateral eyes absent. Medial eye large elongate (Figure 4*h*).

Rod-shaped organ (Figure 4*h*): Elongate, single jointed, with triangular process at tip.

Genitalia (Figure 4*e*): Oval amber-colored spermatophore present on each side in vicinity of genital opening.

Brush-like organ (Figures 4*e*, *g*): Consisting of about 7 minute ringed bristles posterior to and above genitalia.

Posterior (Figure 4*i*): Posterior margin of thorax above furca with clusters of long hairs.

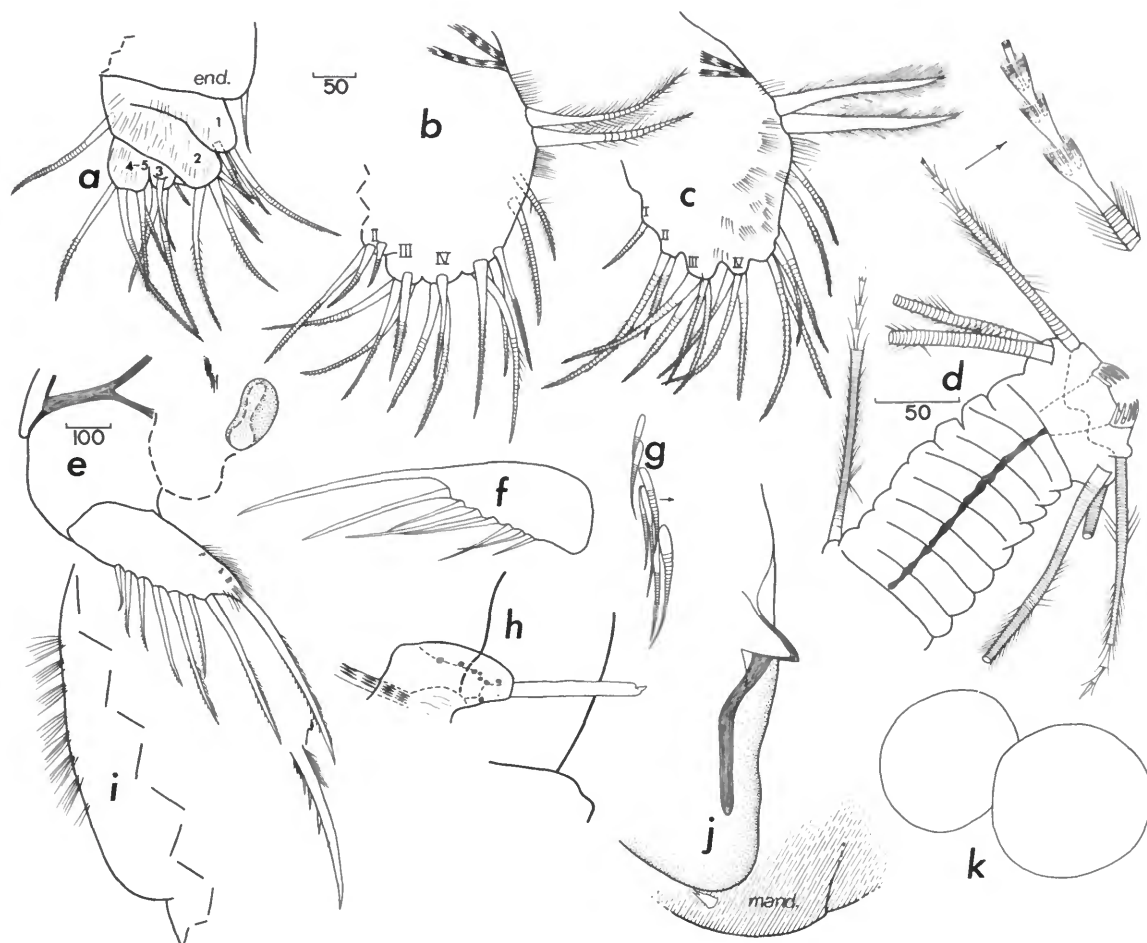


FIGURE 4.—*Spinacopia menziesi*, ♀ holotype: *a*, 5th limb; *b*, *c*, 6th limbs; *d*, left 7th limb (all proximal bristles not shown); *e*, furca, brush-like organ and spermatophore, viewed laterally from right side; *f*, left furcal lamella, lateral view (marginal spines not shown); *g*, brush-like organ; *h*, rod-shaped organ and medial eye in front of 1st joint of left 1st antenna; *i*, posterior; *j*, anterior of animal, showing position of coxale endite relative to upper lip; *k*, 2 eggs from marsupium. (Same scale in microns: *a-c*, *h-j*; *d*, *g*; *e*, *f*, *k*.)

Upper lip (Figure 4j): Simple curvature, surface bare. Triangular process present on each side between lip and 1st antenna.

Eggs (Figure 4k): About 9 unextruded oval eggs present in holotype.

Spinacopia variabilis, new species

FIGURES 5-9; PLATES 1d, 3e, f

ETYMOLOGY.—The specific name is derived from the Latin "variabilis" = changeable, in reference to the variability of appendages among specimens in the species.

HOLOTYPE.—USNM 122191, ♀ with eggs in brood chamber, carapace length 1.92 mm; carapace and some appendage in alcohol, remaining appendages on slides; sta. V-15-131, specimen no. 4.

PARATYPES.—USNM 122192, ♀ from sta. V-18-13; USNM 122193, ♀, specimen no. 5 from sta. V-15-131; USNM 122195, juvenile ♂, instar IV, specimen no. 1 from sta. V-15-131; USNM 122196, juvenile ♂, instar IV, specimen no. 204 from sta. V-15-131; USNM 122194, ♀ with eggs, specimen no. 8 from sta. V-15-131; USNM 122547, ♀ with eggs, specimen no. 3 from sta. V-15-131; USNM 122548, ♀, specimen no. 2, sta. V-15-131; USNM 122549, ♀ specimen no. 6, sta. V-15-131; USNM 122550, 67 adult ♀ ♀ and juvenile ♀ ♀ and ♂ ♂, sta. V-15-131; USNM 122691, adult female carapace figured on Plate 1d, sta. V-15-131.

MATERIAL.—Adult females: 27 inflated, 13 noninflated; instar IV, 36; instar II, 1.

TYPE-LOCALITY.—Lamont Geological Observatory Sta. V-15-131, South Atlantic along western slope of Argentine Basin, lat. 40°14.6'S, long. 55°24.7'W, 1475 meters; collected in small bottom trawl on bottom 45 minutes, 3 April 1959.

OTHER LOCALITIES.—LGO Sta. V-18-13, South Atlantic on Falkland Rise north of Falkland Islands, lat. 47°10'S, long. 61°02'W, 135 meters; collected in small bottom trawl 17 February 1962.

DISTRIBUTION.—South Atlantic on Falkland Rise north of Falkland Islands and along western margin of the Argentine Basin between latitudes 40°14.6'S and 47°10'S, and longitudes 55°24.7'W and 61°02'W, at depths of 135 to 1475 meters.

DISCUSSION OF VARIATION WITHIN THE SPECIES.—This species includes specimens collected at station V-15-131 on the western margin of the Argentine Ba-

sin at a depth of 1475 m, and 1 specimen from station V-18-13 from the Falkland Rise at a depth of 135 m. The latter specimen differs somewhat from those collected at greater depth in having a carapace with a slightly greater height-to-length ratio and in having a different distribution and number of claws on one lamella of the caudal furca, but is tentatively considered herein to be conspecific with the deeper water specimens.

The species contains many individual variants, and it is difficult to be certain that the collection does not contain more than one species. The presence of 2 bristles on the end joint of the endopodites on the second antennae of specimen number 4 from station V-15-131 suggests that it might belong to a different species than the many specimens with only 1 bristle; however, 2 specimens in the collection with 1 bristle on one end joint of the endopodite and 2 on the endopodite of the opposite limb seem to be intermediate forms. Therefore, this presence of 2 bristles is considered to be due to individual variation within the species. The 6th limb of specimen 4 also differs from other specimens in having 5 bristles on the 4th endite of one limb and 4 bristles on the other. Other specimens in the species have 3 bristles on this endite with the exception of one specimen which has 3 bristles on the endite of one limb and 4 on the other. The linkage of this difference with differences on the 2nd antennae noted above strengthens the possibility of specimen 4 being another species. However, the 2 specimens having "intermediate" endopodites on the 2nd antennae have "normal" 6th limbs. Therefore, the 4th endite of the 6th limb of specimen 4 is considered herein to be an individual variant.

Specimens 3 and 6a, both from station V-15-131, have 3 posterior bristles on the end joints of the 6th limbs, whereas 5 specimens (and all specimens of the other 3 species of the genus) have only 2. This also suggests that 2 species are in the sample; however, 2 specimens have 3 posterior bristles on one limb and 2 on the other. Therefore, the presence of 3 posterior bristles on the end joint of the 6th limb is considered herein to be the result of individual variation.

Specimen 3 in addition to having 3 posterior bristles on the end joint of the 6th limb also has 2 bristles on the outer lobe of the 3rd joint on the 5th limb; other specimens have only 1. This linkage strengthens the

possibility of specimen 3 being another species; however, specimen 6a, which also had 3 posterior bristles on the end joint of the 6th limb, has the "normal" number of bristles on the outer lobe of the 3rd joint of the 5th limb. Therefore, the presence of 2 bristles on the outer lobe of the 3rd joint is considered herein to be an individual variant.

Considerable variability was also noted in the frontal organ: some have a pointed tip, some a rounded tip, and others have a rounded tip with small protuberances. Most are 1-jointed, but on one specimen the frontal organ is 2-jointed. The frontal organ of specimen 4 is bifurcate. All these are considered here to be individual variants.

The number of bristles in the proximal group on the 7th limb varies from 4 to 7, but as differences could not be linked to differences on other appendages, this, too, is considered herein to be due to individual variation.

The sample from station V-15-131 is from a trawl which was dragged on the bottom for 45 minutes. It is possible that specimens from many different habitats and populations are included in the sample. Additional collections from the area sampling smaller areas may elucidate whether more than one species or population is included in *S. variabilis*.

DESCRIPTION OF FEMALE (adult male unknown).—**Shape** (Figures 5a-g; Plate 1d), ornamentation, selvage, muscle scars, and pore canals: Similar to *S. menziesi*.

Infold: Infold below incisur with single bristle near inner margin as in *S. menziesi*; infold in front of caudal process with 5 spinous bristles forming row in middle near dorsal margin of process (Figures 5h-l); 4 to 8 small spinous bristles present below the 5 larger bristles; numerous minute bristles present along inner margin of infold in front of and dorsal to caudal process. The distribution of spinous bristles forming row on infold in front of caudal process of six adult females is tabulated below:

Station (specimen no.)	Left valve		Right valve	
	Large bristles	Small bristles	Large bristles	Small bristles
V-18-13	5	5	5	5
V-15-131 (5)	5	4	5	4
" (4)	5	4	5	5
" (6a)	5	6	5	7
" (10)	5	5	5	4
" (11)	5	8	5	5

Size: Length of adult females 1.76–1.92 mm, average 1.84 mm. Dimensions of twelve adult females are tabulated below:

Station (specimen no.)	Length mm (includes caudal process)	Height mm	Height as percent of length
V-18-13	1.90	1.57	82.6
V-15-131 (5)	1.81	1.59	87.8
" (4)	1.92	1.64	85.4
" (6a)	1.85	1.74	94.1
" (6)	1.81	1.62	89.5
" (3)	1.90	1.71	90.0
" (2)	1.76	1.50	85.2
" (8)	1.83	1.63	89.1
" (9)	1.83	1.55	84.7
" (10)	1.79	1.60	89.4
" (11)	1.85	1.58	85.4
" (12)	1.84	1.55	84.2

First antenna (Figures 5m-o): Bristles of joints 1–3 similar to *S. menziesi*; joint 4 with single dorsal bristle and 2 ventral bristles, 1 long, 1 medium; sensory bristle of 5th joint with 2 short filaments; 6th joint without bristle or with minute medial bristle; 7th joint with a-, b-, and c-bristles: a-bristle with spines distally and one-half length of sensory bristle of 5th joint; b-bristle longer than a-bristle and with short filament near middle; c-bristle about same length as sensory bristle and with 3 short filaments near middle; bristles of 8th joint shorter than sensory bristle of 5th joint; d- and e-bristles bare, f- and g-bristles each with 3 short filaments near middle.

Second antenna (Figures 5p-t; Plate 3e, f): Exopodite similar to *S. menziesi* except comb of short spines present on distal margins of joints 2–8. Endopodite distinctly 2-jointed: 1st joint with 2–4 (generally 3) short bristles; 2nd joint with 1 or 2 (usually 1) long bristles. Distribution of bristles on endopodite of fourteen adult females is tabulated below:

Station (specimen no.)	1st joint		2nd joint	
	Left limb	Right limb	Left limb	Right limb
V-18-13	3*	3	1	1
V-15-131 (5)	4	3	2	1
" (4)	3	3	2	2
" (6a)	3	3	1	1
" (6)	3	3	1	1
" (3)	3	3	1	1
" (2)	3	2	1	1
" (8)	3	3	1	1
" (203)	3	3	1	1
" (9)	3	3	1	2
" (10)	3	3	1	1
" (11)	3	3	1	1
" (12)	3	3	1	1
" (203)	3	3	1	1

* 1 of the bristles bifurcate (see Figure 5r).



FIGURE 5.—*Spinacopia variabilis*, ♀ adult carapace, station V-15-131, specimen 24, L=1.81 mm: *a*, lateral view; *b*, dorsal view; *c*, posterior view. Specimen 27, L=1.85 mm: *d*, lateral view; *e*, dorsal view; *f*, posterior view. Specimen from station V-18-13, L=1.90: *g*, lateral view showing eggs; *h*, caudal process left valve, medial view; *i*, caudal process right valve, medial view. Caudal process left valve: *j*, specimen 4, station V-15-131, medial view; *k*, specimen 11, station V-15-131, medial view. Caudal process right valve, specimen 4: *l*, medial view. First antenna, specimen from station V-18-13: *m*, right limb showing rod-shaped organ, medial view; *n*, distal posterior corner of 4th joint; *o*, end joints. Second antenna: *p*, endopodite and 1st joint of exopodite of left limb, specimen 5, station V-15-131, medial view; *q*, endopodite of right limb, specimen 5, medial view; *r*, endopodite of left limb, specimen from station V-18-13, medial view; *s*, endopodite and 1st joint of exopodite of left limb, specimen 4, medial view; *t*, endopodite of right limb, specimen from station V-18-13, medial view. (Same scale in microns: *a-g*; *j-l*, *p, q, s, t*; *h, i*; *n, o, r*.)

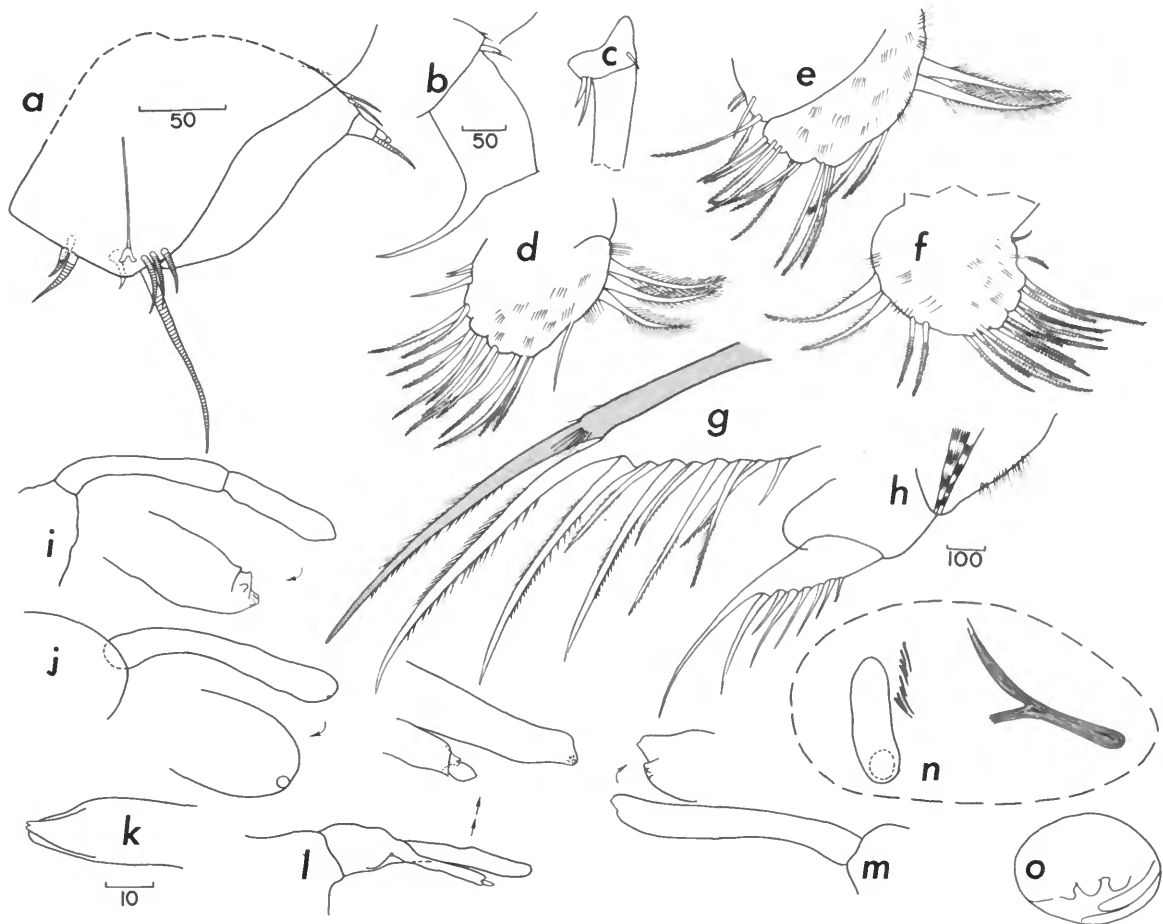


FIGURE 6.—*Spinacopia variabilis*, ♀ adult, mandible: *a*, basale and exopodite of right limb, specimen from station V-18-13, lateral view; *b*, 1st endopodite joint and exopodite, same limb; *c*, end joint of endopodite, left limb, specimen 4, station V-15-131, medial view. Sixth limb: *d*, limb from specimen 3, station V-15-131; *e*, limb of specimen from station V-18-13; *f*, limb from specimen 4, station V-15-131. Furca: *g*, limbs, specimen from station V-18-13; *h*, limb from specimen 4 showing hairs of posterior (spines of furcal claws not shown). Rod-shaped organ: *i*, limb from specimen 3, station V-15-131; *j*, limb from specimen 6, same station; *k*, tip of limb from station V-18-13; *l*, limb from specimen 4; *m*, limb from specimen 8, station V-15-131. Posterior region: *n*, brush-like organ, spermatophore, Y-shaped sclerite of furca. Embryo: *o*, specimen from station V-18-13. (Same scale in microns: *h*, *o*; *b*, *d*-*g*, *n*; *a*, *c*, *i*, *j*, *l*, *m*; *k*.)

Mandible (Figures 6a-c): Similar to *S. menziesi* with following exceptions: 3 short bristles form row on lateral surface near ventral margin of basale on both limbs; bristle of exopodite only about one-fourth length of ventral margin of 1st endopodite joint.

Maxilla: Similar to *S. menziesi*.

Fifth limb: Epipodial appendage with 40-42 hirsute bristles; single endite with bristle. Exopodite: 1st joint with 3 bristles; 2nd joint with 6 bristles; 3rd joint with bristles on inner lobe and 1 or 2 bristles on outer lobe; 4th and 5th joints with 4 or 5 bristles; surface of exopodite joints hirsute. The distribution of bristles on limbs of ten adult females is tabulated below:

Station (specimen no.)	Exopodite						
	Endite	1st joint	2nd joint	3rd joint		4th + 5th joints	Epipodite
				Inner lobe	Outer lobe		
V-18-13	1	3	6	3	1	4	frag.
	1	3	6	3	1	5	frag.
V-15-131 (4)	1	3	6	3	0	4	40
	1	3	6	3	1	4	42
" (3)	1	3	6	3	2	4	frag.
	frag.	3	6	3	2	4	42
" (6a)	1	3	6	3	1	5	42
	1	3	6	3	1	5	42
" (203)	1	3	6	3	1	4	frag.
	1	3	6	3	1	4	42
" (2)	1	4	6	3	1	5	frag.
	1	3	5	3	1	4	frag.
" (5)	1	3	6	3	1	4	frag.
" (8)	frag.	3	6	3	1	4	frag.
	1	4	5	3	1	4	frag.
" (9)	1	3	6	3	1	4	frag.
" (6)	1	3	6	3	1	4	frag.
	1	3	6	3	1	4	frag.

Sixth limb (Figures 6d-f): 4 endites present, but on some specimens 3rd endite only slightly separated from end joint: 1st endite with 3 bristles, 2 short and 1 medium; 2nd endite with 2 long terminal bristles; 3rd endite with 4 bristles; 4th endite with 3-5 bristles.

End joint with 3 or 4 anterior bristles, 1 or 2 bristles near middle, and 2 or 3 hirsute posterior bristles; medial surface of limb with clusters of hairs. The distribution of bristles on limbs of ten adult females is tabulated below:

Station (specimen no.)	Endite I		Endite II	Endite III	Endite IV	End joint		
	Short	Medium				Anterior	Middle	Posterior
V-18-13	2	1	2	4	3	3	2	2
	2	1	2	4	3	4	2	2
V-15-131 (4)	1	1	2	4	5	4	2	2
	2	1	2	4	4	4	2	2
“ (6)	2	2	2	4	3	4	frag.	3
	3	1	3		3	4		2
“ (3)	2	1	2	4	3	4	1	3
	2	1	2	4	3	4	1	3
“ (6a)	2	1	2	4	3	4	1	3
	2	1	2	3	3	3	2	3
“ (203)	2	1	2	4	3	4	1	2
	3	1	2	4	3	5	1	2
“ (2)	2	1	2	4	3	5	1	2
	2	1	2	4	3	4	1	2
“ (5)	2	1	2	4	3	4	2	2
	2	1	frag.	frag.	3	4	2	frag.
“ (8)	2	1	2	4	3	4	2	3
	2	0	3	3	4	4	1	2
“ (9)	2	1	2	4	3	4	1	2
	2	1	2	4	3	3	1	2

Seventh limb: Proximal group with 4-7 bristles (usually 4-6); distal group with 6 bristles, 3 on each side; each bristle with 2-6 bells, and with long marginal spines distally; terminus with opposing combs, each with 9-12 teeth. Numbers of bristles in proximal group on left and right limbs of seven adult females are tabulated below:

Station (specimen no.)	Left limb	Right limb
V-18-13	frag.	5
V-15-131 (5)	6	6
" (4)	4	5
" (6a)	4	4
" (6)	6	6
" (3)	5	5
" (2)	7	5

Furca (Figures 6g, h): Each lamella with 7-9 claws (usually 8): claw 1 continuous with lamella, remaining claws separated by suture; claw 3 more slender and shorter than claw 4, remaining claws decreasing gradually in length proximally on lamella (an exception is left lamella of specimen from station V-18-13 on which both claws 3 and 5 are smaller than claw 4, apparently an aberrant form (Figure 6g)); spines and hairs as in *S. menziesi*, but with some variation between specimens. The number of claws on each lamella of eight adult females is tabulated below:

Station (specimen no.)	Left lamella	Right lamella
V-18-13	9 *	7
V-15-131 (5)	7	8
" (4)	8	8
" (6a)	8	8
" (6)	8	7
" (3)	8	8
" (2)	8	7
" (203)	8	8

* Claw 3 smaller than claw 4, claw 5 smaller than claw 6.

Eyes: Lateral eyes absent. Medial eye similar to *S. menziesi*.

Rod-shaped organ: Generally 1-jointed with pointed tip adjacent to rounded flap (Figure 6k); sclerotized pit present at end of tip. Variations observed included a 2-jointed organ (Figure 6i), one with 2 branches (Figure 6l), and some with rounded tip, or with rounded tip and protuberances (Figures 6j, m). The number of joints and shape of tip of eight adult females are given in tabular form below:

Station (specimen no.)	Number of joints	Shape of tip
V-18-13	1	pointed
V-15-131 (5)	1	pointed
" (4)	bifurcate with both branches 1-jointed	pointed
" (6a)	1	with protuberance
" (6)	1	with protuberance
" (3)	2	rounded with protuberances
" (12)	1	pointed
" (8)	1	pointed with protuberances

Genitalia (Figure 6n): Oval amber-colored spermatophore present on each side over genital pore.

Brush-like organ (Figure 6n): Consisting of about 8 minute ringed bristles posterior to and above genitalia.

Posterior: Clusters of long hairs present on posterior margin of thorax above furca.

Upper lip: Similar to *S. menziesi*.

Eggs (Figure 6o): Gravid females contain 2-6 eggs in the marsupium. Some specimens with eggs in the marsupium also have as many as 7 eggs in the ovaries. The number of eggs in the marsupium and ovaries of twelve adult females is tabulated below (eggs in ovaries obscure in some specimens):

Station (specimen no.)	In brood chamber	In ovaries
V-18-13	6	7
V-15-131 (5)	3	4
" (4)	3	0
" (6a)	0	0
" (6)	3	0?
" (3)	2	7
" (2)	0	1?
" (8)	4	0
" (9)	3	5
" (10)	4	0
" (11)	4	5
" (12)	0	0

Food (Plate 2e): Gut of specimen 4 from station V-15-131 contained remains of 3 harpacticoid copepods, 1 nematode, and 3 pellets. Two of the pellets are oval and dark brown and are probably fecal pellets, 1 is rectangular and yellowish. Their position in the gut suggests that they were ingested. The gut of specimen 28, an adult female from station V-15-131, contained a polycopid ostracod and copepod fragments.

The polycopid carapace was closed and contained undisturbed appendages which appeared cleaned of protoplasm.

DISCUSSION OF DIMORPHISM IN SHELLS OF ADULT FEMALES.—Thirteen of the adult females in the collection are not inflated in the posterodorsal region, but instead are evenly rounded as in juveniles (Figures 5a–c). The dimensions of three carapaces are as follows:

Station (specimen no.)	Length mm (includes caudal process)	Height mm	Height as percent of length
V-15-131 (15)	1.86	1.60	86.0
" (16)	1.75	1.55	88.6
" (24)	1.81	1.50	82.9

The appendages of the 3 specimens are similar to specimens with inflated posterodorsal regions (Figures 5d–f) with the exception that specimens 15 and 16 have 3 ventral bristles on the 4th joint of the 1st antenna; this number was present only rarely on inflated forms. All inflated forms examined have attached spermatophores, whereas only specimen 24 of the noninflated forms has them. The above 3 specimens do not contain eggs in either the ovaries or carapace. All specimens contained harpacticoid copepods in their gut, and in addition specimen 24 had 1 free living nematode, showing that the diet of the inflated and noninflated forms are similar.

The reason for the observed dimorphism is not clear. The similarity in lengths and heights of both types make it unlikely that the noninflated forms are juveniles, although it is a possibility; for example, when preadult males of some sarsiellids molt to form adults, the resulting carapace has a different shape than the preadult, but has about the same length and height. Another possibility is that the preadult female molted to form adults not having all characters of mature females. The absence of eggs in the few specimens examined supports either hypothesis.

DESCRIPTION OF INSTAR II (sex undetermined) (Figure 7).—Shell (Figure 7a): Shell similar in lateral outline to adult female but without inflated posterodorsal region; infold below shallow sinus with single bristle; infold in front of caudal process with 2 long spinous bristles and 1 shorter bristle. Dimensions of single specimen (no. 20) in collection is as follows: length 1.11 mm, height 0.94 mm, height as percent of length 84.6.

First antenna: Similar to adult female except for having on 2nd and 4th joints only 1 dorsal bristle and no ventral bristles.

Second antenna (Figure 7b): Protopodite and exopodite similar to adult; endopodite 2-jointed; 1st joint with short bristle; 2nd joint with long distal bristle.

Mandible, maxilla, 5th limb: All well developed and similar in general morphology to adult female.

Sixth limb (Figure 7c): Outer margin divided into 2 hirsute lobes; 1 long bristle present anterior to middle.

Seventh limb (Figure 7f): Short, bare.

Furca (Figure 7d): Each lamella with 4 claws decreasing in length posteriorly; claw 1 continuous with lamella; spines present posterior to claw 4.

Rod-shaped organ (Figure 7e): Elongate, with restriction about one-third distance from terminal end.

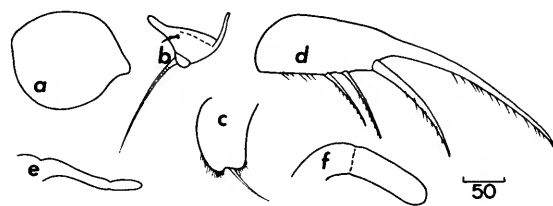


FIGURE 7.—*Spinacopia variabilis*, instar II, specimen 20, station V-15-131; a, carapace, lateral view, L=1.11; b, endopodite right 2nd antenna, medial view; c, 6th limb; d, right furcal lamella, lateral view; e, rod-shaped organ; f, 7th limb. (Same scale in microns: a; b–f.)

DESCRIPTION OF FEMALE INSTAR IV (Figure 8).—Shell (Figure 8a): Shape of carapace similar to adult female but not globose in posterodorsal region. Infold below shallow sinus with single bristle; infold in front of caudal process with 3 or 4 large and 3 small spinous bristles forming row near middle and additional bare bristles along inner margin. Dimensions of specimen 23, station V-15-131, are as follows: length 1.59 mm, height 1.29 mm, height as percent of length 81.1.

First antenna, mandible, maxilla, 5th and 6th limbs: Well developed, similar in general morphology to adult female.

Second antenna: Protopodite and exopodite similar to adult female; endopodite 2-jointed (Figure 8b): 1st joint with 2 or 3 short bristles; 2nd joint with 2 bristles, 1 long and 1 medium.

Seventh limb: Proximal group with 5 bristles; distal group with 4 bristles; bristles tapering distally, each

with 2-5 bells; terminus with opposing combs, each having about 10 teeth.

Furca: Each lamella with 7 claws; claw 1 continuous with lamella; claw 3 shorter than claw 4, clusters of hairs medially at base of claw 1.

Rod-shaped organ: Elongate, single jointed with rounded tip.

Genitalia: Undeveloped.

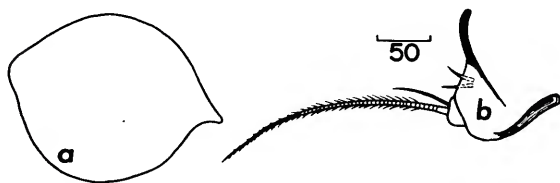


FIGURE 8.—*Spinacopia variabilis*, ♀ instar IV, specimen 23, station V-15-131: a, carapace, lateral view, L=1.59 mm; b, endopodite, 2nd antenna.

DESCRIPTION OF MALE INSTAR IV (Figure 9).—Shell (Figures 9a, b): Shape of carapace in lateral view similar to adult female but not globose in posterodorsal region. Infold below shallow sinus with single bristle; infold in front of caudal process with 4 or 5 large spinous bristles and several smaller spinous bristles forming row near middle of infold and about 12 bare slender bristles along inner margin. Distribution of spinous bristles is listed below:

Station (specimen no.)	Left valve		Right valve	
	Large bristles	Short bristles	Large bristles	Short bristles
V-15-131 (1)	4	5	5	4
" (2)	4	4	4	4
" (21)	4	3	4	3
" (204)	4	5	4	4
" (22)	4	3	4	3

Dimensions of measured specimens are listed as follows:

Station (specimen no.)	Length mm (includes caudal process)	Height mm	Height as percent of length
V-15-131 (1)	1.72	1.56	90.7
" (2)	1.65	1.28	75.6
" (21)	1.56	1.32	84.6
" (204)	1.48	1.24	83.8
" (22)	1.58	1.27	80.4

First antenna, mandible, maxilla, 5th and 6th limbs, rod-shaped organ, posterior: Well developed, similar in general morphology to adult female.

Second antenna: Protopodite and exopodite similar to adult female. Endopodite quite variable, 2- or 3-jointed (Figures 9c-e); number of joints and bristles per joint are listed below for specimens studied:

Station (specimen no.)	1st joint		2nd joint		3rd joint	
	left	right	left	right	left	right
V-15-131 (1)	3	2	2P*, 1T*	2P, 1T	no third joint	
" (2)	3	3	3P	3P	2T	2T
" (21)	3	3	2P, 1T	1P, 1T	no third joint	
" (204)	3	3	3P	3P	2T	2T
" (22)	3	3	3P	3P	1T	2T

* Proximal bristles.

† Terminal bristles.

Seventh limb (Figures 9f, g): Proximal group with 3-5 bristles, distal group with 4-6, each with 2-5 bells distally; terminus with opposing combs with few to many teeth. The number of bristles on proximal and distal groups of specimens studied is as follows:

Station (specimen no.)	Proximal group		Distal group		Remarks
	Left	Right	Left	Right	
V-15-131 (1)	4	5	6	5	(not tapered)
" (2)	4	4	4	4	(tapered)
" (21)	6	5	4	4	"
" (204)	5	4	4	4	"
" (22)	4	4	4	4	"

Furca: Each lamella with 7 or 8 claws; claw 1 continuous with lamella; claw 3 shorter than claw 4. The number of claws on each lamella of specimens studied is listed below:

Station (specimen no.)	Left lamella	Right lamella
V-15-131 (1)	8	8
" (2)	7	7
" (21)	7	7
" (204)	7	7
" (22)	7	7

Copulatory organ: Very weakly developed (Figure 9i).

Brush-like organ (Figure 9h): Consisting of about 6 annulated bristles above copulatory organ (observed only on specimen no. 1).

DISCUSSION OF SPECIMEN NUMBER 1.—Although this specimen has been included in the description of instar IV, it differs from other specimens in this group in many respects. In carapace size, number of furcal claws, and absence of tapering bristles on the 7th limb, the specimen resembles an adult. In shape of cara-

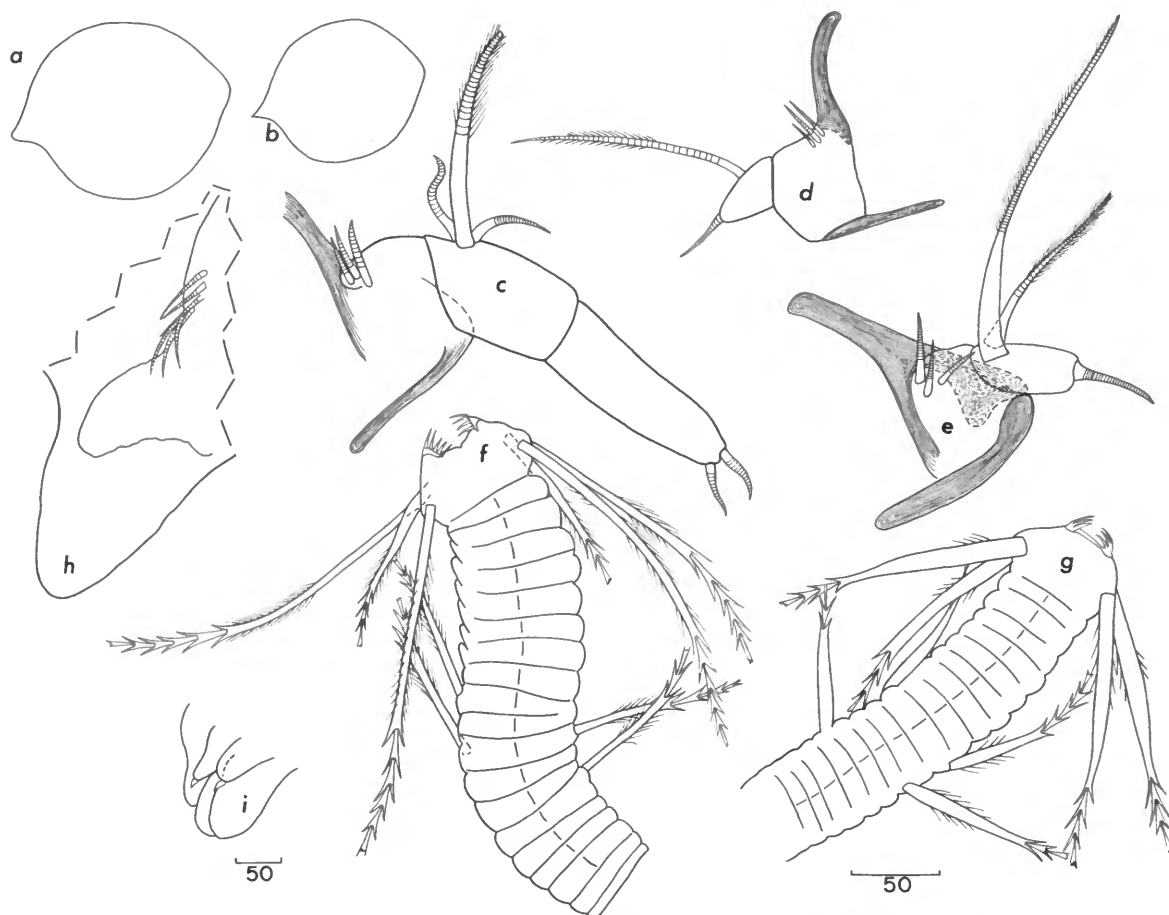


FIGURE 9.—*Spinacopia variabilis*, ♂ instar IV, station V-15-131, carapace: *a*, lateral view, specimen 1, L=1.72 mm; *b*, lateral view, specimen 204, L=1.48 mm. Endopodite 2nd antenna: *c*, left limb, specimen 204; *d*, right limb, specimen 21; *e*, limb from specimen 1. Seventh limb: *f*, limb from specimen 1; *g*, limb from specimen 204. Posterior region: *h*, brush-shaped organ; *i*, copulatory organ. (Same scale in microns: *a-b*; *i*; *c-h*.)

pace, development of the 1st antenna, mandible, endopodite of the 2nd antenna, and copulatory organ, the specimen resembles instar IV.

COMPARISONS.—The adult ♀ of *Spinacopia variabilis* is much smaller than *S. menziesi*; the former 1.76–1.92 mm long compared to 2.75 mm for the latter. Another difference is that the 4th joint of the female 1st antenna of *S. menziesi* has 3 ventral bristles, whereas the 4th joint of *S. variabilis* rarely has more than 2. Each 7th limb of *S. variabilis* has 4–7 bristles in the proximal group compared to 8–10 for *S. menziesi*. The epipodial appendage of the 5th limb of *S. variabilis* has

40–42 hirsute bristles compared to 45 or 46 for *S. menziesi*.

Spinacopia bisetula, new species

FIGURE 10; PLATES 3d, 6

HOLOTYPE.—USNM 122545, ♀ with eggs in brood chamber, carapace length 2.03 mm; carapace and some appendages in alcohol, remaining appendages on slides; station V-16-15.

TYPE-LOCALITY.—Lamont Geological Observatory Station V-16-15, lat. 45°00'S, long. 45°46'E, 1622

meters, southern Indian Ocean, Madagascar Rise; collected in small bottom trawl on bottom 20 minutes, 8 January 1960.

ETYMOLOGY.—The specific name is derived from the Latin "bi" = two and "setula" = diminutive of seta, in reference to the 2 small bristles on the 1st joint of the endopodite of the 2nd antenna.

DESCRIPTION OF FEMALE.—Shape (Figure 10a; Plates 3d, 6), ornamentation, muscle scars, selvage and pore canals: Similar to *S. menziesi* except for postero-dorsal bulge having ridgelike ventral margin outlined by long hairs forming horizontal row.

Infold: Infold below incisur with single bristle near inner margin; infold in front of caudal process with 5 spinous bristles forming row in middle near dorsal margin of process (Figures 10b, c); 3 or 4 smaller bristles present below 5 larger bristles; minute bristles present along inner margin of infold in front and dorsal to caudal process.

Size: Holotype length 2.03 mm, height 1.81 mm; height as percent of length 89.2.

First antenna: Similar to 1st antenna of *S. menziesi* except both limbs have a short medial bristle on 6th joint and only 2 ventral bristles on 4th joint.

Second antenna: Exopodite similar to *S. menziesi* except combs of short spines present on joints 2–8. Endopodite 2-jointed with 2 short bristles on 1st joint and 1 long spinous bristle on 2nd joint.

Mandible (Figures 10d, e): Similar to *S. menziesi* with the following exceptions: 3 short bristles form a row on lateral surface near ventral margin of basale on both limbs; bristle of exopodite reaches less than one-fourth length of ventral margin of 1st endopodite joint.

Maxilla: Similar to *S. menziesi*.

Fifth limb (Figures 10f, g): Epipodial appendage with 41 hirsute bristles; single endite with 1 or 2 bristles. Exopodite: 1st joint with 3 bristles; 2nd joint

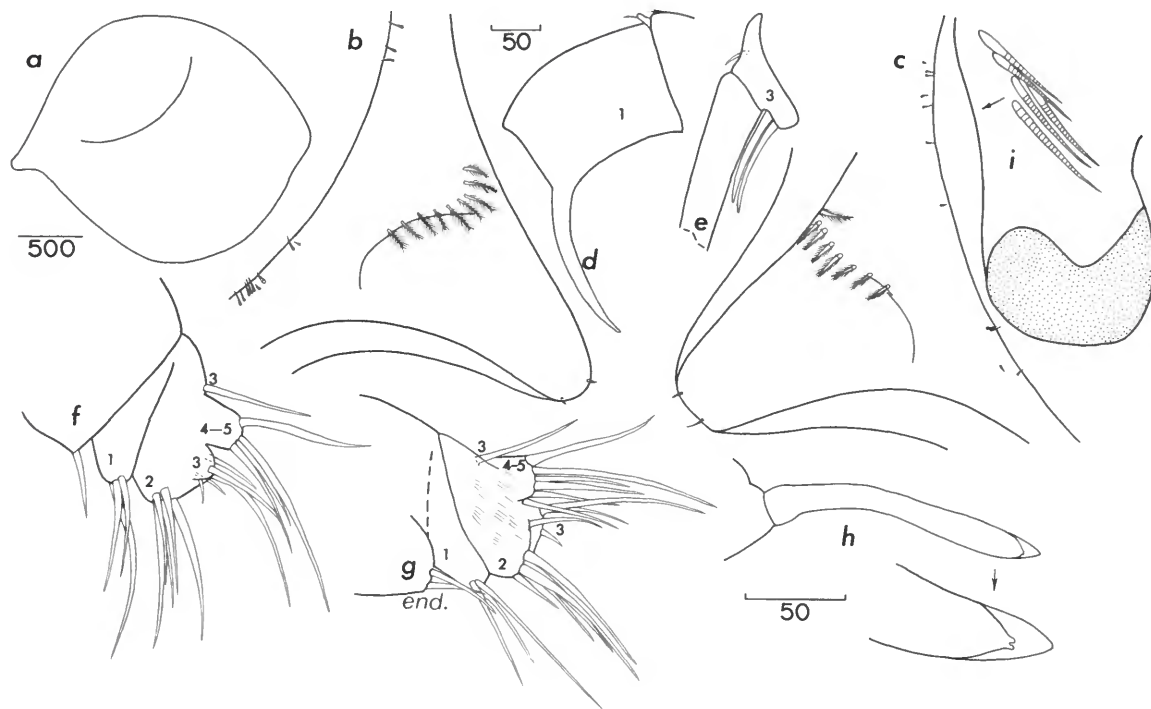


FIGURE 10.—*Spinacopia bisetula*, ♀ holotype: a, carapace, right lateral view, L=2.03 mm; b, caudal process right valve, medial view; c, caudal process left valve, medial view; d, right mandible, exopodite and 1st joint of endopodite, medial view; e, left mandible, end joint of endopodite, lateral view; f, g, 5th limbs; h, rod-shaped organ; i, brush-shaped organ and spermatophore. (Same scale in microns: b–d, f, g; e, h, i.)

with 6 bristles; 3rd joint with 4 bristles on inner lobe and 1 on outer lobe; 4th + 5th joints with 4 or 5 bristles; surface of exopodite joint hirsute.

Sixth limb: Four endites present: 1st endite with 3 bristles, 2 short and 1 medium; 2nd endite with 2 long terminal bristles; 3rd endite with 3 or 4 bristles; 4th endite with 4 bristles. End joint with 3 or 4 anterior bristles; clusters of hairs present on medial surface and in vicinity of posterior bristles of end joint.

Seventh limb: Proximal group with 4 bristles, 2 on each side; distal group with 6 bristles, 3 on each side; each bristle with 3–6 bells, and with long spines distally; terminus with opposing combs, each with about 10 teeth.

Furca, eyes, rod-shaped organ (Figure 10h), brush-like bristles (Figure 10i), posterior, upper lip: Similar to *S. menziesi*.

Genitalia: Oval amber-colored spermatophore present on each side in vicinity of genital pore (Figure 10i).

Eggs: 5 round eggs present in brood pouch, about 4 in ovaries.

Food: Gut contained copepod fragments.

COMPARISONS.—*Spinacopia bisetula* is smaller than *S. menziesi* and larger than *S. variabilis*. The 1st joint of the endopodite of the 2nd antenna of *S. bisetula* has only 2 bristles compared to 3 on *S. menziesi* and *S. variabilis*. The endite of the 5th limb of the latter two species has only 1 bristle, whereas, one of the limbs of the holotype of *S. bisetula* has 2 bristles, but whether this character is consistent is not known. The inner lobe of the 3rd joint of the exopodite of the 5th limb of *S. bisetula* has 4 bristles compared to 3 on *S. menziesi* and *S. variabilis*. The shell of the species is characterized by having long hairs in a horizontal row along the ventral margin of the inflated posterodorsal region.

Spinacopia sandersi, new species

FIGURES 2, 11, 13–20; PLATES 1a–b, 2a–c, 4, 5

HOLOTYPE.—USNM 122551, ♀ with eggs in brood chamber, carapace length 1.77; carapace and some appendages in alcohol, remaining appendages on slides; station 118A, specimen no. 1. Allotype: USNM 122558, adult ♂ specimen no. 3, carapace length 1.59 mm.

PARATYPES.—USNM 122557, ♀ specimen no. 2; USNM 122559, 12 adult ♀♀; USNM 122560, ♀ specimen no. 6, figured on Plate 1b; USNM 122561, 4 adult ♂♂; USNM 122562, 5 specimens instar I, 12 specimens instar II and 12 of instar III; USNM

122563, 18 ♀♀ and 19 ♂♂ instar IV; USNM 122564, 260 whole specimens. USNM 122692, adult ♂ no. 45, figured on Plate 1a.

MATERIAL.—Adult females with eggs, 75; adult females without eggs, 48; instar IV, 112; instar III, 39; instar II, 26; instar I, 21; adult males, 32.

TYPE-LOCALITY.—Station 118A, RV *Atlantis II*, cruise 24, near Bermuda, lat. 32°19.4'N, long. 64°34.9'W to lat. 32°19.0'N, long. 64°38.8'W; dredge sample, 18 August 1966, depth 1135–1153 m. Collected by H. Sanders and R. Hessler. All specimens from same epibenthic trawl.

Etymology.—The species is named in honor of Dr. Howard Sanders, Woods Hole Oceanographic Laboratory, under whose direction the sample containing the species was collected.

DESCRIPTION OF ADULT FEMALE (Figures 2l–n, 11; Plates 1b, 4a).—Shape (Figure 11a; Plates 1b, 4a): Similar to *S. menziesi*.

Ornamentation (Figures 11d, e; Plate 1b): Surface with shallow punctations and scattered normal pores; punctae with inwardly pointing spines in vicinity of periphery; surface with scattered spines and hairs, the latter especially abundant around margins.

Infold: Infold below incisure with single bristle near inner margin as in *S. menziesi*; infold in front of caudal process with 5 (rarely 4 or 6) spinous bristles forming row in middle near dorsal margin of process; (Figures 11f–i); 3 (rarely 2) small spinous bristles present below the larger bristle; minute bristles present along inner margin of infold in front of and dorsal to caudal process. The distribution of large and small spinous bristles forming row on infold of caudal process of seven adult females is tabulated below:

Specimen number	Left valve		Right valve	
	Large bristles	Small bristles	Large bristles	Small bristles
1	6	3	5	3
2	5	2	5	3
4	5	3	5	3
6	5	2	3	3
7	5	3	4	2
8	5	3	5	3
21	5	3	4	2

Selva: Similar to *S. menziesi*.

Muscle scars (Figures 11b, c): Central muscle scars consisting of about 14 individual scars.

Pore canals: Normal pore canals scattered over valve surface (Figure 11d). Radial pore canals numerous around anterior, ventral, and posterior margins.

Size: Dimensions of holotype: length 1.77 mm, height 1.42 mm, height as percent of length 80.2. Average dimensions of 7 specimens: length 1.77 mm, height 1.45 mm, height as percent of length 82.0. Dimensions of measured specimens are as follows:

Specimen number	Length mm (includes caudal process)	Height mm	Height as percent of length
1	1.77	1.42	80.2
2	1.74	1.41	81.0
4	1.71	1.45	84.8
6	1.79	1.46	81.6
7	1.79	1.48	82.7
8	1.80	1.45	80.6
21	1.79	1.49	83.2

First antenna (Figures 11j, k), mandible, maxilla: Similar to *S. bisetula*.

Second antenna (Figures 11l-n): Exopodite similar to *S. bisetula*. Endopodite weakly 2-jointed: 1st

joint with 2 (rarely 1) bristles, 2nd joint with 1 long bristle. The distribution of bristles on the endopodites of six adult females is tabulated below:

Specimen number	Bristles on 1st joint	
	Left limb	Right limb
1	1	1
2	2	2
4	2	2
6	2	2
7	1	2
8	2	2

Mandible, maxilla Figure 11o: Similar to *S. bisetula*.

Fifth limb (Figures 11p, q): Endite with 1 bristle. Exopodite: 1st joint with 3 bristles; 2nd joint with 6 (rarely 5) bristles; 3rd joint with 3 (rarely 4) bristles on the inner lobe and 1 on outer lobe; 4th + 5th joints with total of 6 (rarely 3, 4, 5) bristles. Epipodite with 38-42 bristles. The distribution of bristles on six adult females is tabulated below:

Specimen number	Exopodite							Epipodite
	Endite	1st joint	2nd joint	3rd joint		4th + 5th joints		
				inner lobe	outer lobe			
1	1	3	6	3	1	5	frag.	
	1	3	6	3	1	6	41	
2	1	3	6	3	1	6	frag.	
	1	3	6	4	1	3?	38	
4	1	3	6	3	1	6	39	
	1	3	6	3	1	6	38	
6	frag.	3	6	3	1	6	frag.	
	1	3	5	3	1	6	42	
7	1	3	6	3	1	6	frag.	
	1	2?	6	3	1	5	frag.	
8	1	3	6	3	1	6	frag.	
	1	3	6	3	1	4	frag.	

Sixth limb (Figures 11r, s): Endites not sharply defined from each other or from end joint except by spaces between them; 1st endite with 3 (rarely 4) bristles; 2nd endite with 2 or 3 bristles; 3rd endite with 3 or 4 bristles; 4th endite with 3 (rarely 2, 4)

bristles; end joint with 2-4 (rarely 5) anterior bristles, 1 or 3 (rarely 3) middle bristles, and 2 posterior bristles; surface and margin in vicinity of posterior bristles of end joint hirsute. The distribution of bristles on six adult females is tabulated below:

Specimen number	End joint						
	Endite I	Endite II	Endite III	Endite IV	Anterior	Middle	Posterior
1	3	2	4	4	2	2	2
	3	2	3	3	3	1	2
2	3	2	4	3	4	2	2
	3	2	3	3	4	2	2
4	3	3	4	2	5	2	1
	3	2	4	3	4	2	2
6	3	2	4	3	4	2	2
	4	1	2	3	4	2	2
7	4	3	4	3	4	2	2
	3	3	4	3	2	2	2
8	3	2	3	3	2	2	2
	3	2	4	4	2	1	2

Seventh limb (Figures 11*t*, *u*): Proximal group with 4 (rarely 3) bristles; distal group with 6 bristles, 3 on each side; each bristle with 2-4 bells and marginal spines distally; terminus with opposing combs, each with about 10 teeth. Number of bristles in proximal group on left and right limbs of six adult females is tabulated below:

Specimen number	Number of bristles in proximal group
1	4
	3
2	4
	4
4	4
	4
6	4
7	4
	4
8	4
	3

Furca: Each lamella with 7 or 8 claws; 3rd claw smaller than 4th; only claw 1 continuous with lamella. (A single specimen has 7 claws on 1 lamella and 9 on the other; on the latter, the 5th as well as the 3rd claw is smaller than the following claw.) The distribution of claws on seven specimens is as follows:

Specimen number	Left lamella	Right lamella
1	7	8
2	8	7
4	8	8
6	8	7
7	8	8
8	8	8
21	7	7

Rod-shaped organ (Figures 11*v*, *w*): Elongate, 1-jointed (rarely weakly 2-jointed), tip acuminate or rounded. The number of joints and shape of tip of six adult females are tabulated below:

Specimen number	Number of joints	Shape of tip
1	1	pointed
2	1	rounded
4	1	pointed
6	1	rounded
7	faintly 2-jointed	pointed
8	2	pointed

Eyes, brush-like organ, posterior, upper lip: Similar to *S. menziesi*.

Genitalia (Figures 2*l-n*): Not observed on whole mount. In section, genital opening observed to be cov-

ered laterally by thin flap; opening in spermatophore facing outward abutting against genital opening; tubular oviduct passing upward into body.

Discussion of reproduction: Only distal portion of oviduct could be clearly observed in sections studied. Sperm present in duct only in vicinity of genital opening suggesting that eggs are fertilized as they leave oviduct. Eggs are present both in the ovaries and marsupium of some adult females having attached spermatophores. It seems probable that part of the genital opening is sufficiently free from the spermatophore to permit passage of eggs.

Eggs: Gravid females contain 2-4 eggs in the marsupium; some specimens also contain 3 or 4 eggs in the ovaries. Generally, when 4 eggs were observed in the brood chamber 2 were in the right valve and 2 in the left. The distribution of eggs in thirteen adult females is tabulated below:

Specimen number	In brood chamber	In ovaries
1	3	0
2	4	0
4	4	4
6	3	3
7	0	4
8	2	0
21	3	0
29	3	0
66	4	3
67	3	1
68	4	3
69	3	?
71	3	3

COMPARISONS.—The adult ♀ of *S. sandersi* differs from previously described species in having large, but shallow, punctations. The endopodite of the 2nd antenna on the ♀ differs from that of *S. menziesi* and *S. variabilis* in having only 2 bristles on the 1st joint. The 5th limb of *S. sandersi* differs from that of described species in having a total of 6 bristles on the 4th + 5th joints of at least 1 limb; all other species have a maximum of 5 bristles. The carapace of *S. sandersi* is much smaller than those of *S. menziesi* and *S. bisetosa*, and slightly smaller than that of *S. variabilis* (see Figure 12).

DESCRIPTION OF ADULT MALE (Figures 2*a-k*, 13; Plates 1*a*, 4*e-f*, 5).—Shape (Figure 13*a*; Plate 1*a*): More elongate than female and with prominent rostrum and caudal process; carapace highest posterior to middle.

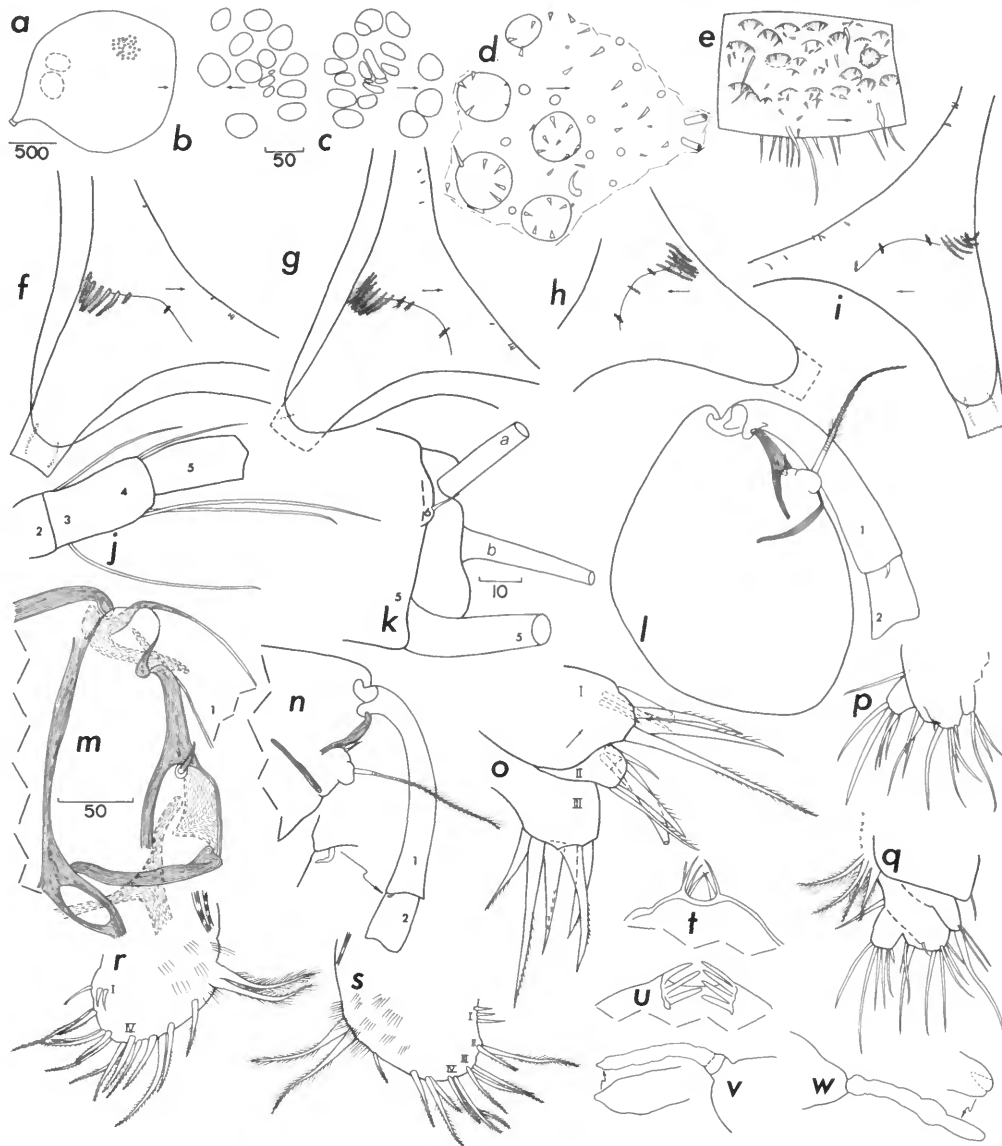


FIGURE 11.—*Spinacopia sandersi*, ♀ adult: *a*, carapace, right lateral view showing some eggs and punctae, L=1.77 mm. Central muscle scars, lateral view: *b*, left valve; *c*, right valve. Punctae and hairs on left valve: *d*, posterodorsal area; *e*, ventral margin. Caudal process, medial view: *f*, *g*, left valve; *h*, *i*, right valve. Left 1st antenna, medial view: *j*, joints 3–5; *k*, joints 6, 7 (not all bristles shown). Left 2nd antenna, medial view: *l*, protopodite, endopodite, exopodite joints 1 and 2; *m*, sclerotized region in vicinity of endopodite; *n*, endopodite and joints 1 and 2 of exopodite, medial view. Left maxilla, endites I–III: *o*, medial view. Limbs: *p*, *q*, 5th (spines on bristles not shown); *r*, *s*, 6th. Terminal combs of 7th limbs: *t*, right, *u*, left. Head region: *v*, *w*, rod-shaped organs. (Same scale in microns: *b*, *c*, *e*–*j*, *l*, *n*, *p*–*s*; *d*, *m*, *o*, *v*, *w*; *k*, *t*, *u*. Figures *a*, *g*, *h*, *j*–*m*, *o*–*u* from specimen 1; *c*–*e* from specimen 6; *b*, *f*, *i*, *n*, *w* from specimen 2; *v* from specimen 8.)

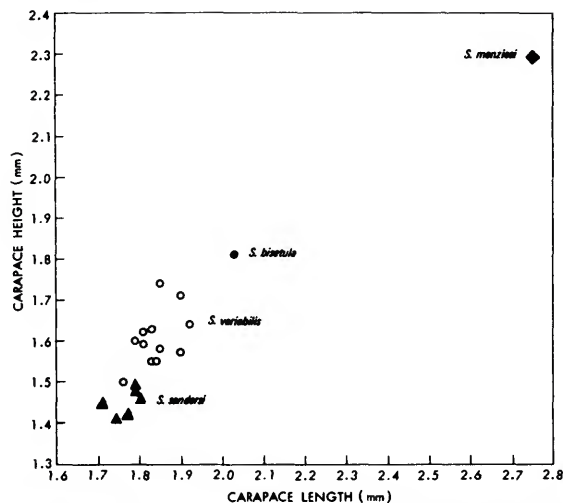


FIGURE 12.—Comparison of relationship between shell length and height of gravid females of *Spinacopa menziesi*, *S. bisetula*, *S. variabilis*, and *S. sandersi*.

Ornamentation, selvage, pore canals: Similar to female.

Infold: Infold below rostrum with single bristle (Figure 13e); infold in front of caudal process with 4 or 5 spinous bristles near posterior margin and 2 or 3 smaller spinous bristles ventral to them (Figures 13b, c); minute bristle present along inner margin of infold anterior to caudal process.

Muscle scars: Central muscle scars consisting of about 18 individual scars (Figure 13d).

Size: Length of allotype 1.70 mm, height 1.18 mm, height as percent of length 69.4. Average dimensions of 10 specimens: length 1.56 mm, height 1.08 mm, height as percent of length 77.1. Dimensions of measured specimens are as follows:

Specimen number	Length mm (includes caudal process)	Height mm	Height as percent of length
3	1.59	1.17	73.6
5	1.60	1.09	68.1
38	1.62	1.08	66.7
39	1.54	1.07	69.5
40	1.53	1.06	69.3
42	1.52	1.08	71.1
43	1.48	1.02	68.9
45	1.54	1.08	70.1
48	1.54	1.12	72.7
49	1.46	1.05	71.9

First antenna (Figure 13f; Plate 5b): 2nd joint with 1 dorsal bristle and clusters of surface spines; 3rd

joint not separated from 4th and with a ventral and dorsal bristle; 4th joint with 2 ventral and 1 dorsal bristle; 5th joint triangular and placed ventrally between 4th and 5th joints; sensory bristle with 3 filaments; filaments of basal part of sensory bristles numerous (not shown in Figure 13f) and about equal in length to bristles; 6th joint with short medial bristle. 7th joint: a-bristle with marginal spines distally; b-bristle with 2 filaments; c-bristle with 6 filaments. 8th joint: d- and e-bristles bare, slightly longer than b-bristle; f-bristle with 4 filaments; g-bristle with 6 filaments.

Second antenna (Figures 13g, h; Plate 5c): 1st joint with short recurved medial spine on distal margin; joints 2–8 with combs of short spines along distal margins; bristles of joints 2–8 with sparse natatory hairs; joint 9 with 1 long stout bristle with natatory hairs and 1 shorter and more slender bristle. Endopodite 3-jointed: 1st joint with 2 short proximal spines and clusters of surface hairs; 2nd joint with 3 medium bristles near proximal end; 3rd joint recurved, with 2 short bristles near terminal end.

Mandible (Figures 13i–k): Basale with 3 dorsal bristles with sparse marginal spines and 1 very long and 7 short ventral bristles; exopodite reaching about one-third length of 1st endopodite joint and with spinous ventral bristle with base near middle (Figure 13j). Endopodite: 1st joint with clusters of surface spines and 1 long and 2 short distoventral bristles; 2nd joint with clusters of surface spines, 2 dorsal bristles near middle of margin, 1 medial bristle on distal margin, and 1 long stout distoventral bristle; 3rd joint with short a-bristle, stout clawlike b-bristle with short spines on surface, short clawlike c-bristle with teeth along ventral margin, and long spinous d-bristle; dorsal margin of 1st endopodite joint indented in region of exopodite (Figure 13i).

Maxilla (Figure 13l): Appendage reduced; exopodite with 3 bristles; coxale with spinous dorsal bristle.

Fifth limb (Figure 13m): Reduced to about half size of female. Epipodite with about 39 bristles; single endite with short spinous bristles. Endopodite: 1st joint with 3 spinous bristles; 2nd joint with 1 short bare bristle and 5 longer spinous bristles; inner lobe of 3rd joint with 3 spinous bristles; outer lobe of 3rd joint with 1 long bristle; 4th + 5th joints with 5 spinous bristles.

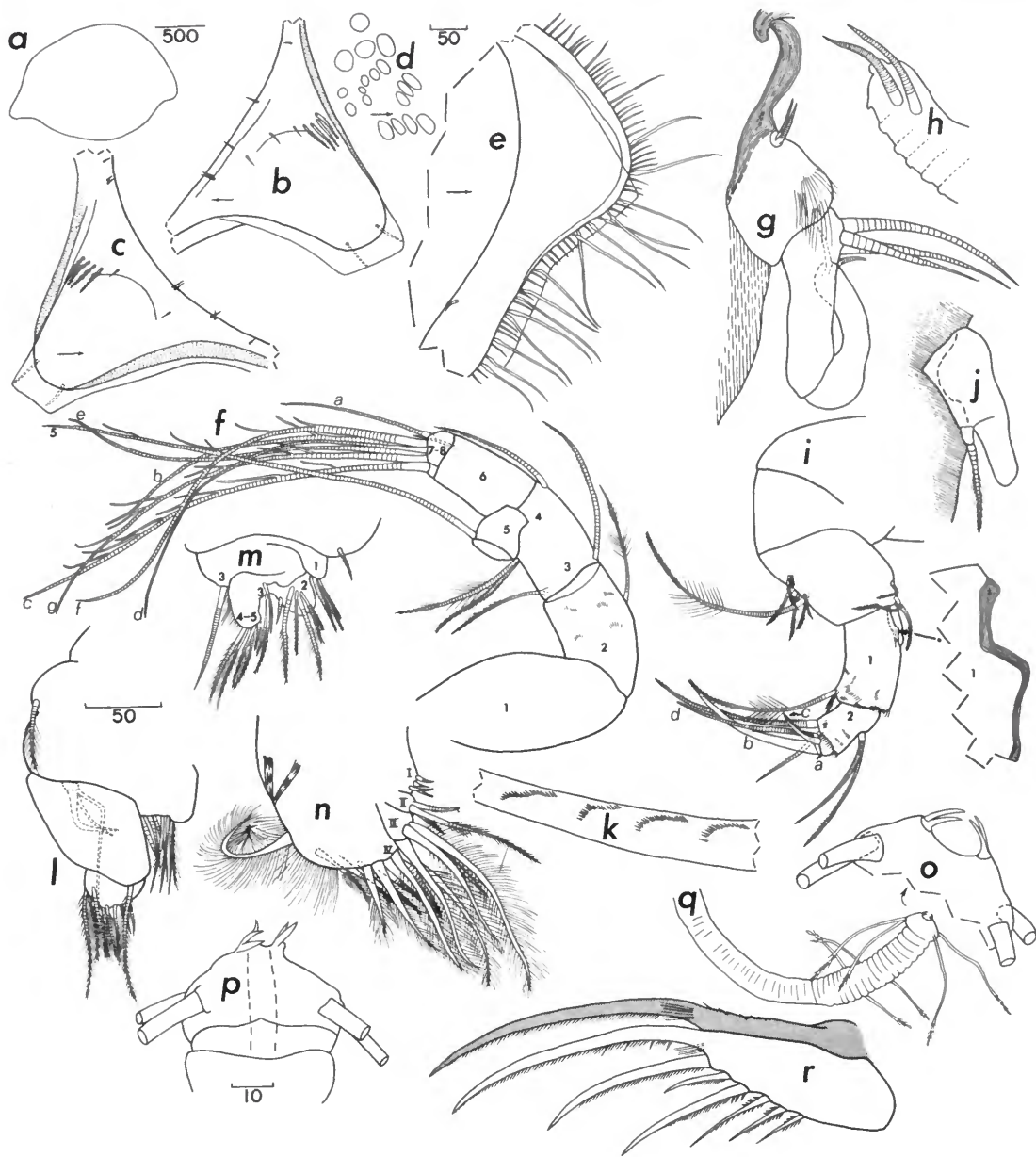


FIGURE 13.—*Spinacopia sandersi*, ♂ adult, allotype, carapace: *a*, lateral view, L=1.70 mm. Caudal process, medial view: *b*, right valve; *c*, left valve. Central muscle scars, left valve: *d*, medial view (scars obscure). Anterior left valve: *e*, medial view. Left 1st antenna: *f*, lateral view (filaments of sensory bristle of 5th joint not shown). Endopodite of 2nd antenna: *g*, medial view; *h*, tip of 3rd joint. Mandible: *i*, left limb, medial view; *j*, exopodite of right limb, lateral view; *k*, detail of b-claw on 3rd joint of endopodite on right limb, medial view. Limbs: *l*, maxilla; *m*, 5th; *n*, right 6th, lateral view. Seventh limb: *o*, tip of left limb; *p*, tip of right limb; *q*, left limb. Posterior region: *r*, furca. (Same scale in microns: *b*–*f*, *i*, *n*, *q*, *r*; *g*, *l*, *m*; *h*, *j*, *k*, *o*, *p*.)

Sixth limb (Figure 13n): 1st, 2nd, and 4th endites with 3 bristles; 3rd endite with 4 bristles; end joint with 4 anterior bristles, 2 middle bristles and 1 or 2 posterior bristles; 4th endite not differentiated from end joint except by narrow space; bristles of middle and anterior group of end joint not distinctly separated from each other.

Seventh joint (Figures 13o-q; Plate 5d): Well developed, 4 bristles in distal group, 3 or 4 in proximal group, each with 2-4 bells and marginal spines distally; terminus with opposing combs each containing 3 teeth; joint is shorter and more slender than that of adult female.

Furca (Figure 13r): Each lamella with 7 claws (rarely 8); claw 1 continuous with lamella; claw 3 about half length of claw 4; claw 1 with medial hairs near base; all claws with marginal spines; dorsal margin of right lamella with about 5 spines.

Rod-shaped organ: Elongate, 1-jointed.

Eyes: Lateral eyes absent, medial eye about same size as on female.

Posterior: Posterior differs from female in not having clusters of long hairs.

Genitalia (Figures 2a-k; Plates 4e, f, 5e-f): Two pear-shaped testes present, one on each side above penis, connected to seminal vesicle by tubular vas deferens. Seminal vesicle bilobed consisting of core (secretion) and sperm peripheral to core, sperm mainly restricted to ventral part; core of secretion consisting of 2 discrete masses either completely separated or fused at middle (vas deferens somewhat larger when secretion fused). Ductus ejaculatorius curved, apparently opening at side of penis. Complex clasping organs hanging down on each side of penis; each clasper consisting of 3 lobes, each with 3-5 bristles; main lobe terminating in sclerotized hook and with triangular tooth proximally; ridges and minute projections present on triangular tooth (Figures 2g, i).

Spermatophore (observed on adult female): Ovoid having amber color in transmitted light; consisting of sperm enclosed in sheath of secretion (Figures 2l-n).

Sperm: Numerous in testis (Figure 2j), seminal vesicle (Figure 2k) and spermatophore (Figures 2l, m). When stained with Mallory's, head yellow, posterior blue; flagellum observed on some. When stained with aceto-carmine, head pink, posterior unstained (Plate 4e, f).

Gut content: Gut examined in three specimens and found empty.

DESCRIPTION OF INSTAR I (sex undetermined) (Figure 14).—Shell (Figure 14a): Oval with shallow sinus and short caudal process and similar in lateral outline to adult female, but not inflated in postero-dorsal region; infold below sinus with single bristle as in adult female; infold in front of caudal process with single large spinous bristle near middle; in addition, several small bare bristles present along inner margin of infold in front of caudal process.

AVERAGE DIMENSIONS OF FIVE SPECIMENS.—Length 0.88 mm, height 0.64 mm, height as percent of length 72.4. Dimensions of measured specimens are as follows:

Specimen number	Length mm (includes caudal process)	Height mm	Height as percent of length
16	0.89	0.68	76.4
24	0.86	0.62	72.1
26	0.89	0.65	73.0
27	0.91	0.64	70.3
30	0.84	0.60	71.4

First antenna: Similar to adult female but with no bristles on 2nd and 4th joints.

Second antenna (Figure 14b): Protopodite similar to adult female; medial spine on 1st joint of exopodite not recurved as on adult female; endopodite 1 or 2 jointed with single long terminal bristle.

Maxilla, mandible, 5th limb: Well developed, similar in general morphology to adult female.

Sixth limb (Figure 14c): Reduced, not divided into endites, without bristles but with abundant marginal and surface hairs.

Seventh limb: Absent.

Furca (Figure 14d): Each lamella with 2 claws similar to claws 1 and 2 of adult female followed by a single prong with long marginal hairs; prong continuous with lamella; clusters of hairs present on margin of lamellae posterior to prong and medially at base of claw 1.

Rod-shaped organ (Figure 14e): Elongate without joints or with 1-3 weak sutures.

Gut content: Specimen 26 contained in the gut 1 polycipid ostracod and 3 copepods.

DESCRIPTION OF INSTAR II (sex undetermined) (Figure 15; Plate 2c).—Shell (Figure 15a): Similar in shape to instar I; infold differs from instar I in having 2 long spinous bristles forming row in front of caudal process. Average dimensions of 3 specimens: length 1.02 mm, height 0.78 mm, height as percent of length 77.1. Dimensions of measured specimens are as follows:

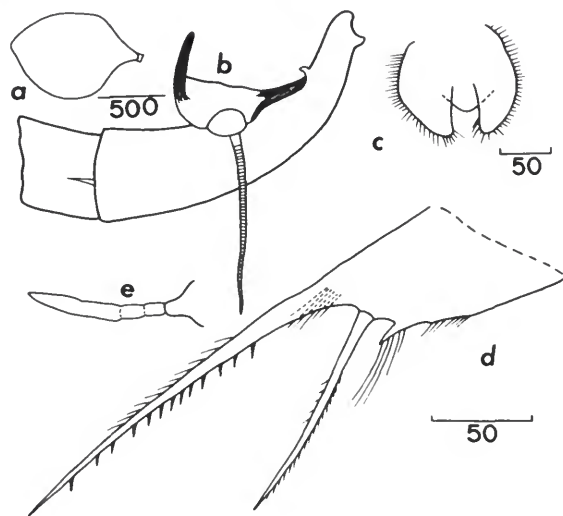


FIGURE 14.—*Spinacopia sandersi*, instar I, specimen 16: *a*, carapace, left lateral view, $L=0.89$; *b*, endopodite and joints 1 and 2 of exopodite of left 2nd antenna, medial view; *c*, 6th limbs; *d*, furcal lamella; *e*, rod-shaped organ. (Same scale in microns: *b*, *d*, *e*.)

Specimen number	Length mm (includes caudal process)	Height mm	Height as percent of length
17	1.06	0.86	81.1
28	1.07	0.79	74.2
29	0.92	0.70	76.1

First antenna: Similar to instar I except for having 1 dorsal bristle on 2nd and 4th joints.

Second antenna: Protopodite similar to instar I. Exopodite similar to instar I except medial spine of 1st joint recurved. Endopodite 2-jointed (Figure 15*b*): 1st joint with 1 or 2 short proximal bristles; 2nd joint with 1 long terminal bristle.

Mandible, maxilla, 5th limb, rod-shaped organ: All well developed and similar in general morphology to instar I and adult female.

Sixth limb (Figure 15*c*): Similar to instar I except for having single bristle on anteroventral section of margin.

Seventh limb (Figure 15*d*): Very short and without bristles or terminal comb.

Furca (Figures 15*e*, *f*): Each lamella with 3 or 4 (usually 4) claws decreasing in length posteriorly; differs from adult female in having fewer claws and in 3rd claw not being shorter than 4th. The distribution of claws on each lamella of three specimens is as follows:

Specimen number	Left lamella	Right lamella
17	4	3
28	4	4
29	4	4

Gut content (Plate 2*c*, *d*): Specimen 28 contains within the gut a large complete copepod with its head toward the posterior part of the gut, indicating that it had been swallowed head first. The gut of specimen 29 contains a large podocypid ostracod; although the ingested specimen is toward the rear of the gut, it is still strongly calcified, and the shell fragmented when flattened under a cover glass. This suggests that the gut is not sufficiently acid to dissolve the calcium carbonate of the podocypid. The ingested ostracod contains its appendages in place, but they appear cleaned of internal muscles and cells.

DISCUSSION OF SPECIMEN 29.—The dimensions of the carapace of specimen 29 would suggest that the specimen is a stage I instar. However, the number of spinous bristles on the infold of the caudal process, the number of bristles on the 2nd and 4th joints of the 1st antenna, the recurved nature of the medial spine on the 1st joint of the exopodite of the 2nd antenna, the number of furcal claws, and especially the presence of a single bristle on the 6th limb indicate that specimen 29 is a stage II instar, and it has been considered so herein.

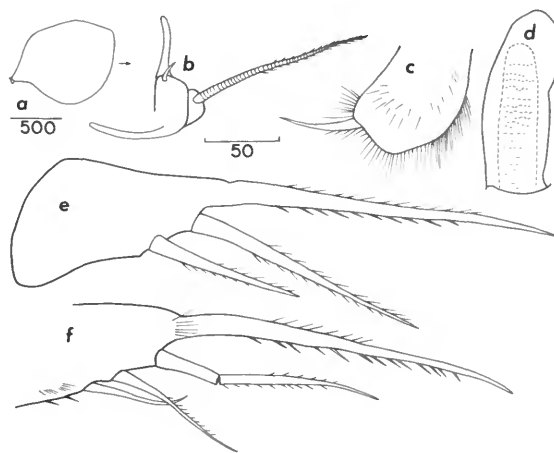


FIGURE 15.—*Spinacopia sandersi*, instar II, specimen 17: *a*, carapace, right lateral view, $L=1.06$ mm; *b*, endopodite, 2nd antenna; *c*, 6th limb; *d*, 7th limb. Furcal lamellae: *e*, right, lateral view; *f*, left, medial view. (Same scale in microns: *b*–*f*.)

DESCRIPTION OF FEMALE INSTAR III (Figure 16; Plate 2a).—Shell (Figure 16a): Differs from instar II in having 2 or 3 (usually 3) large spinous bristles and 1 or 2 small spinous bristles forming row near middle of infold in front of caudal process. Average dimensions of 2 specimens: length 1.22 mm, height 0.92 mm, height as percent of length 75.5. Dimensions of measured specimens are as follows:

Specimen number	Length mm (includes caudal process)	Height mm	Height as percent of length
19	1.18	0.91	77.1
34	1.26	0.93	73.8

First antenna: Differs from instar II in having a ventral bristle on the 4th joint.

Second antenna, maxilla, mandible, 5th limb, rod-shaped organ (Figure 16e): Similar in general morphology to instar II.

Sixth limb (Figure 16b, c): Well developed, similar in general morphology to adult instar, except having only 3 endites and fewer bristles, about 15.

Seventh limb (Figure 16d): Longer than on instar II but otherwise similar.

Furca: Each lamella with 6 claws; 3rd claw shorter than 4th, otherwise similar to instar II.

DESCRIPTION OF MALE INSTAR III (Figure 17; Plate 4b, d).—Shell (Figure 17a): Similar to female instar III. Average dimensions of 5 specimens are length 1.25 mm, height 0.92 mm, height as percent of length 73.7. Dimensions of measured specimens are as follows:

Specimen number	Length mm (includes caudal process)	Height mm	Height as percent of length
10	1.21	0.92	76.0
18	1.28	0.93	72.7
25	1.21	0.88	72.7
32	1.28	0.94	73.4
33	1.29	0.95	73.6

First antenna (Plate 4b), mandible, maxilla, 5th, 6th, 7th limbs (Figure 17d), rod-shaped organ (Figure 17c), furca: Similar to female instar III.

Second antenna: Protopodite and exopodite similar to female instar III. Endopodite 2-jointed or weakly 3-jointed (Figure 17b; Plate 4d): 1st joint with 2 short proximal bristles; 2nd joint with 2 long proximal bristles; 3rd joint with 1 short terminal bristle (this bristle is on tip of 2nd joint when 3rd joint is absent).

DISCUSSION OF SPECIMEN 31 (Figure 18).—This specimen could not easily be placed in any particular stage. The shell dimensions are as follows: length 1.14 mm, height 1.04 mm, height as percent of length 91.2. The shell dimensions, the number of bristles on the infold of the caudal process (Figure 18a), the number of bristles on the 4th joint of the 1st antenna and the development of the 6th limb, which has 15 bristles, and the length of the bare 7th limb (Figure 18c) indicate that it belongs in stage III. The endopodite of the 2nd antenna is 2-jointed (Figure 18b), the 1st joint has the usual 2 short bristles, but the end joint has 1 long terminal bristle and 1 longer proximal bristle

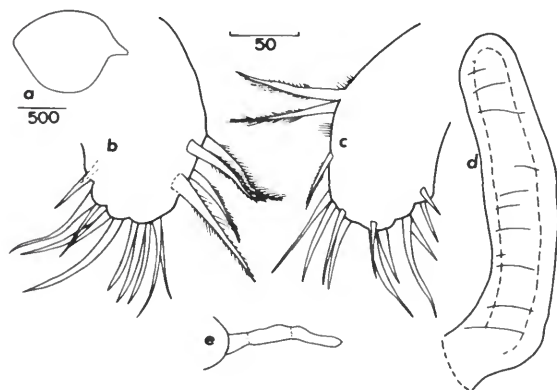


FIGURE 16.—*Spinacopia sandersi*, ♀ instar III, specimen 19, carapace: a, left lateral view, L=1.18 mm. Lateral view, limbs: b, 6th, left; c, 6th, right; d, 7th. Head region: e, rod-shaped organ. (Same scale in microns: b–e.)

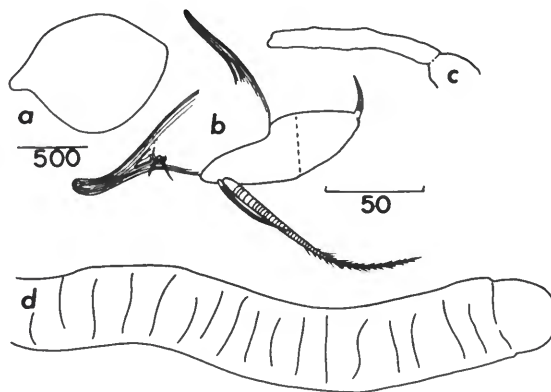


FIGURE 17.—*Spinacopia sandersi*, ♂ instar III, specimen 10: a, carapace, right lateral view, L=1.21 mm; b, endopodite of left 2nd antenna, medial view; c, rod-shaped organ; d, 7th limb. (Same scale in microns: b–d.)

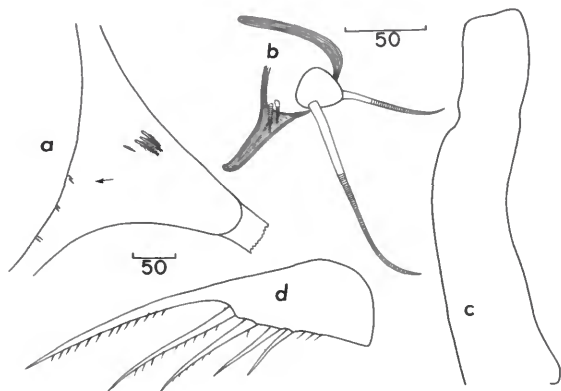


FIGURE 18.—*Spinacopia sandersi*, ♂ instar III, specimen 31: a, caudal process right valve, medial view; b, endopodite 2nd antenna; c, 7th limb; d, right furcal lamella, medial view. (Same scale in microns: a, d; b, c.)

oriented anteriorly. This type endopodite is not present on either male or female instars. The endopodite would fit nicely as a developmental stage between male instars II and III. The 5 claws on the furca (Figure 18d) also fit between the number on the furcae of instar II (3 or 4 claws) and instar IV (6 claws). The dimensions of instars II and III, however, are such that it seems unlikely that another instar could fit between them. I have considered specimen 31 to be an aberrant male instar III on Figure 21 but have not included it in the description of male instar III above.

DESCRIPTION OF FEMALE INSTAR IV (Figure 19; Plates 2b, 4c).—Shell (Figures 19a, b): Shape of carapace similar to adult female but not globose in postero-dorsal region. Infold below shallow sinus with single bristle; infold in front of caudal process with 4 (rarely 3) large and 2 or 3 small spinous bristles forming row

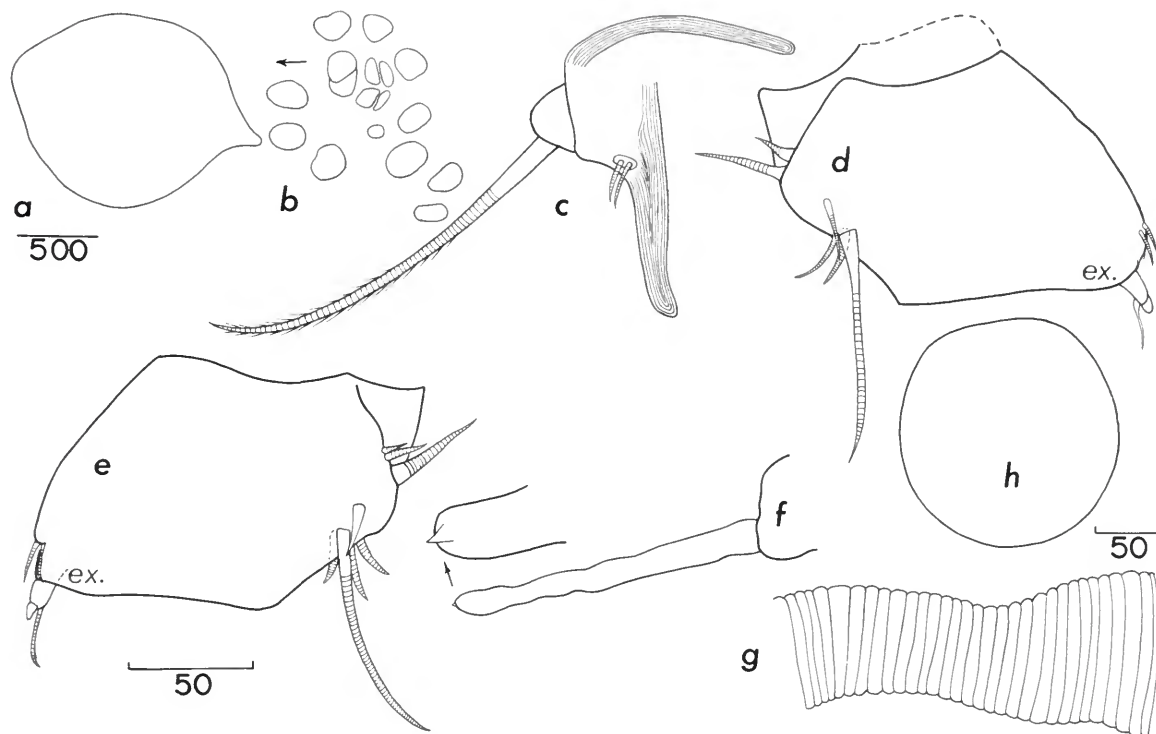


FIGURE 19.—*Spinacopia sandersi*, ♀ instar IV: a, carapace, left lateral view, L=1.54 mm; b, muscle scars right valve, medial view; c, endopodite of 2nd antenna; d, right mandible, basale and exopodite, lateral view; e, left mandible, basale and exopodite, lateral view; f, rod-shaped organ; g, section of esophagus; h, *Polycope* from gut. (Same scale in microns: b, g, h; c-f. Figures a-c from specimen 13; d-h from specimen 15.)

near middle of infold and about 10 bare slender bristles along inner margin. Average dimensions of twelve specimens: length 1.54 mm, height 1.23 mm, height as percent of length 80.3. Dimensions of measured specimens are as follows:

Specimen number	Length mm (includes caudal process)	Height mm	Height as percent of length
13	1.54	1.21	78.6
15	1.54	1.21	78.6
22	1.54	1.24	80.5
51	1.56	1.27	81.4
53	1.53	1.25	81.7
55	1.53	1.26	82.4
58	1.51	1.24	82.1
59	1.50	1.18	78.7
60	1.49	1.17	78.5
62	1.51	1.28	84.8
64	1.58	1.22	77.2
65	1.59	1.26	79.2

First antenna: Similar to instar III except for having 2 ventral bristles on the 4th joint.

Second antenna (Figure 19c), mandible (Figures 19d, e; Plate 4c), maxilla, rod-shaped organ (Figure 19f): Similar in general morphology to instar III female and adult female.

Fifth limb: Similar to adult female. Distribution of bristles on 1 appendage is as follows: endite with single bristle. Exopodite: 1st joint with 3 bristles; 2nd joint with 6 bristles; inner lobe of 3rd joint with 3 bristles; outer lobe of 3rd joint with 1 bristle; 4th + 5th joints with 5 bristles; surface of exopodite hirsute; epipodial appendage with about 39 bristles.

Sixth limb: Similar to adult female. Distribution of bristles on 1 appendage is as follows: endite I with 3 bristles; 2nd endite with 3 bristles; 3rd endite with 4 bristles; 4th endite with 3 bristles; end joint with 2 or 3 anterior bristles, 2 middle bristles and 2 hirsute posterior bristles; all endites fairly well defined; surface and margin of end joint hirsute.

Seventh limb: Proximal group with 4 bristles; distal group with 4 or 5 (usually 4) bristles; bristles tapering distally, each with 2-5 bells; terminus with opposing closely spaced combs with few teeth.

Furca: Each lamella with 7 claws; claw 1 continuous with lamella; claw 3 shorter than claw 4; clusters of hairs medially at base of claw 1 and following claw 7.

Gut: Specimen 15 with complete specimen of the ostracod *Polycoppe* sp. present in rear portion of gut

(Plate 2b). Measured length of polycopid shell 0.21 mm; height 0.20 mm (Figure 19h). (Apparently the esophagus [Figure 19g] of this specimen is capable of stretching to a diameter of about 0.2 mm.)

DESCRIPTION OF MALE INSTAR IV (Figure 20).—Shell (Figure 20a): Similar to female instar IV. Average dimensions of 13 specimens: length 1.51 mm, height 1.18 mm, height as percent of length 78.0. Dimensions of measured specimens are as follows:

Specimen number	Length mm (includes caudal process)	Height mm	Height as percent of length
9	1.43	1.19	83.2
11	1.54	1.18	76.6
12	1.55	1.21	78.1
14	1.51	1.24	82.1
20	1.56	1.20	76.9
23	1.53	1.18	77.1
35	1.42	1.09	76.8
52	1.55	1.22	78.7
54	1.51	1.15	76.2
56	1.57	1.20	76.4
57	1.49	1.12	75.2
61	1.50	1.19	79.3
63	1.53	1.18	77.1

First antenna, maxilla, mandible, 7th limb, furca, frontal organ, posterior: Similar to female instar IV.

Second antenna: Protopodite and exopodite similar to adult female; endopodite 3-jointed (Figure 20b): 1st joint with 2 small proximal bristles and clusters of surface hairs; 2nd joint elongate with 3 proximal bristles; 3rd joint elongate with 2 terminal bristles.

Fifth limb: Similar to female instar IV. Distribution of bristles on fifth limb of 1 specimen is as follows: endite with single bristle. Exopodite: 1st joint with 3 bristles; 2nd joint with 4 or 5 bristles; outer lobe of 3rd joint with 4 or 5 bristles; inner lobe of 3rd joint with 1 bristle; 4th + 5th joint with 5 bristles; surface of exopodite hirsute.

Sixth limb: Similar to female instar IV. Distribution of bristles of 1 appendage is as follows: endite I with 3 bristles; 2nd endite with 2 bristles; 3rd endite with 3 bristles; 4th endite with 4 bristles; end joint with 3 anterior bristles, 2 middle bristles, 2 hirsute posterior bristles; surface and margin of end joint hirsute.

Copulatory organ: 2 or 3 poorly developed lobes with few bristles (Figure 20c).

Gut content: Specimen 9 contained remains of a copepod.

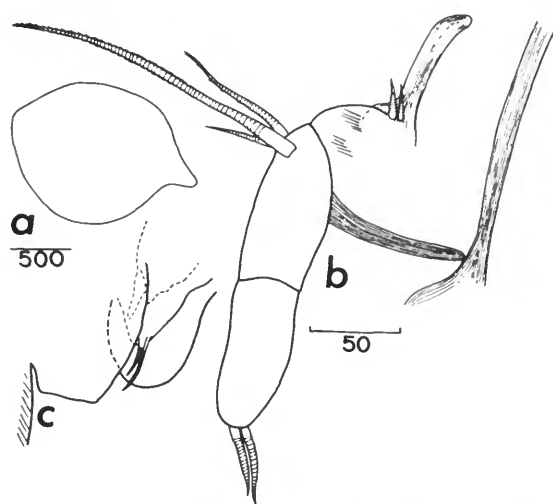


FIGURE 20.—*Spinacopia sandersi*, ♂ instar IV: *a*, carapace, left lateral view, $L=1.43$ mm; *b*, endopodite of right 1st antenna, medial view; *c*, copulatory apparatus, lateral view from right. (Same scale in microns: *b*, *c*. Figures *a* and *b* from specimen 9; *c* from specimen 11.)

SUMMARY OF DEVELOPMENT.—Shell: The overall shape of the instars are quite similar to the female adult except for not having the inflated posterodorsal region which serves as a brood pouch for eggs. As indicated in Table 4 below, the average adult female is also higher relative to length than juveniles of both sexes. The number of both large and small spinous bristles on the list of the infold in front of the caudal process increases fairly regularly in each succeeding developmental stage (Table 5; Figure 21A). The average growth factor of the shell excluding the growth factor between male instar V and the adult male is 1.216. This estimated factor was obtained by averaging both the length and height factors between male and female instars (see Tables 6 and 7). The growth factors between the preadult and adult male is quite low, 1.03 for the length growth factor and 0.92 for the height factor.

TABLE 4.—Height as percent of length

	Sex not determined	Female	Male
Instar	72.4 (N=5)		
Instar II	77.1 (N=3)		
Instar III		75.5 (N=2)	73.7 (N=5)
Instar IV		80.3 (N=12)	78.0 (N=13)
Adult		82.0 (N=7)	77.1 (N=10)

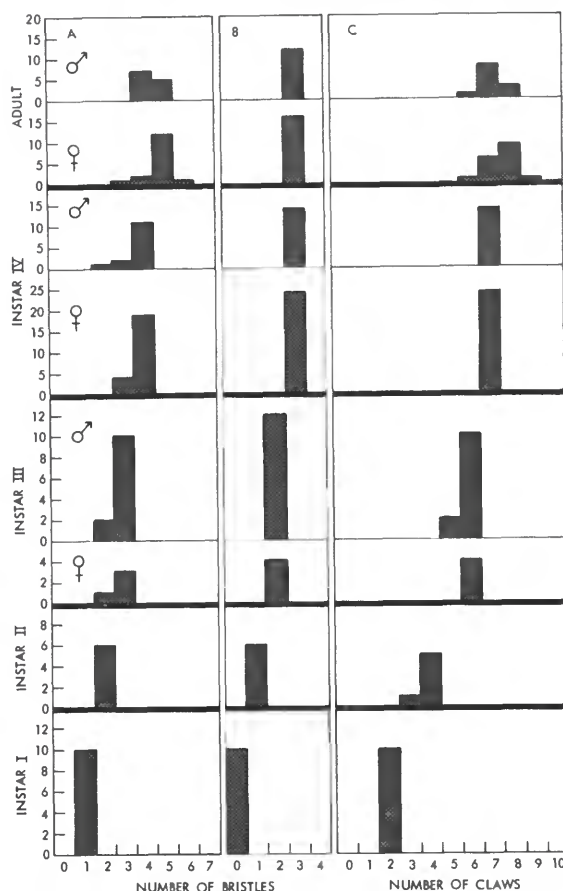


FIGURE 21.—Development: A, number of long spinous bristles on infold of caudal process of each valve; B, number of bristles on 4th joint of 1st antenna; C, number of furcal claws on each lamella. (Figures on left indicate number of valves or appendages examined.)

Specimen 29 is especially interesting in that the dimensions of the shell would lead one to believe that the specimen is at the instar I stage of development. The appendages of the specimen, however, have reached the same stage of development as those at the instar II stage. The mechanism causing the specimen to develop in this manner is not clear, nor is it known whether it is a rare or common phenomenon. One must conclude that either the shell is dwarfed, or the appendages have skipped one stage. I have assumed the former to be true in the present paper.

First antenna: The general morphology of the 1st antenna is quite similar for all instars and the adult female. The adult male develops the characteristic

TABLE 5.—*Summary of development*

Character	Sex undetermined		Females			Males		
	I	II	III	IV	Adult	III	IV	Adult
Shell, infold of caudal process:								
Large spinous bristles	1	2	2-3	3-4	5 (rarely 4 or 6)	2-3	3-4	4-5
Small spinous bristles	0	0	1-2	2-3	3 (rarely 2)	1-2	2-3	2-3
First antenna: bristles on 2d joint	0	1	1	1	1	1	1	1
Dorsal bristles on 4th joint	0	1	1	1	1	1	1	1
Ventral bristles on 4th joint	0	0	1	2	2	1	2	2
Sixth limb: bristles	0	1	15	20	20	15	20	20
7th limb: proximal bristles	limb absent	0	0	4	4	0	4	4
Distal bristles	" "	0	0	4	6	0	4	4
Terminal teeth per comb	" "	0	0	3	10	0	3	3
Furca, claws per lamella	2 + prong	3-4	6	7	7-8	6	7	7-8

TABLE 6.—*Average shell dimensions and calculated growth factors for females*

Growth stage	Average length (mm)	Growth factor	Average height (mm)	Growth factor	Number of specimens
adult	1. 77		1. 45		7
		1. 15		1. 18	
IV	1. 54		1. 23		12
		1. 26		1. 34	
III	1. 22		0. 92		3
		1. 20		1. 18	
II*	1. 02		0. 78		3
		1. 16		1. 22	
I*	0. 88		0. 64		5

* Sex not determined.

TABLE 7.—*Average shell dimensions and calculated growth factors for males*

Growth stage	Average length (mm)	Growth factor	Average height (mm)	Growth factor	Number of specimens
Adult	1. 56		1. 08		10
		1. 03		0. 92	
IV	1. 51		1. 18		13
		1. 21		1. 28	
III	1. 25		0. 92		5
		1. 23		1. 18	
II*	1. 02		0. 78		3
		1. 16		1. 22	
I *	0. 88		0. 64		5

* Sex not determined.

small 5th joint with its brush-like bristle and the long 6th joint. Instar I is without a dorsal bristle on the 2nd and 4th joints; a single dorsal bristle is present on each joint on all following stages. The number of ventral bristles on the 4th joint increases fairly gradually: Instars I and II have no bristles; instar III has 1; instar IV and adults of both sexes have 2. The distribution of bristles on the 2nd and 4th joints is tabulated in Table 5. The number of bristles on the 4th joint is shown in Figure 21b.

Second antenna: The form of the protopodite remains about the same in all stages of development. The medial spines on the 1st joint of the exopodite is straight on instar I and recurved in all following stages. The sclerotized proximal tip of the exopodite, where it attaches to the protopodite, seems less developed in instar I than in following stages, but this was not studied in detail herein. The endopodites of instars I and II are fairly similar to that on female instars III, IV, and the adult but differ as follows: instar I is without bristles on the 1st joint and on some specimens the 2nd joint cannot be distinguished; instars II-IV, and the adult have well defined 2nd joints and 1 or 2 bristles on the 1st joint; 1st joints with only 1 bristle are rare among adult females, but are fairly common in juveniles. The 1st joint of male instars III, IV, and the adult are similar, each usually having 2 bristles, but the 2nd and 3rd joints become more complex in each succeeding growth stage. The 2nd joint of male instar III, which bears 1 proximal bristle, is short and on some specimens fused with the 3rd joint. The 2nd joint of instar IV and the adult male is elon-

gate and bears 3 proximal bristles. The 3rd joint of instar III bears 1 short terminal bristle (this bristle is on the 2nd joint if the 3rd joint should be undeveloped). On instar IV the 3rd joint is much longer than on instar III and it bears 2 bristles on the terminal end. In the adult male the 3rd joint is recurved and, in addition to the 2 terminal bristles, the tip bears several ridges.

Specimen 31 is unusual in that the short 2nd joint of the 2-jointed endopodite bears 2 long bristles. I have considered this specimen herein to be an abnormal male at the instar II stage of development; however, it could also be an abnormal female or a male intermediate between what is considered herein instars I and II.

Kornicker and Wise (1962, p. 69) suggested that the 2-jointed endopodite of the 2nd antenna of the female of *Sarsiella texana* may have developed by a reduction in the number of joints. Although such a reduction may occur in some species, e.g., *Philomedes dentata* Poulsen (1962), it is possible with present knowledge to conclude from the data presented by Kornicker and Wise that the development of the endopodite of the 2nd antenna of *S. texana* is similar to that described herein for *Spinacopia sandersi*, and previously for *Sarsiella zostericola* by Jones (1958) and Kornicker (1967).

Mandible, maxilla, 5th limb: These appendages are well developed in instar I and are similar in both males and females. Little change except for size and possibly numbers of bristles takes place during later development. The male mandible differs considerably from the female, but in a manner typical for the family, and so will not be described here; both males and females have well-developed exopodites. The maxilla and 5th limbs of the adult male are reduced, but otherwise are fairly similar to those of the female.

Sixth limb: No sexual dimorphism. The 6th limb on instar I is a hirsute plate without bristles. On instar II the 6th limb bears 1 anteroventral bristle; on some specimens the margin is indented, suggesting division into more than 2 joints. Instar III has the 6th limb well developed, with 3 endites and a broad end joint; the limb bears a total of about 15 bristles; the 6th limb is fully developed in instar IV with 4 endites and the end joint, and bears a total of 17–22 bristles (Table 5).

Seventh limb: A 7th limb was not observed on instar I. On instar II the 7th limbs are short and without

bristles or end combs. The 7th limbs on instar III are longer but still without bristles or end combs. On instar IV the 7th limbs are longer and have 3 or 4 proximal and 4 distal bristles (rarely 5 distal bristles on female) and also 2 opposing terminal combs containing 3 teeth. The adult female has 4 (rarely 3) proximal bristles, 6 terminal bristles, and opposing terminal combs, each with about 10 teeth. The adult male has the same number of proximal bristles as the female, but only 4 distal bristles and 3 teeth in the terminal combs; it is also somewhat shorter and more slender than the female appendage (Table 5).

Furca: Instar I with 2 claws similar to claws 1 and 2 of adult followed by a single prong continuous with lamellae and with long marginal hairs (Table 5). Instar II with 4 claws (rarely 3) decreasing in length posteriorly. Instar III with 6 claws, 3rd claw shorter than 4th; 1 specimen (no. 31) has 5 claws decreasing in length posteriorly. Instar IV with 7 claws, claw 3 shorter than claw 4. Adult with 7 or 8 claws, claw 3 shorter than claw 4. Variability in the number of claws is shown in Figure 21c.

Rod-shaped organ: The organ is elongate and similar in all instars and adults but varies in the number of sutures that vaguely divide the appendage into joints. More of these were observed in early instars than on adults, where they are often absent. In some organs the sides are parallel, in others there are several constrictions or indentations. The tips are rounded or pointed.

POSTADULT MOLTING.—New appendages and valves were observed within the old in 2 instars, but none were present inside 12 adults examined for evidence of molting.

Kornicker (in Bowman and Kornicker, 1967, p. 16) mentions the occurrence in collections from the southern New England coast of 3 males of *Parasterope pollex* equal in size or larger than adult males, but having some juvenile characters. In that paper, I postulated that the large forms were caused by a delay of sexual maturity and did not result from postadult molting. Since then I have read the interesting paper by Word and Hobbs (1958) in which the form I and form II dimorphs of the male crayfish are discussed. Form I (first form males) are fully developed males. These, upon molting, become form II males (second form males), which have some juvenile characters. Upon molting the form II males revert to form I. It seems possible to attribute the juvenile characters of the

large males of *Parasterope pollex* to a similar phenomenon, but data are too fragmentary at this time to draw conclusions. In the present study all adult males of *Spinacopia sandersi* are fully developed.

Comparative Variation

The present study consisted mostly of counting bristles on the appendages and infolds of valves of adult females. These data are discussed below and summarized in histograms in Figures 22–26. Because only one specimen each of *S. menziesi* and *S. bisetula* are available, it is not possible to study their variability; however, they are included for comparative purposes. Knowledge of the variability limits of the two abundant species *S. variabilis* and *S. sandersi* permitted greater confidence in establishing as new species *S. menziesi* and *S. bisetula*, which are each represented in the collections by only one specimen. A similar technique was used by Poulsen (1962, p. 117) for differentiating species of *Gigantocypris*.

CARAPACE.—The carapace of *S. sandersi* is strongly punctate, whereas the carapaces of *S. variabilis*, *S. menziesi*, and *S. bisetula* are not. All specimens examined have a small bristle on the infold below the rostrum. All specimens with the exception of one specimen of *S. sandersi* have 5 large spinous bristles in a row on the infold anterior to the caudal process; the excepted specimen has 6 bristles on one valve and 5 on the other. As shown in Figure 22A, the number of small spinous bristles on the infold anterior to the caudal process varies. In general, *S. variabilis* has a greater number of these bristles than the other species.

Carapace height-to-length and carapace length relationships are presented in histograms in Figures 22B and C, respectively. Both measurements seem useful in distinguishing species.

FIRST ANTENNA.—No variation was observed in the number of bristles on the 2nd or 3rd joints, but the bristles varied somewhat in length and spinosity. The distribution of ventral bristles on the 4th joint is shown in a histogram in Figure 23A. Seventeen specimens of *S. variabilis* were studied; of these, thirteen have 2 ventral bristles on the 4th joint of both limbs, two have 3 bristles on both limbs, and two have 2 bristles on one limb and 3 on the other. Six specimens of *S. sandersi* have 2 ventral bristles on the 4th joint of both limbs. The only specimen of *S. bisetula* available also has 2 bristles on each limb. The specimen of *S. menziesi* differs from the other species in having 3 bristles on each

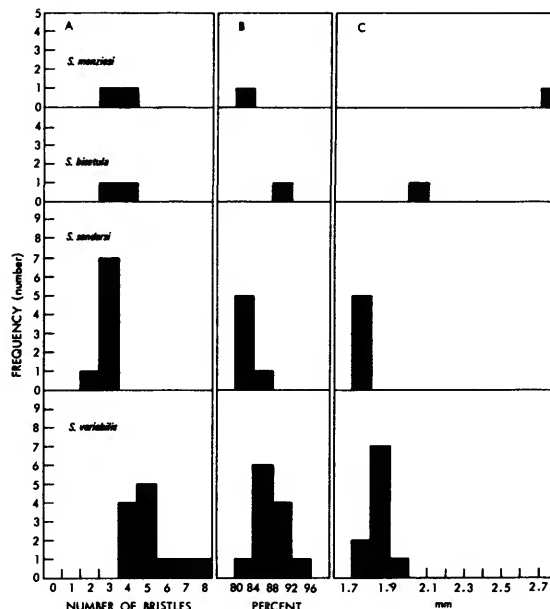


FIGURE 22.—Comparison of adult female carapaces: A, number of short spinous bristles on infold of caudal process; B, height of complete carapace as percent of length; C, length of complete carapace including caudal process.

limb. The constancy of the number of ventral bristles on the 4th joint of the two more numerous species suggests that the number of bristles on the 4th joint may be useful in distinguishing *S. menziesi* from the other three species.

The 6th joint has a small medial spine on most specimens but it is lacking in some. However, no detailed study was made of the distribution of this bristle. The bristles on the 7th and 8th joints may vary somewhat in the number of filaments on some of the bristles, but this was not studied. The length of the a-bristle was observed to vary within specimens of the same species.

SECOND ANTENNA.—The distribution of bristles on the exopodite is quite constant on all four species. It was observed that the lengths of the smaller bristle on the 9th joint and the medial spine on the 1st joint vary, but they were not measured. The distribution of bristles on the 1st and 2nd joints of the endopodite is shown in histogram in Figures 23B and C, respectively. All 14 specimens of *S. variabilis* examined have at least 3 bristles on the 1st joint of the endopodite of either the left or right limbs, 12 have 3 bristles on both left and right limbs; only one specimen has 2 bristles on one of its limbs, and only one specimen has 4

bristles on one limb. The 1st joint of both limbs of the unique specimen of *S. menziesi* has 3 bristles. On the other hand, the 1st joint of the endopodite of *S. bisetula* (one specimen) has only 2 bristles, and *S. sandersi* has 2 bristles on each limb of four specimens, 1 bristle on each limb of one specimen, and on another specimen, 1 bristle on the left limb and 2 on the right. The absence of 1st joints with 3 bristles on *S. sandersi* (six specimens) and the presence of 3 bristles on at least one limb of *S. variabilis* (14 specimens) suggests that 2 versus 3 bristles may be a useful criterion for distinguishing the species in the collection.

The 2nd joints of the endopodites of all specimens of *S. menziesi* (1), *S. bisetula* (1), *S. sandersi* (6), and most specimens of *S. variabilis* (11 of 14) have only 1 bristle. Two specimens of *S. variabilis* have 1 bristle on one limb and 2 on the other; one specimen has 2 bristles on each limb.

MANDIBLE.—The number of bristles on the mandible is constant on all specimens examined with one exception. The basale of one limb of the unique specimen of *S. menziesi* has an additional bristle on the lateral surface near the ventral margin, making 4 bristles compared to 3 on the other limb. All specimens on the other three species in the collection have 3 bristles in this region.

The bristle on the exopodite of *S. menziesi* reaches about one-third the distance up the 1st endopodite joint. The exopodite bristle on specimens of other species reaches only about one-quarter the distance or less.

Two small bristles on the 3rd endopodite joint vary in length in specimens of the same genus, but this was not studied in detail.

MAXILLA.—The number of bristles on the exopodite and endopodite of the maxilla is constant on the specimens examined. The number of bristles on the endites probably vary, but the difficulty in accurately counting these discouraged me from a detailed study.

FIFTH LIMB.—The number of bristles on the endite and exopodite joints of each 5th limb is shown in the histogram in Figure 24. The single endite on all species except *S. bisetula* has 1 bristle. The unique specimen of *S. bisetula* has 1 bristle on the endite of one limb and 2 on the other limb.

The 1st joint of the exopodite has 3 bristles on all except two specimens of *S. variabilis* which have 4 bristles on one of the 2 limbs and 3 on the other. One limb of a specimen of *S. sandersi* has only 2 bristles,

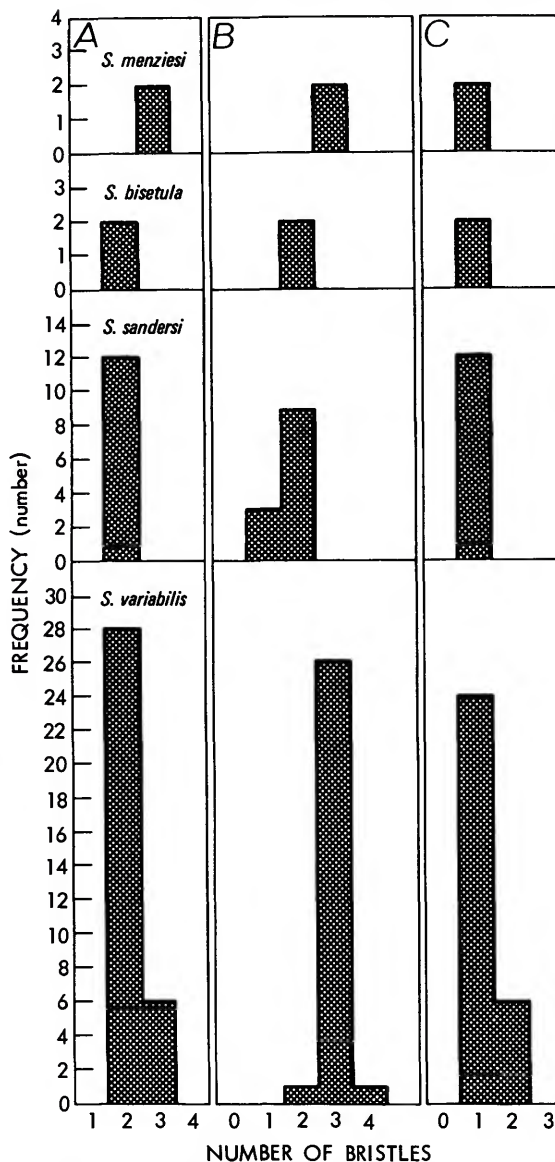


FIGURE 23.—Comparison of 1st and 2nd antennae of adult females: A, 1st antenna, number of ventral bristles on 4th joint. Second antenna, endopodite: B, number of bristles on 1st joint; C, number of bristles on 2nd joint.

but it is possible that a 3rd bristle was broken off during the dissection.

The 2nd joint of the exopodite has 6 bristles on all except two specimens of *S. variabilis* and one specimen of *S. sandersi*, which have 5 bristles on one limb and 6 on the other.

The inner lobe of the 3rd joint of both limbs of *S. bisetula* has 4 bristles. All other specimens examined have only 3 bristles with the exception of one specimen of *S. variabilis*, which has 4 bristles on one limb and 5 on the other. The presence of 4 bristles on *S. bisetula* suggests that this may be a specific character.

The outer lobe of the third joint has 1 bristle on all specimens examined with the exception of a single specimen of *S. variabilis*, which has 3 bristles on each limb.

The end joints (4th +) have a varying number of bristles. The unique specimen of *S. menziesi* has 4 bristles on both limbs. The specimen of *S. bisetula* has 4 bristles on one limb and 5 on the other. Seven specimens of *S. variabilis* have 4 bristles on both limbs; one specimen has 5 bristles on both limbs, and two specimens have 4 bristles on one limb and 5 on the other. The number of bristles on the end joints on specimens of *S. sandersi* differs from the other species. All specimens of this species have at least 6 bristles on one of the limbs; two specimens have 6 bristles on both limbs; two have 5 bristles on one limb and 6 on the other; one has 4 bristles on one limb and 6 on the other; one has 3 bristles on one limb; it is possible, however, that 4 bristles were on this limb prior to the dissection. The presence of 6 bristles on the end joints of *S. sandersi* clearly may be considered a specific character useful in distinguishing that species from others in the collection.

The number of bristles on the epipodial appendage of each 5th limb is not shown in Figure 24, but they may have significance as a specific character. The epipodial appendages of the single specimen of *S. menziesi* have 46–48 bristles; the single specimen of *S. bisetula* has 41 bristles; four specimens of *S. variabilis* examined have 40–42 bristles; four specimens of *S. sandersi* have 38–42 bristles. The large number of bristles on the specimen of *S. menziesi* stands out as being different from specimens belonging to the other three species.

SIXTH LIMB.—The 4 endites are separated from each other by indentations on *S. menziesi*, *S. bisetula*, and *S. variabilis*, but on *S. sandersi* the outer margin of the joint is fairly evenly rounded, and the endites are distinguishable mainly by clumping of bristles. The number of bristles on the endites and end joint of each 6th limb is shown in Figure 25.

First endite: First endite has 3 bristles on most species with the following exceptions: two specimens

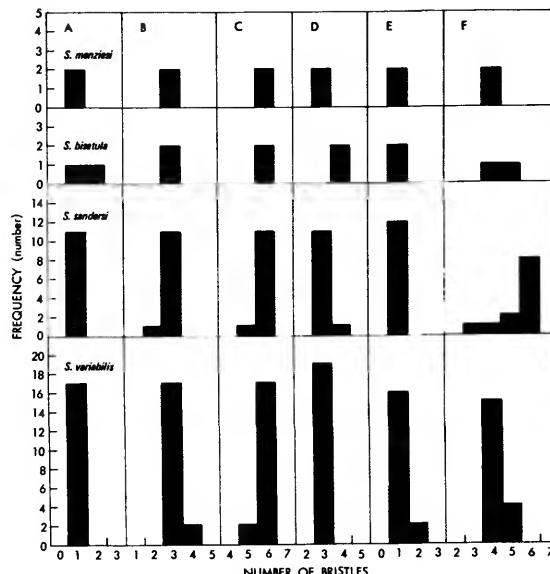


FIGURE 24.—Comparison of number of bristles on 5th limbs of adult females: A, endite. Joints of exopodite: B, 1st; C, 2nd; D, inner lobe of 3rd; E, outer lobe of third; F, 4th plus.

of *S. sandersi* and *S. variabilis* have 4 bristles on one of the limbs; two specimens of *S. variabilis* have 2 bristles on one of their limbs; the unique specimen of *S. menziesi* has only 1 bristle on each 1st endite, but it is possible that additional bristles were fragmented during dissection.

Second endite: All specimens have 2 bristles on the 2nd endite with the following exceptions: The unique specimen of *S. menziesi*, two specimens of *S. variabilis*, and one specimen of *S. sandersi* have 3 bristles on one limb; one specimen of *S. sandersi* has 3 bristles on each limb, and one specimen has only 1 bristle on one limb.

Third endite: The unique specimen of *S. menziesi* and six specimens of *S. variabilis* have 4 bristles on both limbs of the 3rd endite. Only two specimens of the latter species have 3 bristles on one of the limbs and 4 on the other. This suggests that the presence of 4 bristles on both limbs is a fairly stable character for *S. variabilis*. On the other hand, of the six specimens of *S. sandersi* examined, only two have 4 bristles on both limbs; three have 3 bristles on one of the limbs, and one has only 2 bristles on one of the limbs. This suggests the presence of 4 bristles on both limbs is less characteristic of *S. sandersi* than it is of *S. variabilis*. However, more material would have to be examined to

determine whether the differences are statistically significant. The unique specimen of *S. bisetula* has 3 bristles on one limb and 4 on the other.

Fourth endite: Of the ten specimens of *S. variabilis* examined, eight have 3 bristles on the 4th endites of both limbs, one has 3 bristles on one limb and 4 on the other, and one has 4 bristles on one limb and 5 on the other. Clearly the presence of 3 bristles on both limbs of the 4th endite is a fairly stable characteristic of *S. variabilis*. All six specimens of *S. sandersi* have 3 bristles on the 4th endite of at least one of the limbs, only three have 3 bristles on each limb. Two of the remaining three specimens have 4 bristles on the opposing limb, and one specimen has only 2 bristles on one limb. The unique specimen of *S. menziesi* has 3 bristles on each limb. The single available specimen of *S. bisetula* differs from the other species in having 4 bristles on the 4th endite of each limb.

End joint: On all specimens examined the bristles on the end joint may be subdivided into an anterior group, a middle group, and a posterior group, each separated by a space. The posterior bristles differ from the others in being stouter and having long, thin marginal hairs.

All ten specimens of *S. variabilis* examined have at least 4 anterior bristles on one of the limbs; five specimens have 4 bristles on both limbs; three specimens have 3 bristles, and two specimens 5 bristles on the other limb. The single specimen of *S. menziesi* has 4 bristles on both limbs. The single specimen of *S. bisetula* has 3 bristles on one limb and 4 on the other. The number of anterior bristles is more variable on specimens of *S. sandersi* than on the other three species. None of the six specimens examined has the same number of anterior bristles. The combinations of bristles on each limb of the six specimens are as follows: 2-2; 2-3; 3-4; 4-4; 4-5; 2-4.

All six specimens of *S. sandersi* have 2 bristles in the middle group on at least one of the limbs; three specimens have 2 bristles on both limbs, two have only 1 bristle, and one has 3 bristles on one limb. On the other hand, four of the ten specimens of *S. variabilis* examined have only 1 middle bristle on each limb; three have 2 bristles on each limb, and two have 2 bristles on one limb and 1 on the other; one specimen has 2 on one limb, but the number on the opposing limb could not be determined. Both limbs of the unique specimen of *S. menziesi* have 2 bristles; the speci-

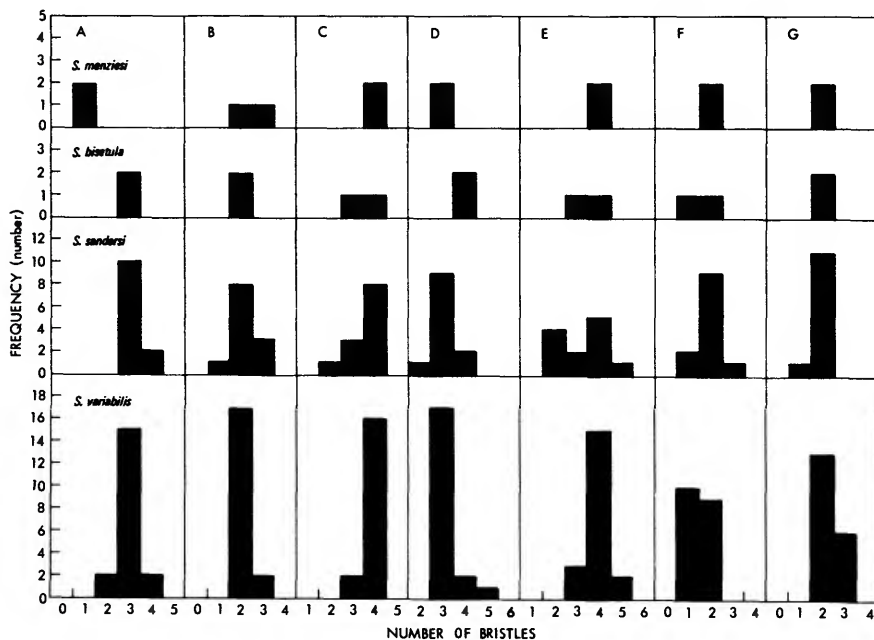


FIGURE 25.—Comparison of number of bristles of 6th limb of adult females: A, endite I; B, endite II; C, endite III; D, endite IV; E, anterior bristles end joint; F, middle bristles end joint; G, posterior bristles end joint.

men of *S. bisetula* has 1 bristle on one limb and 2 on the other.

The single specimens of *S. menziesi* and *S. bisetula* each have 2 posterior bristles on end joint of each limb. Of the six specimens of *S. sandersi* examined, five have 2 posterior bristles on each limb; one specimen has 2 posterior bristles on one limb and only 1 on the other. The variability of numbers of posterior bristles on *S. variabilis* may differ from the other species. Three of ten specimens examined have 3 posterior bristles on each limb; one specimen has 3 bristles on one limb and 2 on the other; five specimens have 2 bristles on each limb; one specimen has 2 bristles on one limb, but the number of bristles on the opposing limb could not be determined.

SEVENTH LIMB.—The number of comb teeth, the angle at which the teeth project, and the distance between combs seem to vary, but were not studied herein. The 7th limbs of all the specimens examined have 6 bristles in the distal group, 3 on each side. The number of bells located distally on each bristle vary somewhat but were counted on only a few specimens. The number of bristles in the proximal group seemed to vary significantly, and their distributions are shown in the histogram in Figure 26A.

All specimens of *S. sandersi* have 4 bristles in the proximal group of at least one of the limbs; three specimens have 4 bristles on each limb; two specimens have 3 bristles on one of the limbs; on one specimen the tip of the 7th limb is missing. The unique specimen of *S. bisetula* has 4 bristles in the proximal group on each limb. The unique specimen of *S. menziesi* is quite different, having 8 bristles in the proximal group of one limb and 10 in the other. *S. variabilis* falls between *S. menziesi* and the other two species in having 5 or 6 bristles in the proximal group of the 7th limb of most specimens; only one of seven specimens examined has 4 bristles on each limb, the rest have at least 5 bristles on one of the limbs; one specimen has 5 on one limb and 7 on the other; two specimens have 6 bristles on each limb.

CAUDAL FURCA.—The number of claws on the left and right lamellae are shown in the histogram in Figures 26B and C, respectively. Six specimens of *S. sandersi* have 8 claws on at least one of the lamellae; three have 8 claws on both lamellae, three have 7 on one and 8 on the other, and one has 7 claws on 1 lamella

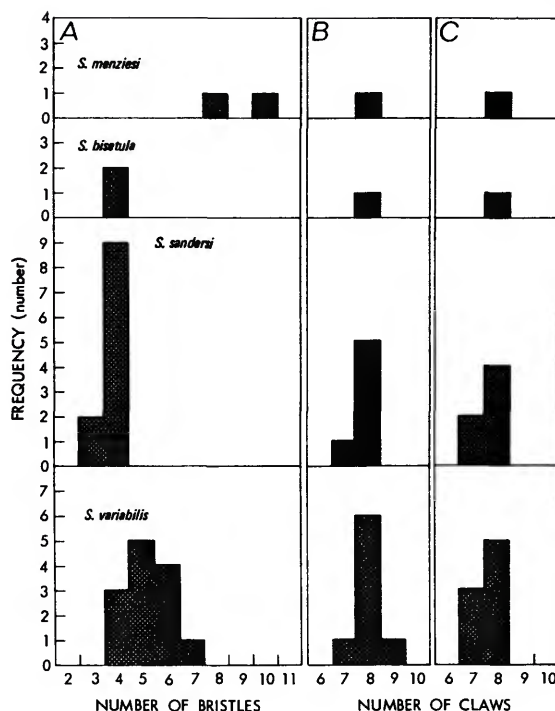


FIGURE 26.—Comparison of 7th limb and furca of adult females: A, bristles in proximal group of 7th limb; B, number of claws on left lamella; C, number of claws on right lamella.

and 9 on the other. Seven of the eight specimens of *S. variabilis* have 8 claws on at least one of the lamellae; four of these have 8 claws on both lamellae, and three have 7 on one and 8 on the other. The eighth specimen of *S. variabilis* has 7 claws on one lamellae and 9 on the other. The single specimen of *S. menziesi* and *S. bisetula* have 8 claws on each lamella.

All specimens examined have only claw 1 continuous with the lamellae; the remaining claws are separated from the lamellae by a suture. On all specimens claw 3 is smaller and weaker than claw 4. The lamella having 9 claws on the single specimens of *S. variabilis* and *S. sandersi* mentioned above differed in having both the 3rd and 5th claws small and weak. It is possibly significant that the specimen of *S. variabilis* with 9 claws and an unusual 5th claw is from station V-18-13 (135 m depth), whereas the remaining specimens with the normal furca are from station V-15-131 (1475 m depth), but additional material is needed to investigate this possibility.

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PLATES

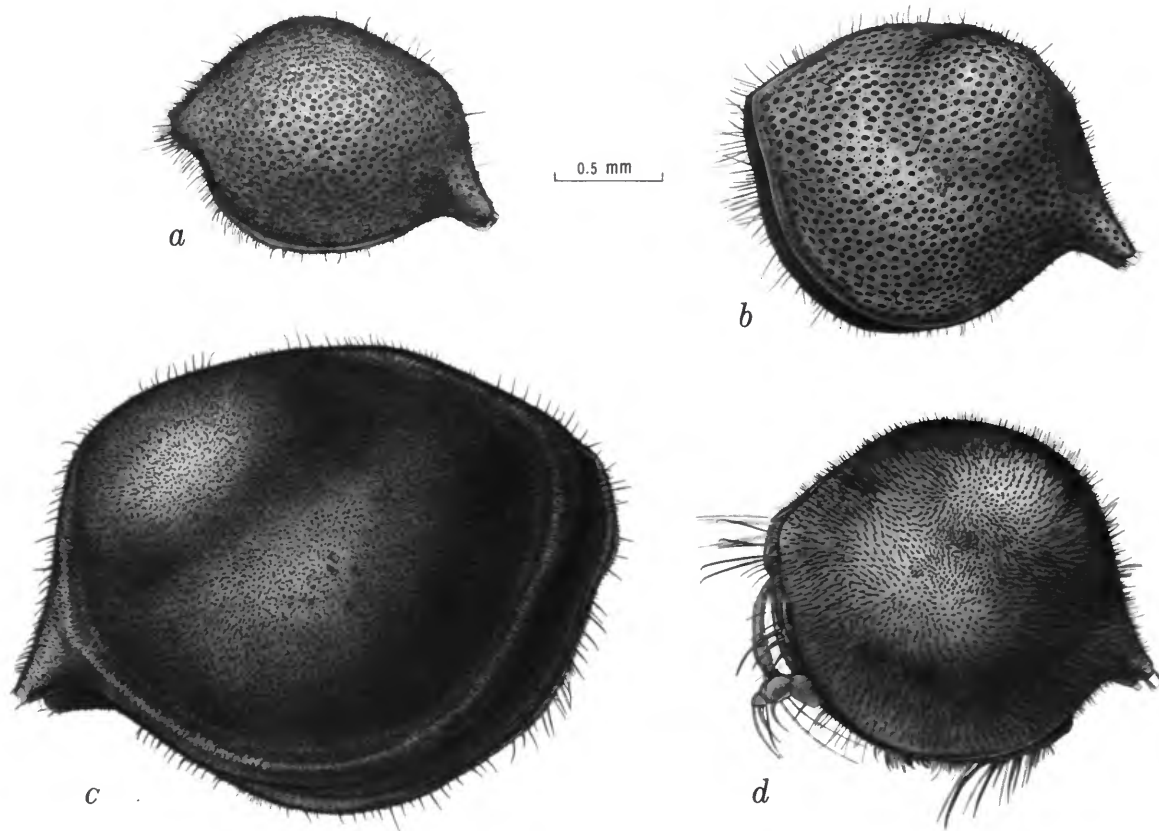


PLATE 1.—*Spinacopia sandersi*: a, ♂ adult, USNM 122692; b, ♀ adult, USNM 122561. *Spinacopia menziesi*: c, ♀ USNM 122086. *Spinacopia variabilis*: d, ♀ adult, USNM 122691.

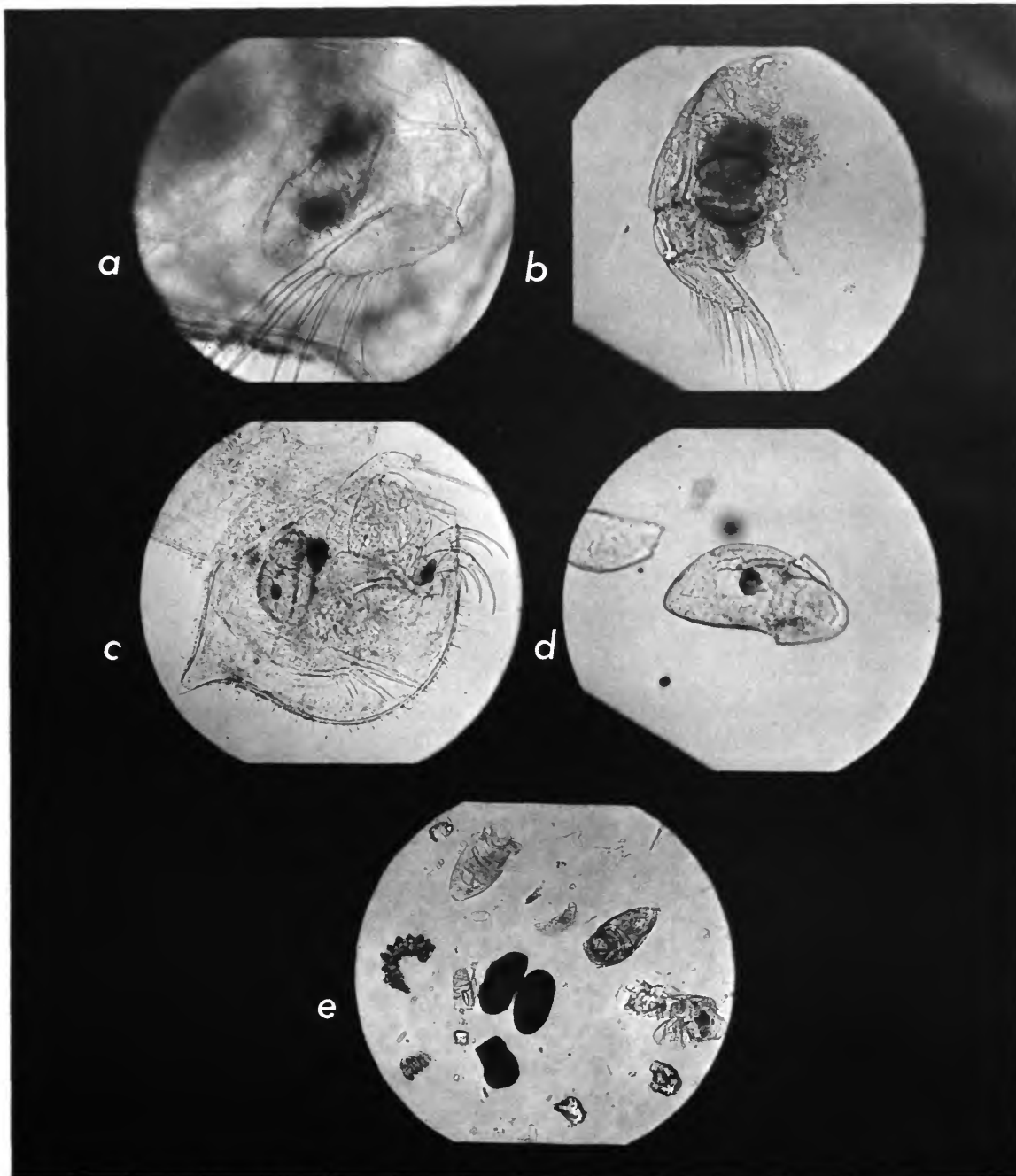


PLATE 2.—Food: *a*, copepod in stomach of *Spinacopia sandersi*, ♀ instar III, specimen 34; *b*, polycopid ostracod in stomach of *S. sandersi*, ♀ instar IV; *c*, podocopid ostracod in stomach of *S. sandersi*, instar II, specimen 29; *d*, detail of podocopid ostracod from specimen 29; *e*, gut content of *S. variabilis* from station V-15-131.

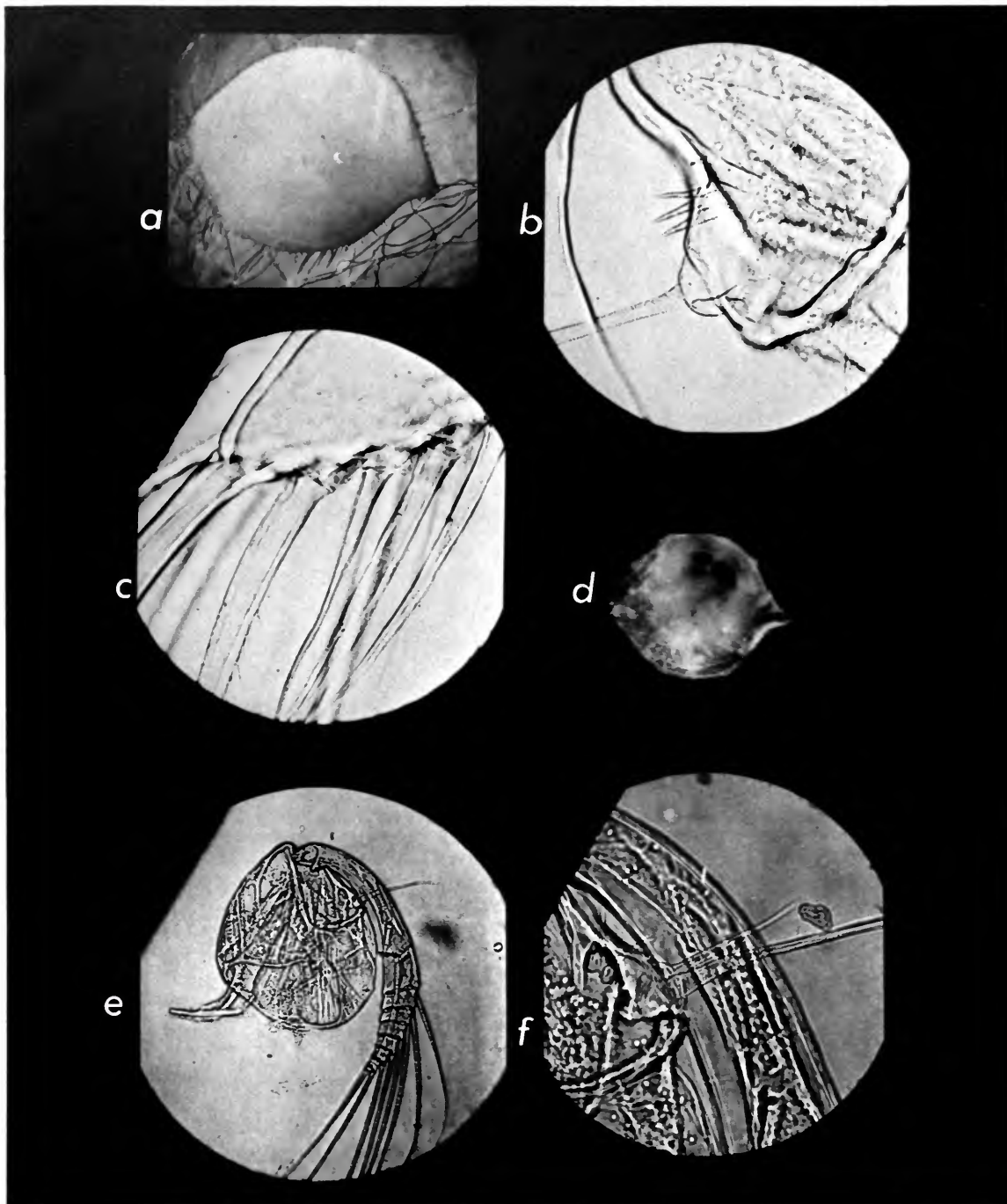


PLATE 3.—*Spinacopia menziesi*, holotype: *a*, carapace, L=2.75 mm; *b*, 2nd antenna; *c*, furca. *Spinacopia bisetula*, holotype: *d*, carapace, L=1.92 mm. *Spinacopia variabilis*, holotype: *e*, *f*, 2nd antenna.

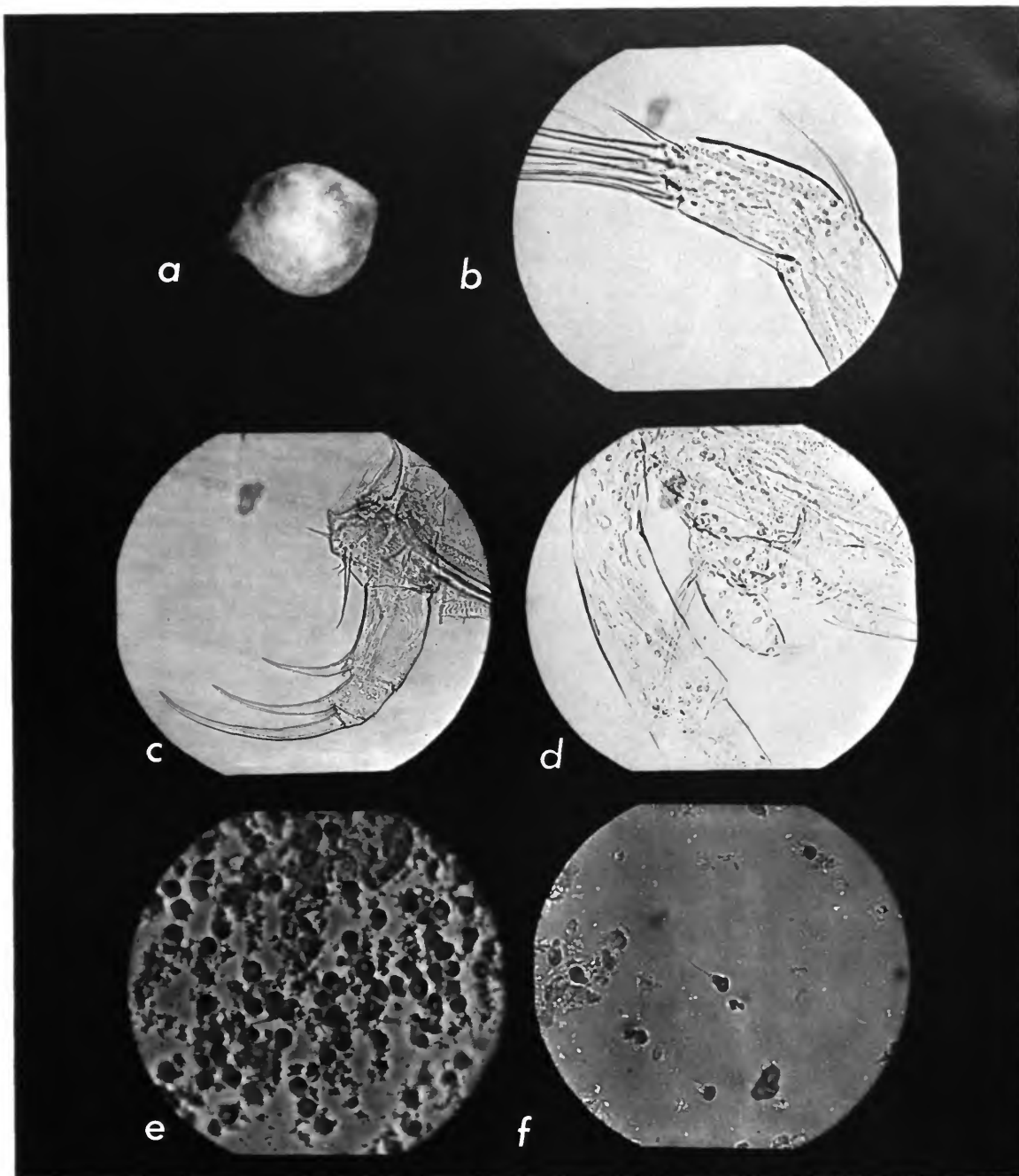


PLATE 4.—*Spinacopia sandersi*: a, carapace, ♀ adult, holotype L=1.77 mm; b, 1st antenna, ♂ instar III, specimen 10; c, mandible, ♀ instar IV, specimen 15; d, 2nd antenna, ♂ instar III, specimen 10; e, smear showing sperm from testes, ♂ adult, specimen 3 (stained); f, smear showing sperm from seminal vesicle, ♂ adult, specimen 36 (stained). (Figures e and f made with phase illumination.)

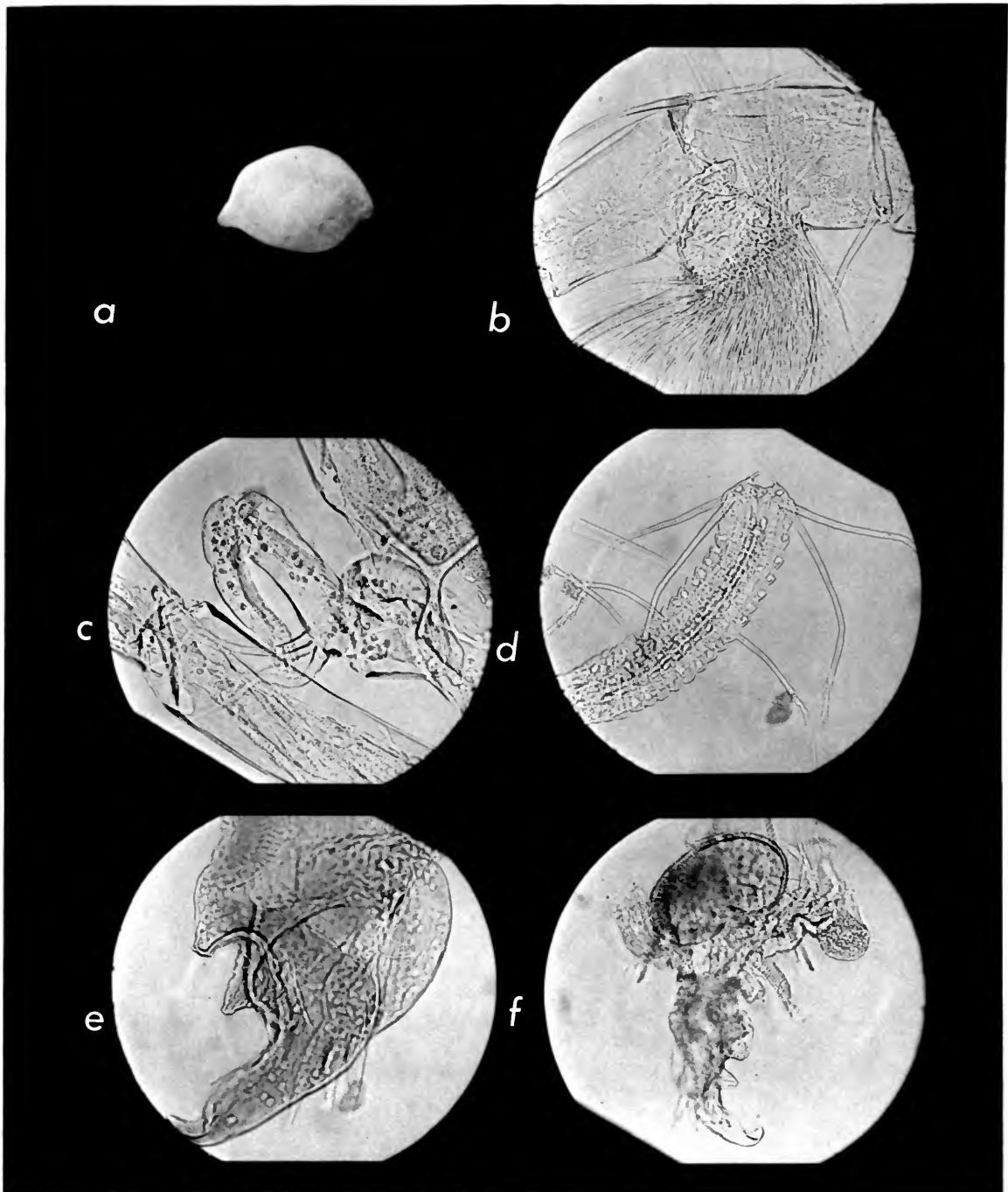
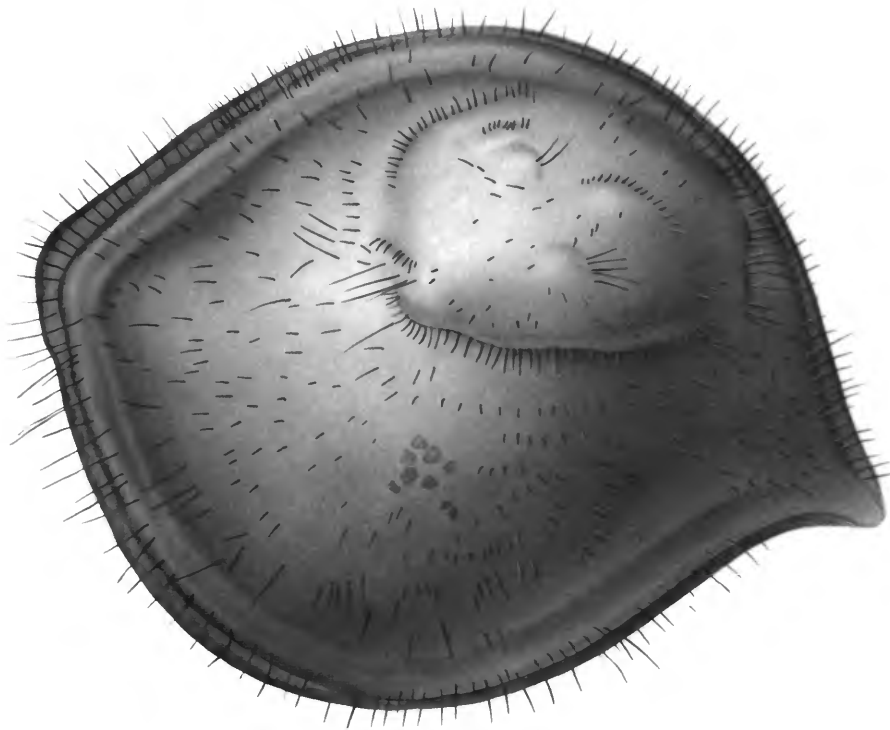


PLATE 5.—*Spinacopia sandersi*, ♂ adult, specimen 3: *a*, carapace, L=1.59 mm; *b*, 1st antenna; *c*, 2nd antenna; *d*, 7th limb; *e*, copulatory organ. Specimen 37: *f*, copulatory organ.



0.1 mm

PLATE 6.—*Spinacopia bisetula*, carapace of holotype.

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