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The Alpheid Shrimp of Australia

Part 2: The Genus *Synalpheus*

By

Dora M. and Albert H. Banner

Hawaii Institute of Marine Biology, University of Hawaii, Honolulu

Figures 1–29.

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SUMMARY

This is the second section of a projected tripartite study on the shrimp of the family in Australian waters; the first section (Banner & Banner, 1973), dealt with the lower genera, and contained also keys to the genera and locality lists for the entire collection; the third section will be confined to the genera *Alpheus, Metalpheus* and *Batella,* with notes on the related family Ogyrididae in Australian waters, and will also contain the bibliography for the series.

This study of the genus *Synalpheus* is based upon 1,437 separate specimens on loan from various Australian museums and other institutions and our personal collections. This section discusses the following species, with those which are new species or subspecies and those which are new records to Australian waters being marked by an asterisk.

**Synalpheus carinatus* (De Man)
**Synalpheus tropidodactylus* sp. nov.
Synalpheus comatularum (Haswell)
Synalpheus stimpsoni (De Man)
**Synalpheus quadriarticulatus* sp. nov.
**Synalpheus pescadorensis* Coutière
**Synalpheus sciro* sp. nov.
**Synalpheus bituberculatus* De Man
**Synalpheus harpagatrus* sp. nov.
**Synalpheus theano* De Man
Synalpheus neptuntus neptunus (Dana) [subspecies designated]
**Synalpheus neptunus germanus* subsp. nov.
**Synalpheus demani* Borradaile
**Synalpheus nilandensis* Coutière

**Synalpheus heroni* Coutière
Synalpheus fossor (Paulson)
Synalpheus haddoni Coutière
Synalpheus coutierei Banner
**Synalpheus bispinosus* De Man
**Synalpheus ancistrorhynchus* De Man
**Synalpheus lophodactylus* Coutière
**Synalpseus hastilicrassus* Coutière
Synalpheus neomeris (De Man)
**Synalpheus streptodactylus* Coutière
Synalpheus pococki Coutière
**Synalpheus iocosta* De Man
Synalpheus charon (Heller)
**Synalpheus gracilirostris* De Man
**Synalpheus echinus* sp. nov.
Synalpheus tumidomanus (Paulson)
**Synalpheus paraneomeris* Coutière

We have placed the following species and subspecies in synonymy:

S. stimpsoni (De Man) synonyms:
S. amboinae (Zehntner); *S. brucei* Potts; *S. striatus* Kubo.

S. fossor (Paulson) synonyms:
A. sp. variatas De Man; *S. bakeri* Coutière; *S. bakeri stormi* De Man.

S. hastilicrassus Coutière synonyms:
S. acanthitelsonis Coutière; *S. hastilicrassus acanthitelsoniformis* De Man

S. neomeris (De Man) synonym:
S. gravieri Coutière

S. streptodactylus Coutière synonym:
S. streptodacytlus hadrungus Banner & Banner

S. charon (Heller) synonym:
S. prolificus (Bate)

S. tumidomanus (Paulson) synonym:
S. maccullochi Coutière; *S. anisocheir* Stebbing

Fourteen nominal species and subspecies have been reported from Australian waters; of these, we have been able to confirm 12, but we have placed 3 of the 12 in synonymy. Of the remaining two, one, *S. haddoni* Coutière, we have carried on our lists although it is not represented in the present collections; the other, *S. latastei* Coutière (1909), we could not confirm and, as it was listed with doubts by the original author, we suggest that the listing was in error.

CONTENTS

INTRODUCTION

In this second section of our projected tripartite study we are confining ourselves to the genus *Synalpheus*. The reader is referred to the initial publication (Banner & Banner, 1973: 294) for a statement of our aims, the adequacy of our sampling, general notes of biology, distribution and ecology of alpheids, the keys to the genera, and for the collection data which is listed in this section under the alphanumerical code. As in Part I (page 306) measurements in millimetres given for the size or length of specimens are always the total length from rostrum to tip of telson unless carapace length is specified. In the third section we plan to publish on the two closely related genera, *Alpheus* and *Metalpheus,* discuss *Batella* and give notes on the related family Ogyrididae. The last section will contain the full bibliography for the three sections and data on additional collections.

We did not remark in Part I that we are studying several other collections concurrently with the study of the Australian species. The most important of these collections come from the Philippines, Indian Ocean and Red Sea; while we plan to publish upon them separately in the form of regional annotated checklists, we have used them where desirable to broaden the basis of our systematic considerations. We have also referred to specimens in these collections under our section on "General Distribution". These unpublished records we have marked with an asterisk.

Support and acknowledgments:

Our support and acknowledgments of aid are the same as those listed in Part I, and again we wish to express our deep thanks to those individuals and institutions who have been so helpful to us in this protracted study. We must repeat our acknowledgment of the financial support from the U.S. National Science Foundation through grants GB3809, GB6386 and GB25020.

Genus **SYNALPHEUS**

Synalpheus Bate, 1888, Challenger Rept. Zool. 24:572*

Type species: *Synalpheus falcatus* Bate, 1888 (= *Alpheus comatularum* Haswell, 1882)

Definition: Rostrum and orbital hoods always developed, orbital hoods completely enclosing eyes from dorsal and anterior aspects. Orbitorostral process usually well developed and protruding ventrally to low ocular beak; both processes lacking in some species. Pterygrostomial angle produced, usually subacute and rounded.

Antennules with basal articles heavy, stylocerite with lateral spine well developed, flagellum with weak bifurcation. Scaphocerite with squamous portion always shorter than lateral spine, and rudimentary in some species. Basicerite bearing one or more teeth.

Mandibles at times with *pars incisiva* reduced. Last article of third maxilliped bearing either setae or spines at tip.

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* While Bate established the genus, it was not given its presently accepted definition until Coutière published his monograph in 1899; it was also at this time that most species previously assigned to *Alpheus* were included (for a full discussion see De Man, 1911: 185).

Large chela massive, carried extended, ovoid and without sculpture; dactylus short and almost always with cylindrical process fitting into chamber at base of pollex; carpus cyathiform. Small chella markedly smaller than large, simple, with fingers usually unarmed and fitting exactly; carpus frequently elongate.

Second pereiopods with carpus usually of five articles, in a few species of four articles. Following legs short and compressed, dactyli with two or three ungui.

Endopod of second pleopods of male lacking in the *appendix masculina.*

Sixth abdominal segment without articulated pleura. Uropods normal in most species, but lacking articulation in outer uropod in some. Telson lacking anal tubercles and posterior margin convex to straight. Caudal fan carrying exceedingly large spines on some species.

Branchial formula: 5 pleurobranchs, 1 arthrobranch, 2 epipodites; no mastigobranchs or setobranchs.

Discussion

Separation of Synalpheus from Alpheus

This genus is most closely related to the genus *Alpheus,* and to one unaccustomed to the appearance of members of both genera the assignment of the species between the two may present difficulties. The most certain criteria for the separation of the genera are the produced pterygostomial angle on the carapace in *Synalpheus* (see fig. 3a) and the branchial formulae which lacks six of the epipodites found in *Alpheus.* With the diversity of characteristics found in both large genera, no other single characteristic can be completely relied upon. However, if the exceptions are kept in mind, the following tabulation may be of value:

	Synalpheus	*Alpheus*
Rostrum and orbital teeth	Always developed, seldom with crests or ridges	Of varying development often without orbital teeth, often with a rostral crest
Large chela	Always ovoid in section, never with sculpturing	Seldom ovoid in section, usually with a combination of compression, twisting, and sculpturing
Carpus, second legs	First article usually about as long as sum of distal four articles	Variable, usually with first article shorter than sum of four following articles
Dactylus of third legs	Always bi- or tri-unguiculate	Usually simple, biunguiculate in a few.

Subgeneric groups:

In 1908b and then more fully in 1909, Coutière established six groups of species within the genus that were supposed to show evolutionary patterns and subgeneric affinities. To each "group"—he did not apply the term "subgenus"—he gave the name of one of the characteristic species found within it. This procedure of naming has caused two of his groups to change names when the species names were synonymized (see below).

What utility the groups originally had we cannot determine at this time except to say that they were accepted by Coutière's contemporary, De Man ("... six groups that are quite natural and that therefore are also accepted by me." 1911: 189). However, the addition of many new species, especially by De Man and the later works of Coutière, caused greater and greater modifications of the definition of the groups. We had hoped to be able to use these collections and this paper for a complete reassessment of Coutière's groups, either their redefinition and re-establishment or for a substitution of another "subgeneric" scheme of separation of the numerous species found in the genus. Our considerations of the individual groups, together with the Australian species that appear to belong to each group, are given below:

Comatularum Group:

Australian species: *S. carinatus, tropidodactylus, comatularum, stimpsoni.*

Notes: This group seems to be well separated from the other synalpheids by a series of characteristics:

1. The orbitorostral process is lacking (we plan to discuss the orbitorostral process and the associated ocular beak in a future paper).

2. The frontal region of the carapace is produced far beyond the eyes; the rostrum usually bears a crest and is markedly longer than the orbital teeth.

3. The merus of the third leg never bears spines, and the dactylus usually has the ungui hooked and the inferior unguis is always narrower in basal width and shorter than the superior.

In addition, most species live in association with crinoids (see Appendix). We have considered whether this group is distinct enough to raise to a separate generic level (in which case it would have to retain the name *Synalpheus*), but have decided that such a revision is unnecessary at this time.

Neomeris Group:

Australian species: *S. demani, nilandensis, heroni, fossor, neomeris, streptodactylus, pococki, iocosta, charon, paraneomeris.*

Notes: The principal characteristics for the group emphasized by Coutière were that the superior unguis of the third dactylus was always smaller than the inferior and that the orbital teeth were always longer than broad at the base. We have found that at least in *S. paraneomeris* and *S. streptodactylus* the relationship between the ungui is variable and the ungui may approach equality; similarly, the orbital teeth are variable in a number of species and they cannot be clearly separated from those of many other synalpheids. Other characteristics, such as the presence of an orbitorostral process and the tapering dactylus of the small chela which is also without a row or tuft of setae, are found in common with most of the other synalpheids. We therefore find the group to be neither of taxonomic use nor of systematic importance.

Paulsoni Group:

Australian species: *S. ancistrorhynchus, hastilicrassus, gracilirostris, echinus. tumidomanus.*

Notes: Coutière characterized this group as (1) with two ungui of the dactylus of the third leg equal in breadth and both long and slender; (2) without spines on the merus of the third legs; (3) with orbital teeth always longer than wide; (4) with having an orbitorostral process; a few other characteristics were also given. Even in this small number of Australian species, we found each part of the definition be to violated by one or more species, or to be so variable within a species as to be unreliable. The sole exception in the presence of the orbitorostral process, but many other synalpheids share this characteristic. We find that this nominal group is not useful.

Brevicarpus Group:

Australian species: none.

Notes: This small group, known only from American waters, was distinguished by Coutière principally by the lack of an orbitorostral process and by the short rostrum and orbital teeth. He did not remark that both the Comatularum and the Gambarelloides (= Laevimanus) Groups also lack the orbitorostral process. The formation of the anterior region of the carapace appears to be a fair characteristic for the group and certainly separates it from the Comatularum group; the lack of a crest of setae on the dactylus of the small chela separates it from the Gambarelloides group. However, our examination of species of this group at the Smithsonian Institution showed that the lack of an orbitorostral process was not consistent. In *S. minus* (Say) (= *S. brevicarpus* (Herrick) see Chace, 1972: 95) we found that some specimens, but not all, have a plate of varying development on the ventral side of the rostrum and this plate may be developed into a small process. In *S. digueti* Coutière a small but definite process is always present. These two species definitely have the reduced rostrum and orbital teeth characteristic of the group. As there are no species assigned to this group in our Indo-Pacific collections we will not evaluate its worth further.

Gambarelloides Group (previously Laevimanus Group—see Holthuis, gottlieb, 1958: 48)

Australian species: possibly *S. haddoni.*

Notes: This group also is known almost entirely from American waters, with the exception of two Mediterranean species and possibly the species listed above. Coutière characterized the group by a "brush" of thick and crowded long hairs normal to the dactyl of the small chela. Our examination of the specimens of species of this group at the Smithsonian Museum and the American Museum of Natural History indicates that this appears to be a consistent characteristic, not found in comparable development elsewhere in the genus. The orbitorostral process was also lacking in these species except for *S. anisimanus* Chace; this species, however, had only a thickened horizontal plate and no projecting process. Again, as we have no species of this group in our Indo-Pacific collections, we refrain from additional evaluation.

Coutièrei Group (previously Biunguiculatus Group—see Banner, 1953: 37)

Australian species: *S. quadriarticulatus, pescadorensis, sciro, harpagatrus, theano, neptunus neptunus, neptunus germanus, coutierei, bispinosus, lophodactylus.*

Notes: This group is characteristically an Indo-Pacific Group and is the largest in Australian waters. As defined by Coutière it had no firm characteristics, such as the brush of hairs on the small chela for the Gambarelloides group. Some members of this large and variable group of species from Australia violate each characteristic as set forth by the definition; therefore the group cannot be regarded as coherent.

Seven species within the group, however, seem to be set off, but rather poorly, from all other species of synalpheids. These are the species with broadened and dentate fingers of the small chela; the fingers often have more than one tooth and usually are excavate. They are found in the following key from dichotomies 6 to 12, inclusive. However, there appears to be two rather fundamental differences in the group thus united by the form of the fingers. Three lack the orbitorostral process and also lack a distal articulation of the outer uropod; the other four species have both the process and the articulation. We believe that to separate these species into subgeneric groups would not be of any great advantage.

Thus of the six groups erected by Coutière, only three may be coherent enough to continue to be recognized; of these three, only one occurs in the Indo-Pacific (with the possible exception of the Gambarelloides group). The other three groups into which the great bulk of the Indo-Pacific species have been assigned, are of "dubious relationships and are of almost no aid in classification" (Banner, 1953: 28). To our knowledge, no other author since Coutière has taken this stand, but we note that Chace (1972: 79–104) did not utilize the groups when classifying the synalpheids, and that he remarked on his only new species outside the well-defined Gambarelloides group: "*Synalpheus obtusifrons* seems to belong to the Brevicarpus group of the genus" (underlining ours).

Variation in the synalpheids

Compared to the members of the genus *Alpheus,* the species in this genus are remarkably uniform in appearance. Most show but little difference in the frontal region of the carapace; there is only slight variation between species in the antennular and antennal peduncles; the large chela varies principally in the armature above the dactylar articulation; the first carpal article of the second legs usually is about equal to the sum of the four following; even the dactylus the third leg is usually biunguiculate.

Previous workers, faced with this uniformity of characteristics, began to rely upon rather small and subtle differences to differentiate between species or subspecies. This differentiation appeared to be satisfactory when the worker had only a few specimens; however, when large numbers of specimens were at hand they encountered such variation that at least Coutière responded by creating a large number of supposedly discrete subspecies (see Coutière, 1909: *passim*).

The amount of variation we have found in our large collections of some species is indeed confusing. Thus *Synalpheus charon* varies in the length of the stylocerite, but is fixed in configuration of the unusual dactylus of the third leg; on the other hand, *S. noemeris* and *S. streptodactylus* are quite constant in the development of the stylocerite, but quite variable in the proportions of the ungui of the third leg. In some, like *S. theano* and *S. neptunus neptunus,* the squame varies from moderate development to occasionally rudimentary; *S. bituberculatus* may lack the supposedly characteristic two tubercles above the dactylar articulation of the large chela; *S. hastilicrassus* shows wide, but apparently continuous variation in the development of teeth on the posterolateral corners of the telson. Yet some rather small characteristics seemingly are constant: as we pointed out in an earlier paper (Banner & Banner, 1972), the only way that *S. theano* and *S. n. neptunus* can be separated is by the armature of the distal article of the third maxilliped.

This variation could be explained if it occurred only in those species which are found in symbiotic relationship with sponges, crinoids, etc. Thus, in the protection of a spongocoel, the variation in the dactylus of the third leg in *S. streptodactylus* would make little difference in survival, or if *S. comatularum* has the strongly hooked dactyli of the walking legs, and the scimitar-shaped dactylus of the small chela for holding to its host crinoid, differences in the length of the rostrum and orbital hoods might have no survival value. However, the variation is not confined to those forms in symbiotic relationship, and those which may be found either free living or in a host show parallel variation in both habitats. *S. paraneomeris,* apparently never found in a symbiotic relationship is one of the most variable of all synalpheids.

So we are left with species that have been separated by subtle differences and that are variable in those characteristics used for their separation. It is obvious that many of the previously described species will be found to be synonyms when larger collections are made; in a few cases, like *S. n. neptunus* and *S. theano* mentioned above, new characteristics may be found that will validate their separation. For the most part, however, we agree with Chace when contemplating Coutière's numerous subspecies of American synalpheids, "Their prevalence [e.g., of varietal differences] emphasized the amount of variability encountered in this genus and the difficulty in finding specifically stable characteristics."

At times in this study we could not reach any firm conclusions as to whether or not we were dealing with a widely variable single population, or with a subspecific or even specific difference, we have pointed out these variations, but except in one case (*S. neptunus germanus*) we have refrained from the use of subspecific names. In one species (*S. nilandensis*) we have resorted to the device of labelling differences as "forms", knowing that the use of this device will not give the names applied any conservation under the rules of nomenlature.

We are even at loss for suggestions to future workers for the resolution of the problem of variation and the separation of the species. It may be that adequate colour notes may aid in the separation, but some species, like *S. comatularum* has been reported to vary with the colour of its host. With species, like *S. neomeris,* which appears to vary their habitats from free-living to a symbiotic life with a series of hosts and which show no correlated morphological changes, it is obvious that a detailed study of their environmental needs would be fruitless. Possibly the only resolution will be in the almost impossible task of investigating the genetics of each species—its chromosomal count, its ability to cross-breed, the variation found within offspring from various parental pairs. It is doubtful if the problem would warrant such excessive expenditure of research time.

*Symbiosis in the synalpheids**

Of the thirty-one species and subspecies of this genus from Australia, three have been reported only as symbionts on sponges, one living only on coral and one only on crinoids; nine have been reported both from sponges and from "dead coral" and two have been reported both from crinoids and as living in non-symbiotic relationships. Several have been reported as "dredged" without any further notes on habitat. We suspect that some of the dredged specimens may have been actually in symbiotic relationship, especially on crinoids, but were displaced from their hosts by the violence of the collections. For example, R. U. Gooding remarked on specimens of *S. carinatus, S. stimpsoni* and *S. demani* that were collected in a trawl off Samarai, Papua, "Virtually the whole haul consisted of comatulids [Crinoida] and some of the shrimp were collected directly from these, but others were loose." Correspondingly during the collection of shrimp by breaking up dead coral heads, the shrimp may fall out of a sponge lodged between the branches as well as from between the branches themselves. Thus, the mere lack of records of symbiotic association does not prove the association did not exist.

However, it is apparent that some species are not obligate symbionts. The contrast of the records of *S. lophodactylus* and the related *S. hastilicrassus* in Australian waters will illustrate the point. All but 7 of 208 specimens of the first species were collected from sponges, most of which were thrown on to a beach by a storm; one would suspect that the 7 escaped from broken sponges. On the other hand, 22 specimens of *S. hastilicrassus* were found in dead coral and only 10 were reported from sponges. *S. stimpsoni* of the Comatularum group is most commonly reported in a symbiotic association, but it was collected intertidally from heads of dead coral and under rocks by a number of trained biologists. Possibly the most strange associations are those of *S. neomeris* which in these collections has been reported from the standard dead coral, from live alcyonarians, from sponges and even from bryozoan colonies. Miya records that *S. bituberculatus* in Japan came similarly from sponges, living corals and alcyonarians.

To our knowledge little has been reported on the nature of the symbiotic relationship between the alpheid and the host except for some of the species in the Comatularum group (*see* Appendix, p. 387). Some of these were seen taking food from the mucous train in the ciliated ambulacral groove of the host. Others have been suspected of using the host for shelter and protection—it is likely that *S. charon*, and *Alpheus lottini* Guérin, uses the host coral for protection, feeding largely upon small invertebrates and algae that they find, but occasionally eating mucous and bits of coral tissue (Barry, 1965: MS thesis). Correspondingly the shrimp in a spongocoel may be there for protection and feed upon particles of food swept into the cavity by the sponge's feeding currents. These particles would be too large for ingestion by the choanocytes of the sponge, so there would be no competition between the associates for food. However, when scores, even hundreds of shrimp are found in a single sponge, as *S. streptodactylus* is found in *Zygomycale parishii* (Bowerbank) in Hawaii, one would suspect a relationship that may be deleterious to the host, and possibly present a case of actual parasitism. In this connection in may be noted that most of the species with subspatulate and denticulate fingers on the small chela at times occur in sponges,

* We have used the term symbiosis in the modern sense of the two animals living together, without implication of benefits to either of the pair.

and that the fingers would appear to be an excellent tool for the tearing off pieces of sponge tissue; perhaps these too may be playing a role other than innocent symbiotism.

Finally under symbiotism the strange case of *Synalpheus neptunus germanus* should be noted. As recorded below (p. 321) all 44 specimens in the collection came from spongocoels, and all 44 were of small size and were sexually immature. One recalls Coutière's report (1909:17) of a single dredge haul of the *Albatross* that produced 5 000 to 6 000 specimens of *S. longicarpus* (Herrick) and *S. pectiniger* Coutière in which none seemed to be of normal size and of sexual maturity—of 227 females examined he could only find "two or three in which the pleura were normal and the eggs present . . . none with the very large eggs carried by normal females". We discuss this anomaly further under the species.

Previous Australian records of synalpheids

Fourteen species and subspecies of *Synalpheus* have been previously reported from Australia in the literature. Nine of these were indicated in the summary (p. 267), and three others have been placed in synonymy: *S. bakeri* Coutière, *S. bakeri stormi* De Man and *S. maccullochi* Coutière. One, originally named *S. laevimanus haddoni*, was not found in the collections but is listed as *S. haddoni* for the description permits its separation from all other Australian synalpheids. The last species, *S. latastei* Coutière (1909: 26), is an American species described from Chile, and was recorded from Australia by that author with the remark: "the species is also met with in Australia (?) [sic]) (one male of great length without indication of locality other than New Holland; Paris Museum)". As the species has not been recorded from anywhere else in the Indo-West-Pacific, as it is large and as it would be difficult to confuse with others we have found in Australia, we have concluded that it probably does not occur in Australia and that the doubts about its record from Australia indicated by Coutière were probably correct. As it does not occur in these collections we do not wish to comment on the validity of its specific name (*cf.* Holthuis 1952: 36 and Crosnier & Forest 1966: 298).

KEY TO THE SPECIES OF THE GENUS SYNALPHEUS IN AUSTRALIAN WATERS

(*S. latastei* Coutière is omitted from this key)

1. Without orbitorostral process 2
   — With orbitorostral process 8

2. (1) With rostrum extending beyond end of first antennular article and markedly longer than orbital teeth; dactylus (free finger) of small chela triangular and acute; exopod of uropod with subterminal articulation 3
   — With rostrum markedly shorter than first antennular article and subequal to orbital teeth; dactylus of small chela broadened; excavate and at times with teeth; outer uropod without subterminal articulation.. 6

3. (2) With strong, acute tooth in middle sector of inferoexternal margin of merus of large chela 4
   — Margins of merus of large chela with at most terminal teeth........ 5

4. (3) Carapace with dorsal carina extending posterior to eyes; orbital teeth one-third or more length of rostrum; dactylus of large chela with normal plunger .... *S. carinatus* (p. 283)
   — Carapace with dorsal carina terminating at level of eyes; orbital teeth small, less than one-quarter length of rostrum; dactylus of large chela with plunger modified into a longitudinal crest...... .... *S. tropidodactylus* (p. 286)

5. (3) Dactylus of small chela sickle-shaped, longer than pollex (fixed finger) and with tip crossing pollex; dactylus of third legs with inferior unguis almost rudimentary, forming a right angle to the proximal margin .... *S. comatularum* (p. 289)
   — Dactylus of small chela normal, almost straight, tip not crossing that of pollex; dactylus of third leg with inferior unguis acute and projecting, but smaller than superior unguis ...... *S. stimpsoni* (p. 292)

6. (2) Antennal squame rudimentary; carpus of second legs of four articles .... *S. quadriarticulatus* (p. 297)
   — Antennal squame well developed; carpus of second legs of five articles 7

7. (6) Sympodite (protopodite) of uropods with tooth about half as long as outer uropod; spatulate dactylus and pollex of small chela terminating each in a single tooth .... *S. pescadorensis* (p. 301)
   — Sympodite of uropods with tooth of normal size, about one-third length of outer uropod; spatulate dactylus and pollex of small chela terminating in several teeth .... *S. sciro* (p. 304)

8. (1) Dactylus of small chela at least broadened at base, subspatulate; tips of both fingers of small chela may bear several teeth............ 9

— Dactylus of small chela conical, never spatulate, fingers terminating in a single tooth.. 13

9. (8) Dactylus of small chela broadened only at base, with tip tapering; inferior margins of merus and carpus of small cheliped with conspicuous rows of fine spines .... *S. bituberculatus* (p. 307)

— Dactylus of small chela broadened and excavate to tip; inferior margins of carpus and merus of small cheliped with at most scattered setae 10

10. (9) Distal third of inferior margin of merus of third legs with conspicuous row of spines; both dactylus and pollex of small chela with teeth at tip .... *S. harpagatrus* (p. 311)

— Merus of third legs unarmed; pollex of small chela with a single acute tip 11

11. (10) Tip of third maxilliped bearing only fine setae .... *S. theano* (p. 314)

— Tip of third maxilliped bearing circlet of short heavy spines........ .... *S. neptunus* 12

12. (11) Squame reduced but present; dactylus of small chela without row of setae near crest .... *S. neptunus neptunus* (p. 317)

— Squame of scaphocerite lacking; dactylus of small chela with row of setae on outer face below crest ...... *S. neptunus germanus* (p. 321)

13. (8) Dactylus of third legs triunguiculate, but with inferior unguis at times reduced to a subacute angle 14

— Dactylus of third legs biunguiculate, never more than slight swelling as indication of third unguis 17

14 (13). Spines on propodus of third legs confined to distal quarter or less; dorsal spines of telson either greatly reduced or absent.......... .... *S. demani* (p. 324)

— Propodus of third legs with spines along entire length; dorsal spines telson always present and conspicuous 15

15 (14). Merus of third legs with two or more spines distally on inferior margin .... *S. nilandensis* (p. 327)

— Merus of third legs always unarmed 16

16. (15) Posterolateral corners of telson forming right angles, not projecting; squame reduced, narrower than adjacent spine; pollex of large chela proximally with rounded excavation on inner face........ .... *S. heroni* (p. 322)

— Posterolateral corners of telson projecting and acute; squame never reduced to narrower than adjacent spine; pollex of large chela normal, not excavate .... *S. fossor* (p. 325)

17. (13) Dactylus of small chela with a definite longitudinal row of setae on crest or on inner face; dactylus and pollex may bear other setae, but not in patterned rows 18

— Dactylus of small chela bearing setae, but not in rows or patches.... 23

18. (17) Squame either absent or at most reaching to near end of first antennular article . . . . *S. haddoni** (p. 341)

— Squame present and reaching at least to middle of second antennular article, usually beyond 19

19. (18) Posterolateral corners of telson normally forming right angles, at most slightly projecting 20

— Posterolateral corners of telson strongly projecting and acute 21

20. (19) Margins of sixth abdominal segment rounded on either side of telsal articulation . . . . *S. coutierei* (p. 343)

— Margins of sixth abdominal segment projecting as acute teeth on either side of the telsal articulation . . . . *S. bispinosus* (p. 346)

21. (19) Merus of third legs usually bearing several spines; if not, then with patches of setae; tips of rostrum and orbital teeth turned upward when seen in lateral view . . . . *S. ancistrorhynchus* (p. 347)

— Merus of third legs with neither spines nor patches of setae; rostrum and orbital teeth following normal curvature, not upturned 22

22. (21) Stylocerite shorter than first antennular article, and shorter than outer tooth of basicerite; row of setae on dactylus of small chela medial to crest of finger; outer angles of telson small . . . . *S. lophodoctylus* (p. 350)

— Stylocerite reaching beyond end of first antennular article, and equal to outer teeth of basicerite; row of setae on dactylus of small chela on crest of finger; outer angles of telson usually heavy and strongly projecting . . . . *S. hastilicrassus* (p. 353)

23. (17) Merus of third legs bearing two or more spines in inferior margin 24

— Merus of third legs without spines 27

24. (23) Superior unguis of dactylus of third legs less than half as long and less than half as broad at base as inferior unguis; numerous spines on merus of mature individuals . . . . *S. neomeris* (p. 357)

— Superior unguis of dactylus of third leg larger than above, approaching equality in size to inferior 25

25. (24) Ungui of dactylus of third legs of normal size, one-third to one-quarter total length of dactylus; numerous spines on merus of third legs of mature individuals . . . . *S. streptodactylus* (p. 362)

— Ungui of dactylus greatly reduced, no more than one-sixth and often one-tenth total length; only two spines on merus of third legs of mature individuals 26

26. (25) With only two spines, plus one or two terminal spines, on propodus of third legs; propodus with distinct superior curvature . . . . *S. pococki* (p. 366)

— With numerous spines on propodus of third legs, propodus only slightly curved . . . . *S. iocosta* (p. 368

* The small chela of this species has not been figured or described; however as Coutière first described the species as a subspecies of *S. laevimanus*, we are presuming it has the tuft of setae on the dactylus like *S. laevimanus*.

27. (23) Superior unguis of third legs broadened laterally into plate; inferior unguis very heavy and excavate on inferior surface.... *S. charon* (p. 369)

— Both ungui of dactylus of third legs conical and tapering, neither broadened nor excavate 28

28. (27) Rostrum long and slender, reaching beyond middle of second antennular article, five or more times as long as broad at base.... .... *S. gracilirostris* (p. 372)

— Rostrum shorter and more triangular, not reaching beyond end of first antennular article and not over three times as long as broad at base 29

29. (28) Terminal article of third maxilliped bearing on inner face numerous elongate spines................................ *S. echinus* (p. 374)

— Terminal article of third maxilliped bearing only setae on inner face with usual circlet of short spines at tip....................... 30

30. (29) Dactylus of third legs with uniform taper and with superior unguis longer and often heavier at base than inferior....*S. tumidomanus* (p. 377)

— Dactylus of third legs with slight swelling on inferior surface proximal to inferior unguis; inferior unguis equal in length to, but thicker at base than superior .... *S. paraneomeris* (p. 383)

Synalpheus carinatus (De Man)

Fig. 1 and Fig. 2n

Alpheus carinatus De Man, 1888a, Arch. Naturgesch. 53 (1): 508, pl. 22, fig. 2.

Synalpheus carinatus De Man, 1911, Siboga Exped. 39a[1] (2): 210, pl. 6, fig. 23. Banner & Banner, 1968, Micronesica 4 (2): 272.

Synalpheus carinatus var. binongcensis De Man, 1909a, Tijdschr. ned. dierk. Vereen. II, 11 (2): 111; 1911, Siboga Exped. 39a[1] (2): 211, pl. 6, fig. 23a.

Synalpheus carinatus var. *ubianensis* De Man, 1909a, Tijdschr. ned. dierk. Vereen. II, 11 (2): 111; 1911, Siboga Exped. 39a[1] (2): 212.

Nec Synalpheus carinatus Pearson, 1905, Rep. Pearl Oyst. Fish., Ceylon, p. 83, pl. 2, figs. 9. [= *S. trispinosus* De Man]

Specimens examined: 4 specimens from AM 209; 2, AM 231; 2, AM 384; 2, AM 394; 1, WM 64–65; 3, WM 88–65; 1, WM 171–65.

Diagnosis: Anterior region of carapace depressed. Rostrum reaching to middle of third antennular article, concave in lateral view. Rostrum and carapace bearing strong median carina which continues almost entire length of carapace; carina compressed and knife-like in gastric and anterior cardiac region, and bearing slight notch in anterior gastric region. Carapace with a "humped" profile to the gastric region, "hump" more pronounced in females than males. Orbital teeth 0.4 as long as rostrum, tilting upward above rostrum and bearing rounded carinae that disappear posterior to corneas. Anterior region between rostral and orbital carinae depressed as moderately deep grooves. Carapace over antennular base inflated and separated from orbital hoods by deep grooves. Pterygostomial angle subacute, but not projecting. Rostral base without orbitorostral process.

Visible part of first antennular article almost 1.5 times longer than second article; second a little longer than third. Stylocerite reaching to middle of second antennular article. Scaphocerite with squamous portion narrow and reaching to end of antennular peduncle. Lateral spine prominent, longer than squamous portion and curved inward. Carpocerite as long as antennular peduncle. Basicerite with divergent inferior and superior teeth; superior tooth as long as orbital teeth, inferior tooth longer than superior.

Large chela slightly compressed, 3.5 times as long as broad; fingers occupying the distal 0.4. Carpus with superior margin bearing two widely set distal teeth, inferior margin with one acute tooth. Merus 2.7 times as long as broad; inferointernal margin terminating in sharp angle, superior margin projecting into an acute tooth. Superior margin of ischium bearing short heavy spine.

Small chela four times as long as broad with fingers 0.4 the total length. Dactylus straight, not hooked, armature of merus, carpus and ischium similar to that of large chela.

Ratio of carpal articles of second leg: 10:3:1:1:4.

Merus of third leg five times as long as broad, carpus half as long as merus, bearing terminally a superior rounded protrusion and an inferior small spine. Propodus as long as merus, bearing on its lower margin, 12–14 spines. Dactylus biunguiculate with ungui curved at right angles to propodus. Superior unguis about three times as long as inferior.

Telson three times as long as posterior margin is broad. Dorsal spines located well posterior of middle. Posterior margin between posterior spines strongly convex.

Discussion: As we pointed out for the specimens from the Marshall and Caroline Islands this species is variable (1968: 272). The cardiac notch varies from well developed to absent; the tip of the rostrum may reach from the middle of the second antennular article to one-half the length of the third antennular article; and the lower tooth of the basicerite may reach from three-fourths the length of the first antennular article to one-fourth of the second. We concluded that the varietal forms described by De Man were within the range of normal variation for the species. We have found the same range of variation in the Australian specimens.

Pearson (1905: 83, pl. 2, fig. 9) reported that his specimen from Ceylon carried three spines on the posterior margin of the sixth abdominal somite. As the condition has not been reported elsewhere nor found in the collections, we believe Pearson's specimens to be *S. trispinosus* De Man.

For the characteristics that distinguish *S. carinatus* from its closest relatives in Australia *see* Table I.

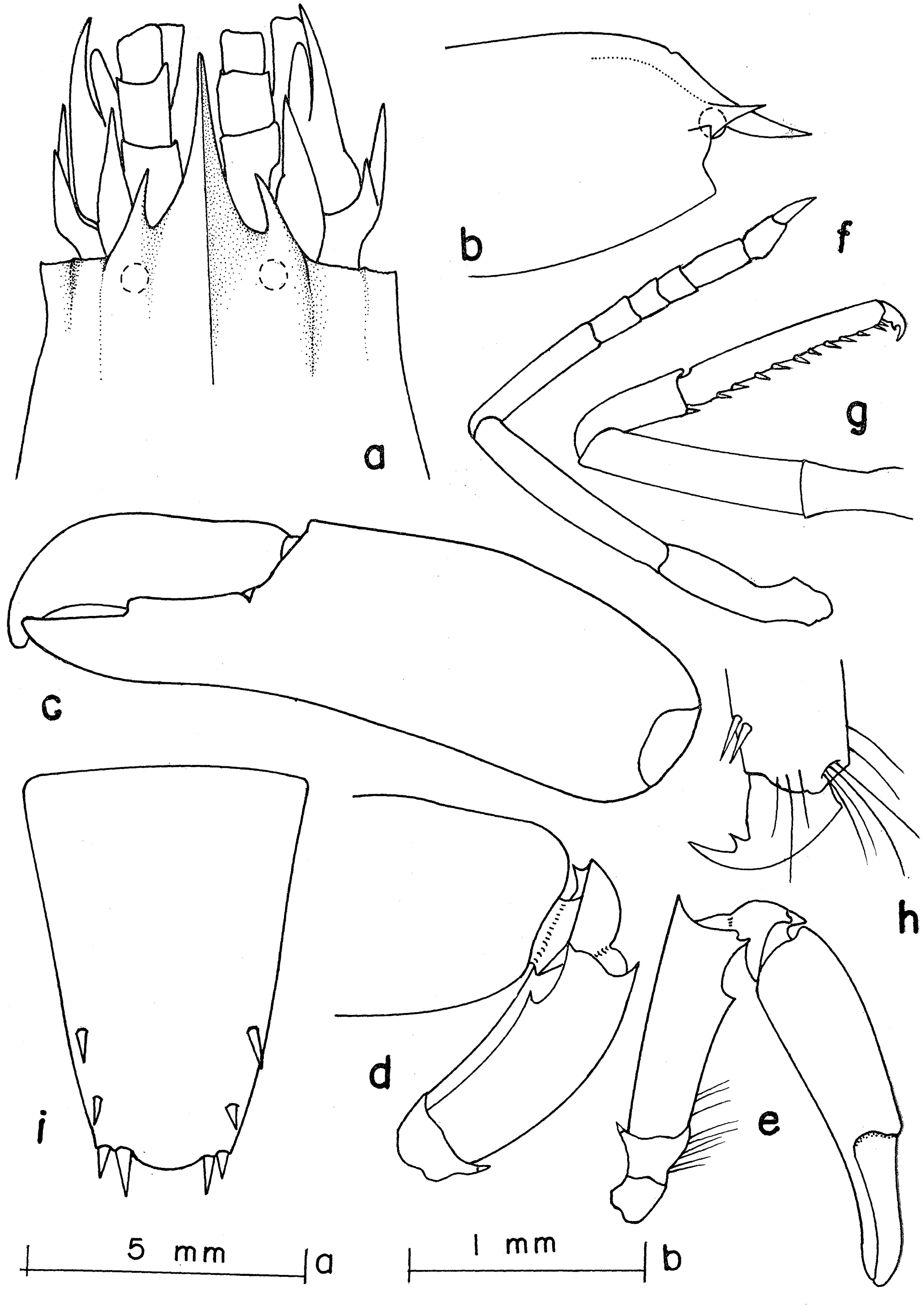
Biological notes: This species has been reported to be associated with crinoids; however, in some collections, as those from Western Australia, no host has been recorded. When associated with crinoids it assumes the colour of its host. Two of the specimens from Moreton Bay were symbiotic with *Comatula purpurea* (Müller) (AM 231), the specimens from Stradbroke Is. (AM 384) were from a "yellow crinoid" and the specimens from One Tree Is. (AM 394) were from a "lemon-yellow comatulid". The specimens from Western Australia were taken by dredge hauls as deep as 98 m. The specimens ranged in size from 15–34 mm, and the males were always smaller than the females.

Australian distribution: This species has not been reported before from Australia. The specimens from Western Australia were collected from Shark Bay and Bluff Pt. In eastern Australia they were taken from between the Capricorn Group and Moreton Bay.

General distribution: Indonesia, Malaysian Archipelago, Caroline, Marshall and Gilbert Islands.

OPPOSITE

Fig. 1 (see also fig. 2n).—*Synalpheus carinatus* (De Man). 34 mm female from AM. 394. a, b, Anterior region, dorsal and lateral view; c, d, large chela and merus, outer face; e, small cheliped, outer face; f, second leg; g, h, third leg and enlarged dactylus; i, telson. All figures except h, scale a., h, scale b.


a
b
f
g
c
h
i
d
e
5 mm
a
1 mm
b

Synalpheus tropidodactylus sp. nov.

Fig. 2

Holotype: 20 mm male from west of Geraldton. 28° 14′ S; 113° 14′ E. Dredged at 60 fathoms. (WM 90–65)

Paratype: 18 mm male from the same location.

Description: Anterior portion of carapace smooth except for rostral carina and slight depression between rostrum and orbital teeth; posterior to upper spine of basicerite and lateral to eyes carapace forming a lateral ridge that extends one-fourth the length of the carapace. Rostrum almost an equilateral triangle, with margins slightly concave, tip reaching almost to middle of second antennular article; slight rostral carina disappearing anterior to eyes. Ventral side of rostral base without orbitorostral process. Orbital teeth short, 0.2 as long as rostrum; not carinate.

Visible portion of first antennular article and second article subequal. Third article less than half as long as second article. Stylocerite reaching to end of first antennular article. Squamous portion of scaphocerite narrow, reaching to end of antennular peduncle, lateral spine a little longer. Carpocerite as long as antennular peduncle. Upper and lower teeth of basicerite almost parallel; with lower tooth longer than upper and reaching three-fourths length of first antennular article.

Large chela subcylindrical, 3.3 times as long as broad, with fingers occupying the distal 0.43. Small subacute tooth above dactylar articulation. Dactylus with "plunger" modified into sharp longitudinal ridge, and pollex with "socket" modified to form deep proximal "v"-shaped groove, open on distal end. Face of dactylus in opposition to pollex developed as sharp, thin cutting edge with crosses, like blades of a scissors, the corresponding sharp cutting edge of pollex. On pollex the proximal groove terminates on medial face as abrupt but rounded shoulder, while lateral margin of groove continues as the shearing blade; the rounded shoulder gives the appearance from inferior view of a twisting of distal half of fingers (fig. 2d). Carpus cup-shaped with acute tooth on distosuperior margin; tooth absent in paratype. Merus twice as long as broad; superior margin terminating in acute tooth; inferoexternal margin bearing strong tooth near midpoint, and an acute terminal tooth; inferointernal margin with distal obtuse tooth.

Small chela 4 times as long as broad; fingers a little more than one-third the total length. Carpus and merus similar to that of large chela; merus 3.4 times as long as broad.

Second leg with ratio of carpal articles 10:3:3:3:5.

Merus of third leg inermous, 4.6 times as long as broad. Carpus half as long as merus; superodistal margin projected, inferodistal margin bearing spine. Propodus as long as merus and bearing on inferior margin 14 spines with a pair distally. Dactylus biunguiculate with both ungui curved at right angles to axis of propodus. Superior unguis almost 3 times as long as inferior unguis.

Telson 2.6 times as long as posterior margin is broad. Posterior margin arcuate; spines on dorsal surface small and posterior to midline; terminal spines also small.

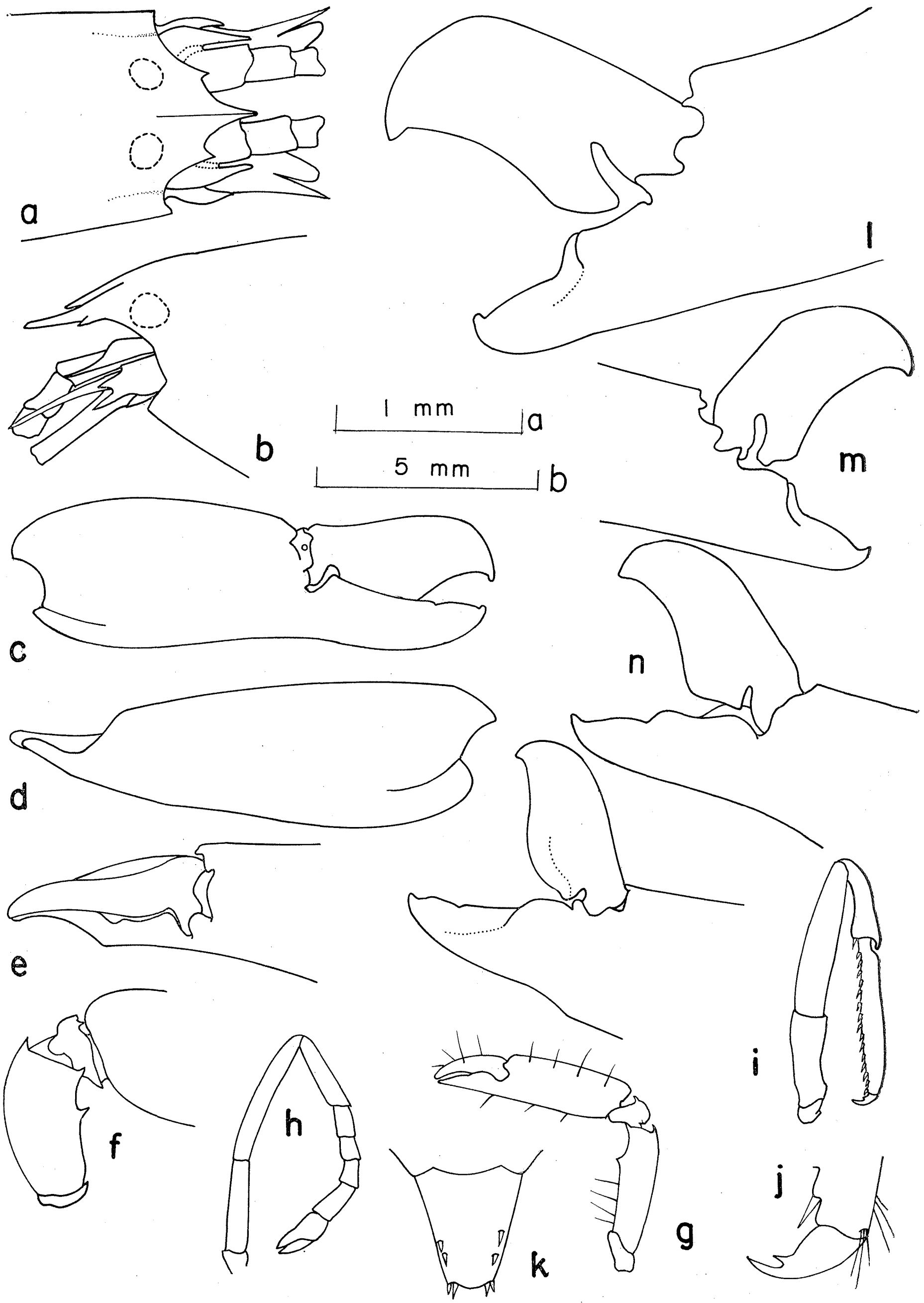


Fig. 2.—*Synalpheus tropidodactylus* sp. nov. Holotype. a, b, Anterior region of carapace, dorsal and lateral view; c, d, large chela, median and inferior aspect; e, distal end of large chela, superior aspect; f, merus large chela, inner face; g, small cheliped; h, second leg; i, j, third leg and dactylus; k, telson; l, distal region of chela of *S. comatularum;* m, distal region of chela of *S. stimpsoni;* n, distal region of chela of *S. carinatus;* o, distal region of chela of *S. tropidodactylus.* All figures except j, scale a; j, scale b.

Discussion: This species plainly belongs to the Comatularum group as it has the characteristic projection of the anterior portion of the carapace beyond the eyes and as it lacks the orbitorostral process.

The characteristics that separate this species and those of the Comatularum group known from Australia are given in Table 1. It may be separated from *S. odontophorus* De Man and *S. albatrossi* Coutière as from the Australian species by the development of the plunger of the dactylus of the large chela as a ridge. Other differences include the tooth on the base of the pollex of the large chela and the merus of the third legs in *S. odontophorus,* and the lack of a meral tooth on the large cheliped in *S. albatrossi.*

The name is derived from the Latin *tropido* or keel, and *dactylus,* and refers to the keel instead of a plunger on the large cheliped. The holotype and paratype have been placed at the Western Australian Museum.

Table 1. *Australian Species of the Comatularum Group*

Characteristic	*S. carinatus*	*S. tropidodactylus*	*S. comatularum*	*S. stimpsoni*
Rostral carina continued past middle of carapace.	yes	no	yes	no
Orbital carinae sharp	yes	no	yes	no
Gastric region of carapace "humped" ..	yes	no	yes	no
Length of orbital teeth to rostrum ..	0·4	0·2	0·3–0·5	0·3–0·5
Tooth on middle of margin of merus of large cheliped.	yes	yes	no	no
"Plunger" on dactylus of large cheliped	yes	no	yes	yes
Pollex of large chela appears twisted from inferior aspect.	no	yes	no	no
Sickle-shaped dactylus of small chela ..	no	no	yes	no
Terminal tooth on merus of third leg ..	no	no	yes	yes

Synalpheus comatularum (Haswell)

Fig. 3

Alpheus comatularum Haswell, 1882a, Proc. Linn. Soc. N.S.W. 6 (4): 762; reprinted in: 1882b, Cat. Austr. Stalk-eyed Crust. p. 189. Miers, 1884, Zool. Coll. H. M. S. Alert, p. 289 [redescription using Haswell's specimen].

Synalpheus comatularum Potts, 1915a, Proc. Camb. phil. Soc. biol. Sci. 18: 59, fig. 1; 1915b, Pap. Dep. mar. Biol. Carnegie Instn. Wash., 8: 76, pl. 1, fig. 1, text—figs 1c, 2d.

Synalpheus falcatus Bate, 1888, Challenger Rept. Zool. 24: 574, pl. 103.

Additional Australian records:

Ortmann, 1894, Denkschr. med. naturw. Ges. Jena, 8: 14. Thursday Is.
Coutière, 1900, Bull. Mus. Hist. nat., Paris 6 (8): 411. Torres Straits.
Balss, 1921, K. Svenska Vetensk.—Akad. Handl., 61 (10): 10. Cape Jaubert.
Clark, 1921, Bull. U.S. natn. Mus., 82, 1 (2): 624, pl. 38, fig. 1234, text fig. 943. Torres Straits.

Specimens examined: 2 specimens from AM 22; 11, AM 48; 2, AM 50; 2, AM 55; 6, AM 97; 4, AM 121; 2, AM 138; 1, AM 159; 1, AM 314; 2, AM 387; 1, AM 389; 3, AM 447; 1 specimen each from CS 29–32; 1, MM 86; 1, WM 33–65; 1, WM 34–65; 1, WM 37–65; 2, WM 44–65; 1, WM 115–65; 1, WM 122–65; 1, WM 128–65; 2, WM 190–65; 1, WM 220–65; 1, WM 274–65; 1, WM 305–65; 1, WM 4986; 2, WM 8972.

Diagnosis: Rostrum variable, tip reaching from near end of second to end of third antennular article and carrying knife-edged carina which extends to cardiac region where it terminates in a small oval depression; in lateral view rostral front depressed in relation to gastric region giving a "humped" appearance. Orbital teeth directed straight forward, dorsally rounded, not carinate, varying from one-third to one-half as long as rostrum. Anterior region of carapace between rostral base and orbital crests depressed as a deep groove. Posterior to upper spine of basicerite and lateral to orbital hoods carapace forming lateral ridges which extend one-fourth length of carapace. Pterygostomial angle strongly projecting at an acute angle but with tip rounded. Without orbitorostral process.

Visible part of first antennular article 1.5 times length of second article; third article a little shorter than second. Tip of stylocerite reaching from one-fourth length of second antennular article to end of that article. Scaphocerite with squamous portion narrow, reaching almost to end of antennular peduncle, lateral spine somewhat longer. Carpocerite reaching beyond antennular peduncle by length of third article. Lower spine of basicerite appreciably longer, upper spine slightly shorter than orbital teeth.

Large chela subcylindrical, 3 times as long as broad, with fingers occupying distal third. Palmar margin at articulation of dactylus with two acute teeth, one superior and one medial. Merus of large chela 2.7 times as long as broad, with superodistal angle projecting as acute tooth; inferior margins distally acute but not projecting.

Small chela 2.8 times as long as broad with fingers occupying distal 0.4. Dactylus crescentric, curving through 90° with acute hooked tip crossing and extending beyond fixed finger. Carpus hemispherical, bearing strong acute tooth on superodistal margin and a longer but more slender tooth on lower margin. Merus similar to that of large cheliped.

Carpal articles of the second legs with a ratio: 10:2:2:2:3.

Ischium of third legs less than 0.4 as long as merus, unarmed. Merus 6 times as long as broad, bearing acute tooth distally. Carpus 0.4 as long as merus, with superodistal margin projecting as a rounded tooth, inferodistal margin bearing short but heavy spine. Propodus slightly shorter than merus, inferior margin armed with two to several short spines. Dactylus strongly hooked with tip narrowly acute, inferior tooth reduced to mere right angle offset to the margin.

Telson 2.7 times as long as posterior margin is broad, posterior margin strongly arcuate, reaching almost half length of inner posterior spine. Spines on dorsal surface strong.

Discussion: The males are smaller than the females. The males can be readily recognized by the acute teeth on the posterior margins of the abdominal pleura. For the differences between *S. comatularum* and its closest relatives in Australian waters *see* Table I.

Biological notes: Of interest is Clark's account of the use of the peculiar adaptation of the small chela in its association with the crinoids. "The individuals were generally seated in pairs on the disc, but when slightly disturbed immediately dug the hook of this chela into the flesh of the disc, from which it was only dislodged with difficulty, or if the alpheid had left the surface of the disc the chela was serviceable for clasping the arm of its host. But this instrument is only used for temporary attachment, nor is it usually embedded in the host when the animal is at rest." (1921: 624.)

A number of authors, including Haswell and Potts, have supplied colour notes on this species, but Potts reported the colour varied with that of the host.

Eleven specimens from Broome (AM 48) were reported as symbiotic with *Comanthus timorensis* (J. Müller). (In Part I (p. 355) this species was listed as *Comanthus angulata;* it has since been changed to *C. timorensis*). Most of the specimens were from crinoids but many of the dredged specimens were not; possibly these had been torn loose from their natural association.

Australian distribution: In this collection are specimens from the West Coast of Australia from Busselton to Broome, on the east coast from the Torres Straits to Cape Grenville. The species had not been reported along the northern coast between Broome and the Torres Straits, nor south of Cape Grenville.

General distribution: Specimens have also been reported from Ceylon and Singapore.

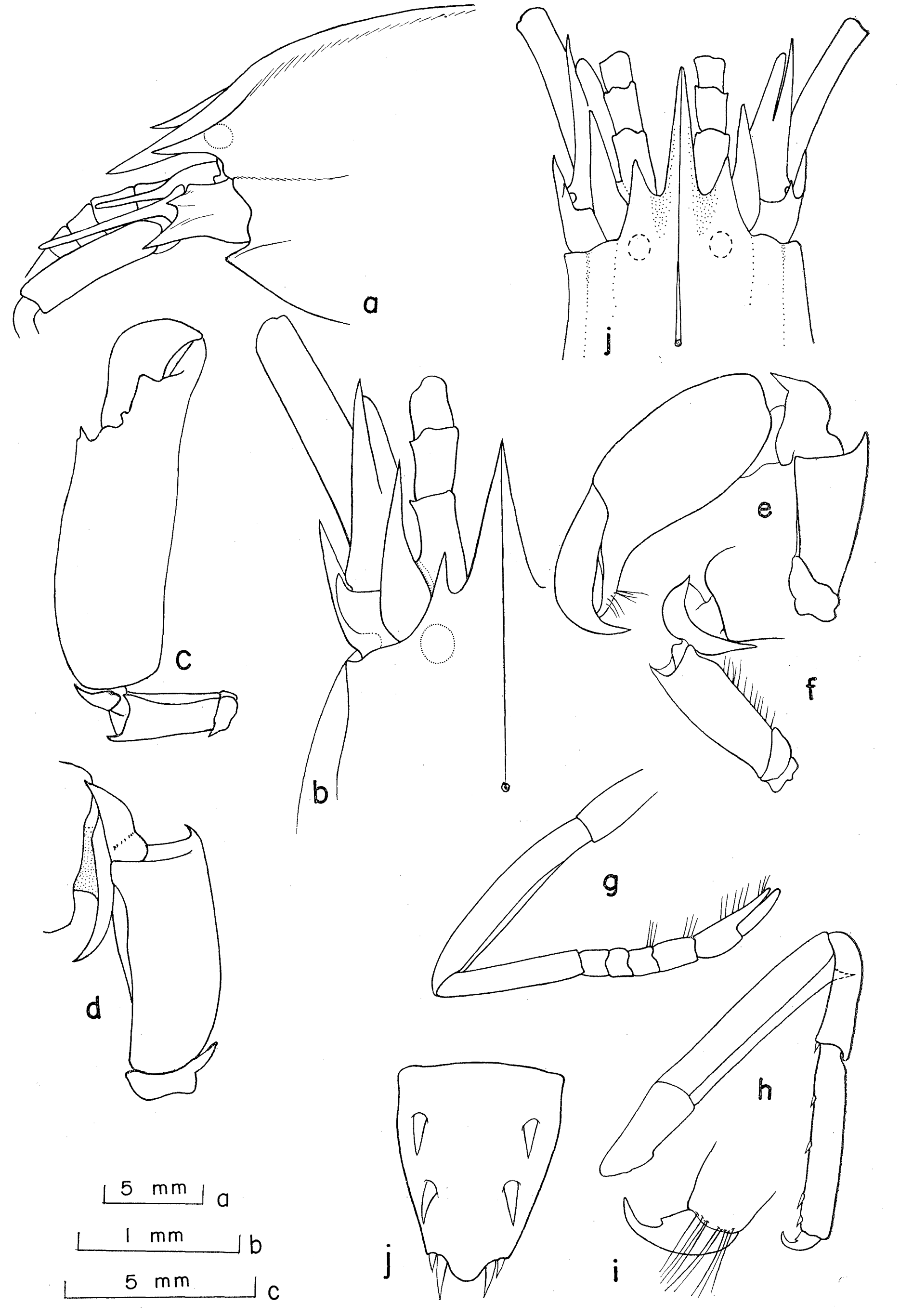


Fig. 3.—*Synalpheus comatularum* (Haswell). 30 mm male from AM. 48: a, b, anterior region of carapace, dorsal and lateral view; c, large cheliped, inner face; d, merus and carpus of large cheliped, outer face; e, f, small cheliped and merus, outer face; g, second leg; h, i, third leg and dactylus; j, telson. 25 mm female from AM. 48: j, anterior region, dorsal view. c, scale a; i, scale b; a, b, d, e, f, g, h, k, j, scale c.

Synalpheus stimpsoni (de Man)

Fig. 2m, 4

Alpheus stimpsonii De Man, 1888a, Arch Naturgesch. 53 (1): 513, pl. 22, fig. 3.

Synalpheus stimpsoni Banner & Banner, 1966b. Siam Soc. Mono. 3, p. 46, fig. 12; 1968, Micronesica 4 (2): 274.

Alpheus amboinae Zehntner, 1894, Rev. Suisse Zool. 2: 202, pl. 8, fig. 23.

Synalpheus amboinae De Man, 1911, Siboga Exped. $39a^1$ (2): 203, fig. 20; 1922, Siboga Exped. $39a^4$ (5): 26, fig. 13. Banner, 1958, Pacif. Sci. 12 (2): 159, fig. 2.

Synalpheus consobrinus De Man, 1911, Siboga Exped. $39a^1$ (2): 204, fig. 21.

Synalpheus brucei Potts, 1915b, Pap. Dep. Mar. Biol. Carnegie Instn. Wash. 8: 76, pl. 1, fig. 2, textfigs 1 a-b, 2 a-c, 3. Clark, 1921, Bull. U.S. natn. Mus. 82, 1 (2): 625.

Alpheus stimpsoni De Man var? Schenkel, 1902, Verh. naturf. Ges. Basel. 13: 567, pl. 13, fig. 22.

Synalpheus striatus Kubo, 1938, Annotnes. Zool. Jap. 17 (1): 89, textfigs. 1, 2. Miya, 1972, Publ. Amakusa Mar. Biol. Lab. Kyushu, 3 (1): 47, pl. 6.

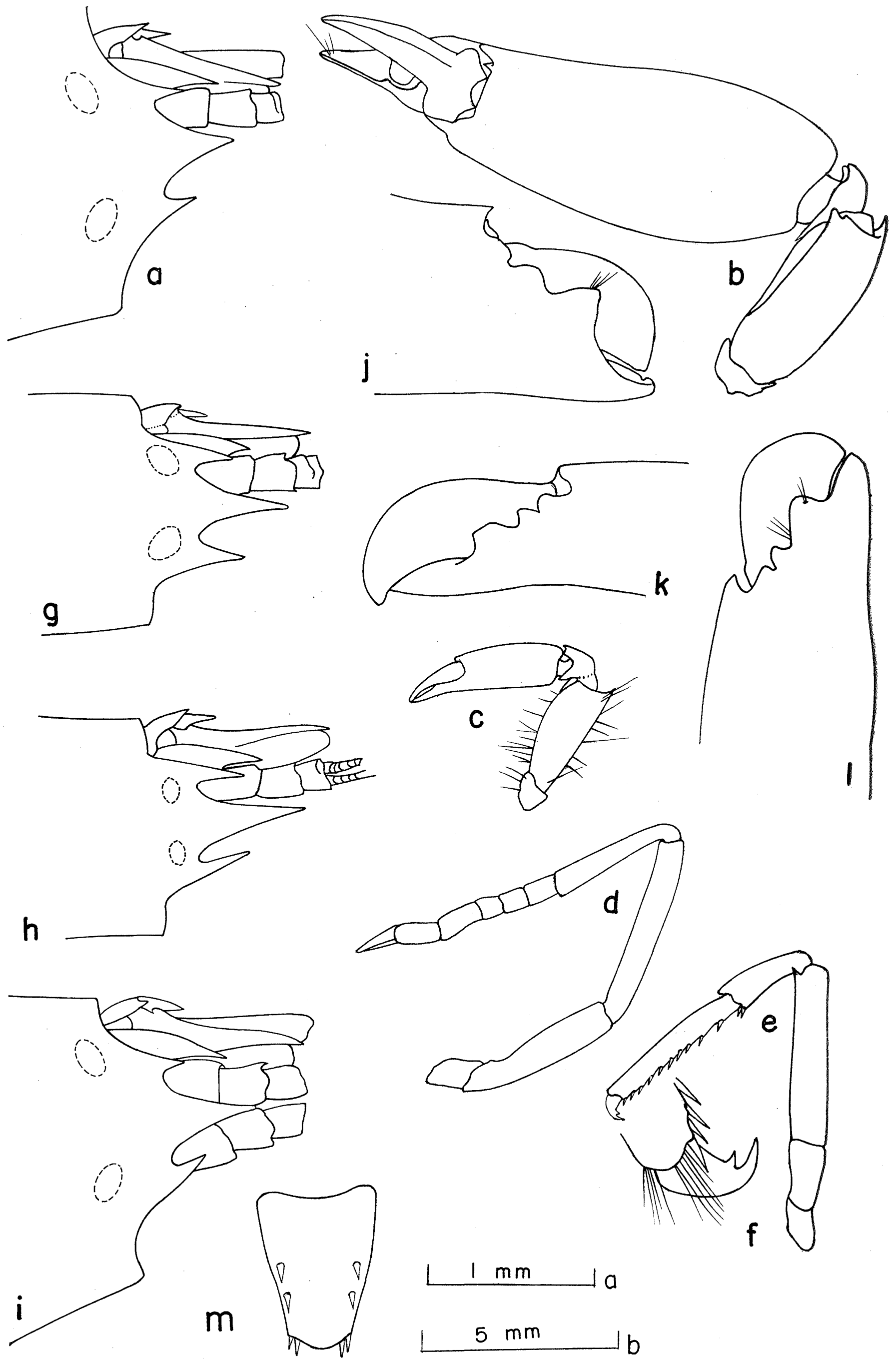
Additional Australian records: Coutière, 1900, Bull. Mus. Hist. nat., Paris 6 (8): 411. Torres Straits.

Specimens examined: 5 specimens from AC S1; 3, AC S5; 1 specimen each from AC 1, 3, 4, 7; 2 specimens each from AC 38, 39; 13, AM 22; 2, AM 35; 12, AM 48; 1, AM 52; 2, AM 57; 1, AM 85; 3, AM 97; 1, AM 139; 1, AM 177; 1, AM 192; 2, AM 231; 1, AM 239; 2, AM 394a; 1, AM 445; 1, AM 447; 1, AM 453; 2, BAU 11; 2, BAU 31; 2, JB2; 2, JB3; 3, JB4; 3, JB5; 3, WM 25–65; 1, WM 34–65; 1, WM 45–65; 1, WM 48–65; 1, WM 54–65; 1, WM 55–65; 1, WM 65–65; 1, WM 71–65; 5, WM 115–65; 2, WM 120–65; 1, WM 133–65; 1, WM 160–65; 1, WM 165–65; 1, WM 193–65; 1, WM 200–65; 2, WM 217–65; 1, WM 233–65; 1, WM 277–65; 2, WM 279–65; 3, WM 282–65.

Diagnosis: Rostrum reaching near end of second antennular article, with slight rounded carina reaching from tip to level of eyes. Orbitorostral grooves moderate, also disappearing at level of eyes. Orbital teeth with acute tips but not carinate, varying from one-third to more than one-half as long as rostrum. Carapace posterior to basicerite and lateral to eyes carrying rounded ridge that extends one-fourth length of carapace, similar to *S. comatularum* but not as strongly demarked. In lateral view rostral region of carapace depressed relative to gastric region. Without orbitorostral process.

OPPOSITE

Fig. 4 (see also fig. 2m).—*Synalpheus stimpsoni* (de Man). 30 mm female from AC S1: a, anterior region of carapace; b, large cheliped, superior aspect; c, small cheliped; d, second leg; e, f, third leg, dactylus enlarged; g, h, i, anterior region dorsal aspect of three different specimens; j, k, l, distal region of large chela of three different specimens; m, telson. All figures except f, scale a; f, scale b.


a
b
j
g
k
c
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m
1 mm a
5 mm b

Relative lengths of antennular articles variable with first from slightly longer to almost twice length of second; third shorter than second. Stylocerite reaching to or slightly beyond end of first antennular article. Scaphocerite with broad squamous portion variable, reaching to about end of antennular peduncle, lateral spine a little longer, often curving inward. Carpocerite equal to lateral spine of scaphocerite. Inferior tooth of basicerite usually reaching near end of orbital teeth, superior spine much shorter.

Large chela varying from 2.5–3.6 times as long as broad; superior margin usually bearing tooth above dactylar articulation. Merus 2.6 times as long as broad, bearing distally a small subacute tooth on inferointernal margin and acute tooth on superior margin. Carpus cup-shaped, similar to *S. comatularum* with superodistal margin bearing a longer acute tooth.

Small chela 3.3 times as long as broad with fingers occupying distal 0.4. Dactylus slightly curved, of usual development. Carpus cup-shaped with distal teeth similar to those for large chela but greatly diminished. Merus 2.5 times as long as broad, bearing only small subacute tooth on superodistal margin; superior and both inferior margins bearing very fine setae.

Carpal articles of second leg with ratio: 10:2:2:2:3.

Merus of third leg 5 times as long as broad, armed with acute tooth distally. Carpus half as long as merus; superodistal margin projecting but rounded, inferodistal margin bearing a pair of short spinules. Propodus as long as merus, bearing on its lower margin numerous small spinules and a pair distally. Dactylus biunguiculate, 0.1 as long as propodus; ungui curved at right angles to the axis of the propodus, superior unguis slightly thicker at base and over twice as long as inferior.

Telson 2.2 times as long as broad at posterior end, anterior pair of spinules located just above middle, posterior pair slightly below middle.

Discussion: Five of the species of *Synalpheus* described as commensals on crinoids have been recognized as being closely related, but other species appear to be distinct. Each species in this group was described on the basis of a few specimens. De Man had only one ovigerous female from Amboina on which to base his species *S. stimpsoni*; eight specimens—two males, four females and two immature forms—from Indonesia for *S. consobrinus*; Zehntner had only one specimen of unspecified sex from Amboina for *S. amboinae*; Potts had seven females from the Torres Straits for the description of *S. brucei*; Kubo had one male and one ovigerous female from Japan for *S. striatus*. *S. stimpsoni* var(?) of Schenkel need not be formally considered, as it is not named and as it easily falls within the range of variation discussed below.

In a previous study (1968: 274) we placed *S. consobrinus* in synonymy under *S. stimpsoni*, the oldest name in this complex. In our present study collection we have eighty-nine specimens from eastern and western Australia (unfortunately none from the Torres Straits, the type locality for *S. brucei*) of which forty are intact. We have studied this group of forty in respect to twelve characteristics that have been used, or could have been used for differentiation of the species. The comparative data is presented in Table II; where possible the conditions reported were from the original texts, but at times the proportions were taken from figures.

Table 2. Nominal species reported in the S. stimpsoni *complex*

Characteristic	*S. stimpsoni*	*S. amboinae*	*S. brucei*	*S. striatus*	Australian specimens
Tip of rostrum to second antennular article.	To middle	Slightly past end.	To end	To end	From distal quarter of first to beyond end of second.
Length, orbital teeth to rostrum	0·3	Less than half	0·3	0·4	0·3–0·6.
Length, orbital teeth to first antennular article.	To middle	Past middle (de Man).	To middle.	To middle.	From middle almost to end.
Length, visible part first antennular article to following articles.	Longer than sum of following.	Equal to sum of following.	Same as *S. stimpsoni*.	Same as *S. amboinae*.	Length of first varying with angle it makes to carapace.
Tip of stylocerite to antennular article.	End first	Same	Same	0·3 of second	From shorter to definitely longer than first.
Relative length, teeth of basicerite.	Teeth subequal	Inferior markedly longer than superior.	Same as *S. amboinae*.	Same as *S. amboinae*.	Varying from condition in *S. stimpsoni* to condition in *S. amboinae*.
Length, carpocerite to antennular peduncle.	Reaching to end.	Same	Same	Same	A little shorter to a little longer than antennular peduncle.
Length/breadth merus, third leg	3·5 (from de Man).	2·8–3·6	3·5	4·0	3·2–4·1.
Length/breadth propodus, third leg.	5·6 (from plate).	4·4–5·2	Not figured or given.	6·5–7·0	4·7–6·0.
Spines of propodus third legs	7	9 (from plate)	Not given	7	6–10.
Size of outer angles, telson	Long	Short	Same as *S. fossor*.	Short.	From short to long.
Size of dorsal spines, telson	Large	Medium	Not given.	Small	From small to large.

From studying the material above we conclude that *S. stimpsoni* is a single but highly variable species and that those forms previously known as *S. stimpsoni* var?, *S. amboinae, S. brucei, S. striatus* as well as *S. consobrinus* are synonyms of *S. stimpsoni.*

We have compared our specimens of *S. stimpsoni* with De Man's type specimen of the closely related *S. odontophorus,* and with six specimens from the South China Sea which are presumably *S. odontophorus.* While both species appear to be variable, as yet there appears to be no overlapping of the characteristics that De Man used for separation; in addition we have found the orbital teeth to be much shorter in relation to the rostrum in *S. odontophorus* than in *S. stimpsoni.* We will discuss these specimens in a future paper.

Biological notes:

In Australia, as elsewhere, this species is commonly associated with crinoids, two being identified as *Comanthus purpurea* (Müller) (AM 231) and *Comanthus timorensis* (Müller) (AM 48), as well as numerous unidentified crinoids. Miya (1972) reported the species (as *S. striatus*) from three different species of crinoid and regarded it as an obligate commensal in Japanese waters. In addition it has been reported as occurring intertidally in heads of dead coral and under rocks, therefore in Australia it does not appear to be an obligate commensal. It has been dredged as deep as 25 fathoms.

The colour of those occurring on crinoids varies with the colour of the host. John Yaldwyn supplied colour notes for a specimen (AM 192) collected under rocks near Sydney: "Overall colour pale green, incipient darker green bands posteriorly on each abdominal segment; large hands with broad green "w" on white background. Through lens shortly after death: small, simple red chromatophores on body with background of granular blue chromatophores, possibly some yellow; details of chromatophores in green and white pattern could not be made out". As Potts (1915a: 77) remarked (*see* Appendix), longitudinal stripes against a translucent white or transparent background is a common colour pattern and was the basis of Kubo's name, *S. striatus.* The body length of our specimens ranged in size from 14–35 mm with the females larger than the males.

Australian distribution: This species is found from Sydney in temperate eastern Australia, northward along the Great Barrier Reef, across northern Australia and south as far as 37° S in Western Australia.

General distribution: Indonesia, Singapore, Thailand, Celebes, Philippines, Japan, Marshall and Gilbert Islands.

Synalpheus quadriarticulatus sp. nov.

Fig. 5

Holotype: 11 mm ovigerous female from sponge in 3 m water between Hammond and Waiwea Islands, Torres Straits (BAU 27).

Allotype: 10 mm male from same location as type.

Paratypes: 6 specimens, immature, 5–8 mm long, symbiotic with sponge from same location as type; 2 immature specimens 7 mm long from Thursday Is., Torres Straits (BAU 28).

Description: Rostrum and orbital teeth of equal length, orbital teeth broader at base, reaching more than one-third length of visible portion of first antennular article. Rostrum without orbitorostral process.

Second antennular article 0.8 as long as visible portion of first and 1.3 times as long as broad; third article 0.8 as long as second. Stylocerite reaching almost to end of first antennular article. Scaphocerite with squamous portion entirely lacking, curved lateral spine reaching past middle of third antennular article. Carpocerite 6 times as long as broad with tip reaching length of third antennular article past that article. Inferior spine of basicerite heavy, reaching to middle of second antennular article, superior spine pronounced and acute.

Large chela subcylindrical, 2.8 times as long as broad, distal end of superior margin of palm terminating in swollen tubercle from which projects an acute tooth. Superior margin of dactylus crescentric, almost circular, with inferior, or opposing, margin convex. Central portion slightly thickened, decreasing in thickness towards margins; tip projecting and rounded, overhanging end of pollex. Merus 2.6 times as long as broad. Both inferior margins distally armed with broad acute teeth, superior margin inermous.

Small chela about 3.5 times as long as broad, fingers a little shorter than palm. Fingers laterally broadened with opposing surfaces slightly excavate; both dactylus and pollex terminating in hooks; outer margin of dactylus finely serrate. Carpus cup-shaped, about a quarter as long as chela. Merus 5 times as long as broad, inermous; superior margin distally produced but rounded.

Carpal articles of second leg with a ratio: 10:2:2:4. Articles heavy, with third article 1.4 times as broad as long.

Merus of third leg 5.0 times as long as broad, inermous. Carpus 0.4 as long as merus, inferior margin terminating in spine, superior margin in obtuse tooth. Propodus 0.7 as long as merus, over 6 times as long as broad, bearing 5 inferior and 2 distal spines. Dactylus biungiuculate, gradually curved, superior unguis a little longer, but thinner, than inferior. Apex between ungui "U"-shaped.

Telson 3.5 times as long as posterior margin is broad, 2.7 times as broad anteriorly as posteriorly, lateral margin straight, posterior margin slightly arcuate, terminal spines prominent, outer pair about half the length of the inner. Outer uropod without distal articulation.

The type carried only two very large eggs with considerable amount of yolk and conspicuous eye spots.

Variation: There are certain pronounced differences between the smaller specimens which we regard as immature, and the holotype. In the holotype the rostrum and orbital teeth are nearly equal, while in the immature forms the rostrum is the longer. The antennules are more slender in the holotype and the stylocerite is longer in relation to the first antennular article. The lateral spine of the scaphocerite is longer in the paratype and the squame exists as a shoulder. The large chela is broader in the smaller specimens. The most important difference is in the small chela which in the holotype is more slender with its fingers as broad at the articulation as they are near the distal end, giving the appearance of a duck bill; the opposing surfaces of the fingers are flattened, not excavate. In the immature specimens the fingers taper slightly distally and the opposing surfaces are excavate. In the smaller specimens the carpal articles of the second leg are much broader than those of the type. Similarly all of the articles of the third leg are relatively broader. We believe these differences are due to different growth and that with the collection of more specimens the range will be bridged.

Discussion: Of the six species of *Synalpheus* with four articles in the carpus of the second leg, five are from the Western Atlantic: *S. filidigitus* Armstrong (1949: 15), *S. barahonensis* Armstrong (1949: 21), *S. rathbunae* Coutière (1909): 84), *S. longicarpus* (Herrick) (1891: 382), and *S. brooksi* Coutière (1909: 69); the Pacific species is *S. redactocarpus* Banner (1953: 29), known only from Hawaii. The present species differs from the six previously known by the broadened and flattened fingers of the small cheliped. This species also lacks the tufts of setae on the superior surface of the dactyl of the small chela which are typical of the Atlantic species. *S. redactocarpus* also lacks these tufts, but unlike *S. quadriarticulatus, S. redactocarpus* carries a well developed squame and lacks both the tooth above the dactylar articulation of the large chela, and the dorsal spinules on the telson. It should be noted that *S. longicarpus* and *S. brooksi* normally have five articles to the carpus, and Coutière (1909) attributes the reduction of articles in these species to immaturity; similarly, Miya (1972: 61) reported two immature males of *S. demani* Borradaile with only four carpal articles. Thus, the condition in *S. redactocarpus,* in which the type was only 5 mm in total length, may be due to immaturity, but the type specimens of *S. quadriarticulatus* are of fair size and are sexually mature.

In the general form of the anterior carapace, antennal and antennular bases, the form of the large and small chelae, third legs and uropods, this species closely resembles *S. pescadorensis* Coutière which is also found in Australian waters. It differs from *S. pescadorensis,* in addition to the conspicuous four articles of the carpus, by shorter basal antennular articles, a degenerate squame, slight differences in proportions of the third legs, the lack of a greatly developed tooth on the sympodite of the uropods, and in the lighter armature and more normal terminal margins of the telson (compare figs 5 and 6). In spite of these differences,

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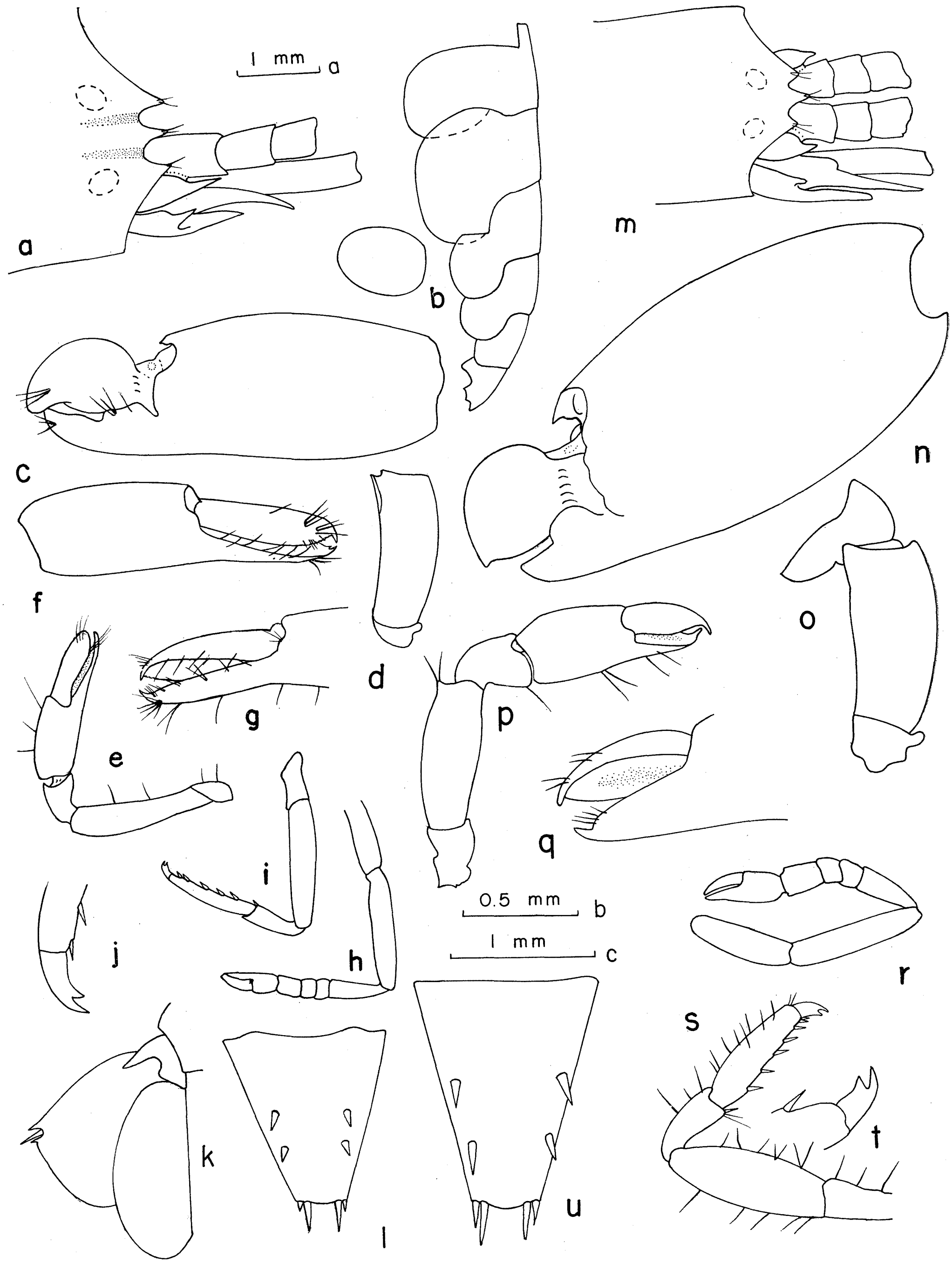
OPPOSITE

Fig. 5.—*Synalpheus quadriarticulatus* sp. nov. Holotype: a, Anterior region; b, abdomen and egg; c, d, large chela and merus; e, small cheliped, superior view; f, outer face of small chela; g ,distal region, inner face of small chela; h, second leg; i, j, third leg and detail of dactylus; k, uropods; l, telson. Paratype: m, anterior region, dorsal view; n, o, large chela and merus; p, q, small cheliped, outer face and distal region enlarged, ventral view; r, second leg; s, t, third leg and detail of dactylus; u, telson. c, d, e, h, i, scale a; j, q, t, scale b; a, b, f, g, k, l, m, n, o, p, r, s, u, scale c.



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we feel the similarities are sufficiently great to suggest that *S. quadriarticulatus* may have evolved from *S. pescadorensis* and that the changes represent an adaption from an open life to that within the body of a sponge.

Mr Paul Jokiel of the Hawaii Institute of Marine Biology has given us a 10 mm specimen that he collected on Canton Is. in the Phoenix Archipelago on June 2, 1972; it came from a coral head from within the lagoon near the pass. It is quite similar in many characteristics to this species, and it has four articles to the carpus of the second legs, but there are several differences: it possesses a narrow squame that reaches to the end of the second antennular article; the rostrum and orbital teeth are reduced to shallow obtuse and rounded projections; the distal end of the palm of the large chela projects above the dactylus but does not carry an acute tooth; the small chela is the same as the immature Australian forms. It may be that this is a new but closely related species, but more specimens must be collected before a decision can be made.

Biological notes: These specimens were all collected from sponges that were lodged in the interstices of the base of dead coral heads. The large chela was more than half as long as the body of the shrimp and was markedly heavy for the size of the body. We have often noticed that alpheids that live in sponges seem to have a disproportionately large chela.

The name refers to the four carpal articles of the second leg. The holotype and allotype will be placed in the Australian Museum; the paratypes will be deposited at the Smithsonian Institution in Washington D.C.

Australian distribution: All specimens in the collection were taken in Torres Straits, north Queensland.

Synalpheus pescadorensis Coutière

Fig. 6

Synalpheus pescadorensis Coutière, 1905a. Fauna and Geog. Mald. and Laccad. 2 (4): 877, pl. 73, fig. 15. De Man, 1926, Mitt. zool. Mus. Berl. 12 (2): 341; 1911, Siboga Exped. 39a[1] (2): 298, fig. 63. Tiwari, 1963, Ann. Fac. Sci. Saigon, p. 279, fig 5.

Specimen examined: A 13 mm female from AME 3147.

Diagnosis: Rostrum reaching to first quarter of visible part of first antennular article. Orbital teeth equal in length to rostrum, but broader at base, almost equilateral triangles. Rostral base without orbitorostral process.

Visible part of first antennular article almost twice as long as second; second article 1.3 times as long as broad; third article only a little shorter than second. Stylocerite reaching to last quarter of first antennular article. Squamous portion of scaphocerite narrow, reaching to end of second antennular article, lateral spine as long as antennular peduncle. Carpocerite reaching the length of third article past that article. Basicerite with inferior tooth reaching past end of first antennular article; superior tooth prominent, almost half as long as inferior tooth.

Large chela subcylindrical, 2.3 times as long as broad. Termination of palm above dactylar articulation bearing swollen tubercle from which projects a smaller acute tooth; slightly medial is a low lobe with two setae. Pollex shorter than dactylus. Dactylus almost circular in outline, with superior margin crescentric, inferior or oppositional surface also strongly convex proximal to terminal tooth. Merus heavy, twice as long as broad, unarmed. Small chela 3 times as long as broad, fingers laterally broadened and excavate. Dactylus terminating in bifurcate tooth, pollex in single tooth; teeth meeting and crossing when chela is closed. Merus slender, 3.5 times as long as broad, also unarmed. Carpus cup-shaped, almost 0.3 as long as chela.

Carpal articles of second leg with ratio: 10:2:2:2:5 middle articles broader than long.

Third leg 3.5 times as long as broad, unarmed. Carpus 0.3 as long as merus, superodistal margin produced, inferior margin terminating in strong spine. Propodus 0.6 as long as merus, inferior margin bearing 8–9 spinules, one pair distally; superior margin somewhat bowed, and markedly broader in middle than proximally. Dactylus biunguiculate, superior unguis longer than inferior, nearly equal in breadth at base.

Telson 2.3 times as long as broad. Dorsal spines large, anterior pair shorter than posterior, posterior pair almost 0.3 length of telson. Terminal spines asymmetrical in the sole specimen with largest almost as long as posterior dorsal spine, other three about two-thirds the length of largest; smaller spines half as long as tip is broad. Posterior margins between spines very narrow and not produced. Sympodite of uropods with unusually long lateral tooth, half as long as external ramus. Outer uropod without articulation.

Discussion: Our specimen differs from Coutière's original specimen in that the squame is longer, reaching to end of second instead of the middle of the second antennular article. The orbital teeth on our specimen are acute rather than obtuse.

Further the dactyl of the small chela terminates in two distinct teeth in Coutière's specimen while in our specimen there is only one tooth that bears a small incision. The principle difference however, is in the posterior margin of the telson which in Coutière's, De Man's (1911), and Tiwari's (1963) specimens bear a slight rounded projection between the posterior pairs of spines. In this specimen, as well as De Man's from the Solomons (1926) the projection is lacking. Yet the Australian, like the other specimens, lack the articulation of the outer uropod and have the enlarged tooth of the sympodite. Therefore, tentatively we are leaving this specimen under Coutière's name.

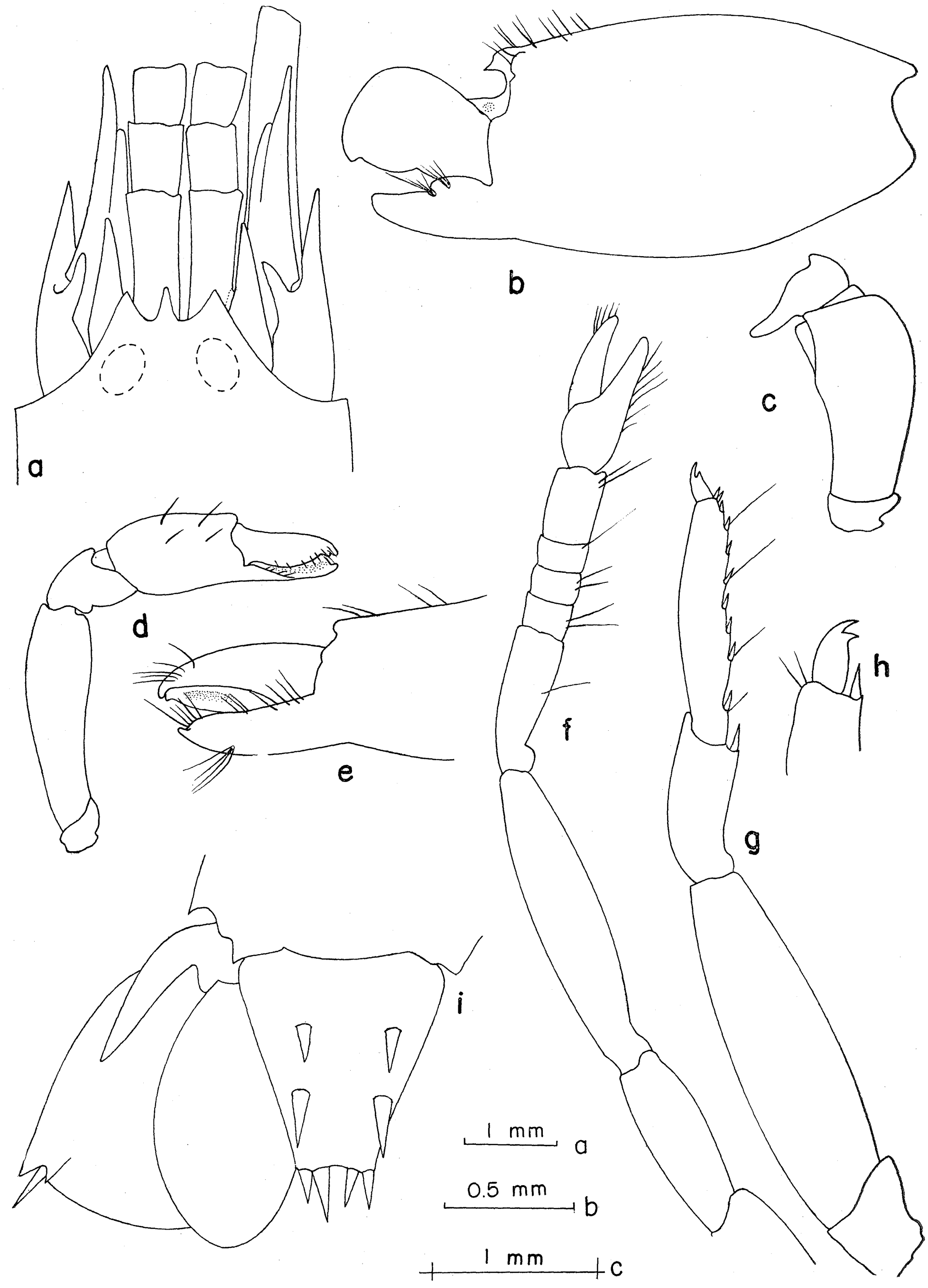
The broadened dactyl of the small chela shows relationship between *S. quadriarticulatus* (discussed above), *S. laticeps* Coutière and *S. antenor* De Man (the latter two not known from Australia). It can be separated from all three by large spines on the dorsal surface of the telson and the large tooth of the sympodite of the uropods.

Australian distribution: The only Australian specimen available was dredged from Keppel Bay in southern Queensland.

General distribution: This species is known from the Maldive Archipelago in the Indian Ocean and the Pacific from Vietnam, Indonesia, Sulu Archipelago, the Pescadores and the Solomon Islands.

OPPOSITE

Fig. 6.—*Synalpheus pescadorensis* Coutière. 13 mm female from AME 3174: a, Anterior region, dorsal view; b, c, large chela and merus; d, e, small cheliped and detail of anterior region in ventrolateral view; f, second leg; g, h, third leg and enlargement of dactylus; i, telson and uropods. b,c,d, scale a; h, scale b; a,e,f,g,i, scale c.


a
b
c
d
e
f
g
h
i
1 mm a
0.5 mm b
1 mm c

Synalpheus sciro sp. nov.

Fig. 7

Holotype: The sole specimen a 12 mm female from CSIRO station 208, 27° 40′ S; 113° 20′ E, northwest of Bluff Point, W.A., 10/10/63. Collected at 7 1/2 fathoms. (WM 64–65).

Description: Rostral tip reaching to well past middle of visible part of first antennular article, slightly upturned, margins concave. Orbital teeth nearly as long as rostrum, but broader at base. Tips of rostrum and orbital teeth rounded and bearing a few setae. Dorsal surface of carapace flat except for slight orbito-rostral grooves that extend only part way to corneas. Corneas lying length of first antennular article posterior to orbitorostral indentation; pigmented area of eyes small. Rostral base without orbitorostral process.

Visible portion of first antennular article 1.6 times length of second; second article a little longer than broad; third article slightly shorter than second. Stylocerite reaching to middle of visible part of first antennular article on one side and to first quarter on other (probably the longer stylocerite is normal). Scaphocerite with narrow squamous portion reaching almost to end of third antennular article; lateral spine reaching length of third article past that article. Carpocerite slender, 6.5 times as long as broad when viewed ventrally, reaching just past end of lateral spine of scaphocerite. Inferior spine of basicerite reaching to first third of second antennular article; superior spine strong, equal to stylocerite.

Large cheliped missing.

Small cheliped with fingers excavate and denticulate. Pollex with three teeth distally, middle tooth the strongest, dactylus with two teeth displaced slightly medially. Chela 3 times as long as broad, fingers about 0.8 length of palm. Carpus cup-shaped, 0.3 as long as chela. Merus slender, 3 times as long as broad with inferodistal margins inermous, superodistal margin projecting as a small acute tooth carrying several hairs.

Carpal articles of the second leg with a ratio 10:1:1:1:5; middle articles broader than long.

Merus of third leg 4 times as long as broad, unarmed; carpus 0.4 as long as merus, inferodistal margin bearing small spine, superodistal angle projecting as rounded tooth. Propodus 0.7 as long as merus, bearing on its inferior margin 7 spines and 2 distally. Dactylus biunguiculate, inferior unguis slightly shorter; apex between the notch subacute.

Telsal tip mutilated. Outer uropod without distal articulation.

Discussion: The long anterior extension of the carapace beyond the eyes, the lack of orbitorostral projection and even the form of the ungui of the third legs is similar to the species in the Comatularum group, but none of these have the spatulate and denticulate dactylus on the small chela. On the other hand, of

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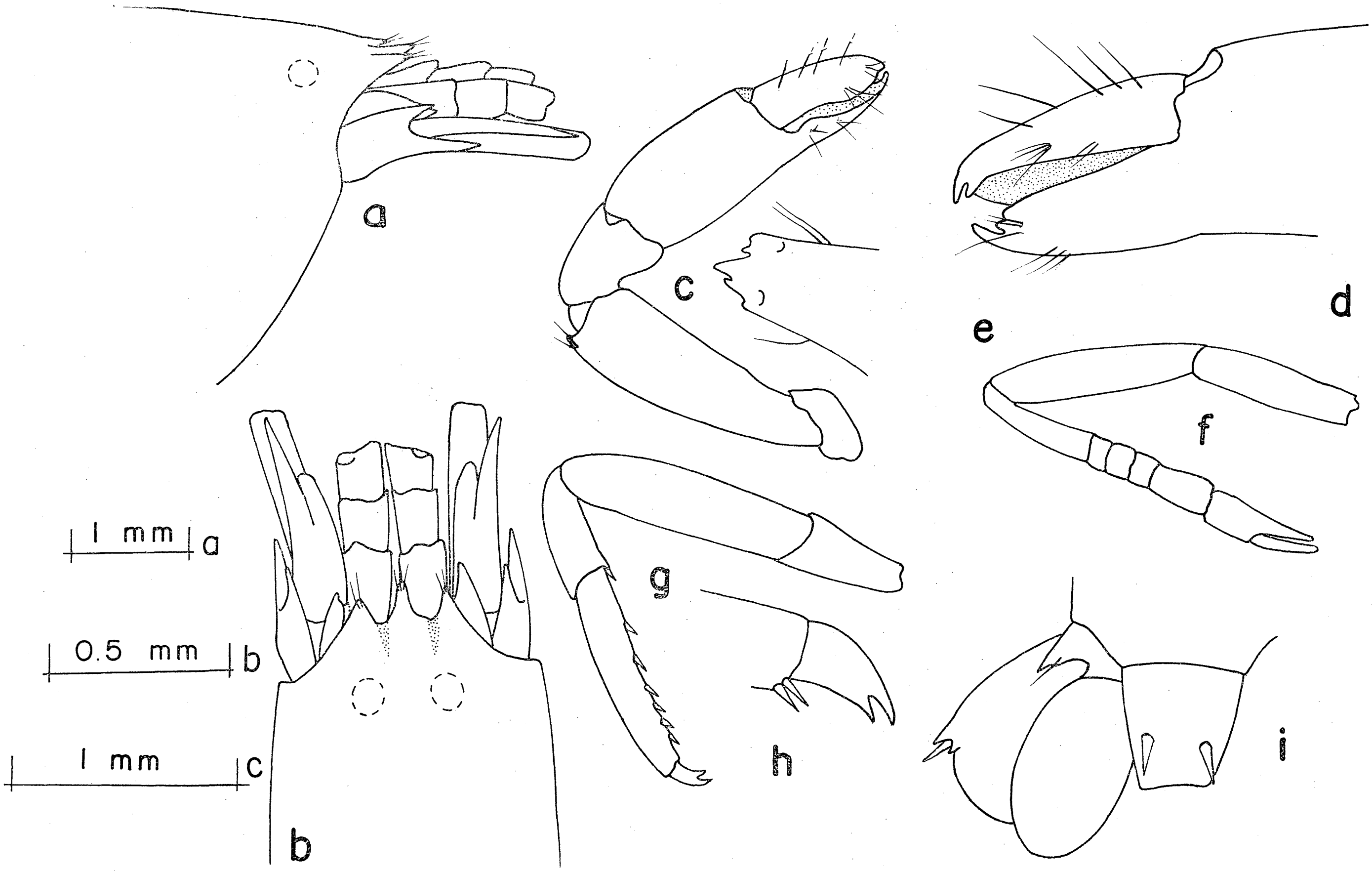
OPPOSITE

Fig. 7.—*Synalpheus sciro* sp. nov. Holotype. a, b, anterior region, dorsal and lateral aspects; c, small cheliped, outer face; d, inner face of distal region of small chela; e, detail of fingers of small chela, ventral aspect; f, second leg; g, h, third leg and enlarged view of dactylus; i, telson and uropods. a, b, c, f, g, i, scale a; h, scale b; d, e, scale c.


a
c
e
d
f
1 mm a
g
0.5 mm b
h
i
1 mm c
b

those with the subspatulate dactylus only *S. pescadorensis* and *S. quadriarticulatus* lack the orbitorostral process; these species also lack the distal articulation of the uropod. This species has the normal number of carpal articles on the second leg; *S. quadriarticulatus* has only four. In *S. pescadorensis* the front of the carapace does not project, and the rostrum is markedly shorter than the first antennular article, the stylocerite and even the superior spine of the basicerite, while in *S. sciro* the rostrum is over half the length of the visible portion of the first antennular article almost as long as the longer (normal?) stylocerite and about equal to the superior spine of the basicerite. The most marked difference between the two species, however, lies in the tooth of the sympodite of the uropods which is half as long as the outer uropod in *S. pescadorensis*, and is less than a quarter the length of the uropod in *S. sciro*.

The name is derived from an anagram of CSIRO, the commonly used abbreviation for Commonwealth Scientific and Industrial Research Organization of Australia, the agency that has loaned many of the specimens for this study. The holotype will be deposited at the Western Australian Museum.

Synalpheus bituberculatus De Man

Fig. 8

Synalpheus bituberculatus De Man, 1910b, Tijdschr. ned. dierk. Vereen, 11 (4): 294; 1911, Siboga Exped. 39a[1] (2): 276, fig. 53. Banner & Banner, 1966b, Siam Soc. Mono. 3, p. 66, fig. 22. Miya, 1972, Publ. Amakusa Mar. Biol. Lab. 3 (1): 57, pl. 10.

Specimens examined: 2 specimens from AM 21; 1, AM 90; 1, AM 334; 1, BAU 10; 7, BAU 25; 9, BAU 27; 8, BAU 28; 2, BAU 30; 1, BAU 37; 1, BAU 38; 1, BAU 40; 1, BAU 42; 1, BAU 43; 10, BAU 44; 4, BAU 48; 2, BAU 56; 2, BAU 57; 1, WM 166–65.

Diagnosis: Rostrum with tip upturned, rounded to acute, sides parallel to triangular; tip reaching to near middle of visible part of first antennular article. Orbital teeth almost as long as rostrum, but broader at base, with several setae at tips. Rostral base with orbitorostral process.

Second antennular article 1.6 times as long as wide, a little shorter than visible part of first antennular article and a little longer than third article. Stylocerite heavy, reaching to proximal portion of second article. Scaphocerite with squamous portion narrow, reaching to near end of antennular peduncles; lateral margin concave, lateral spine varying in length from end of antennular peduncle to as long as carpocerite. Carpocerite slender, 6.0 times as long as broad, reaching length of third article past that article. Superior tooth of basicerite acute, short; inferior tooth acute, longer than stylocerite.

Large chela cylindrical, 2.3 times as long as wide with fingers occupying distal 0.3. Palm usually terminating above dactylar articulation in two conical, obtuse tubercles, tubercles directed forward and upward. Superior margin of dactylus sharply carinate. Merus twice as long as broad, with superior margin strongly curved, inferointernal and superior margins terminating in acute teeth.

Small chela 2.8 times as long as broad. Dactylus proximally broad, tapering slightly towards tip; tip with one distal and one medial tooth. Pollex with strong terminal tooth, at times with a small secondary tooth. When fingers are closed the major tooth of pollex does not appear to fit between teeth of dactylus. Dactylus, pollex and lower side of palm bearing many setae. Inferointernal edge of carpus bearing a few slender spines. Merus almost 4 times as long as broad distally; inferoexternal margin bearing closely spaced fine long setae; inferointernal margin bearing 6–9 slender spines, shorter than the setae on the external margin.

Carpal article of the second leg with a ratio: 10:2:2:2:4.

Merus of third leg 3 times as long as broad, bearing on its inferointernal margin 6–9, or at times less, short strong spines, but without distal teeth or spines. Carpus 0.4 as long as merus, superior margin projecting as tooth, inferior margin bearing strong distal spine. Propodus 0.7 as long as merus, inferior margin bearing 6–10 spines. Dactylus biunguiculate, ungui almost equal at base but with superior unguis about twice as long as inferior. Merus of fourth leg inermous.

Telson 3 times as long as posterior margin is wide; posterior lateral corners angular but not projecting. Outer uropod with transverse articulation. First pair of dorsal spinules located slightly anterior to middle, second pair slightly posterior.

Discussion: We studied the variation in thirty specimens from Australia and twenty-nine from the Philippines; also, through the courtesy of the Zoölogisch Museum in Amsterdam we were able to study the holotype and several paratypes of De Man. We found variation in the frontal region similar to that illustrated by De Man (1911: pl. 11, figs. 53, 53a and 53b; *cf.* our fig. 8a and i). However, we found a range of variation greater than that reported by De Man in a number of characteristics:

1. The spine of the scaphocerite varied from as long as the antennular peduncle to as long as the carpocerite.
2. The two well-developed teeth above the dactylar articulation on the large chela in a few specimens were reduced to a single slight protrusion that could be seen only by rotation of the chela in a light arranged to shadow the irregularity, but these slight knobs were marked by the characteristic setae (the specimen from BAU 42 lacked all traces of the teeth and the setae, but could be identified by the characteristic slender spines on the merus of the large cheliped).
3. The acute tooth on the apex of the superior margin of the merus of the large chela varied in development, and in a few was missing entirely.

However, the shape and the armature of the small chela remained quite constant. De Man had not described the few spines on the carpus and merus of this appendage, yet we found it to be consistent in his type series, in the present collections and in the specimens we previously reported from Thailand (1966b). In a few specimens the spines appear to have been broken off.

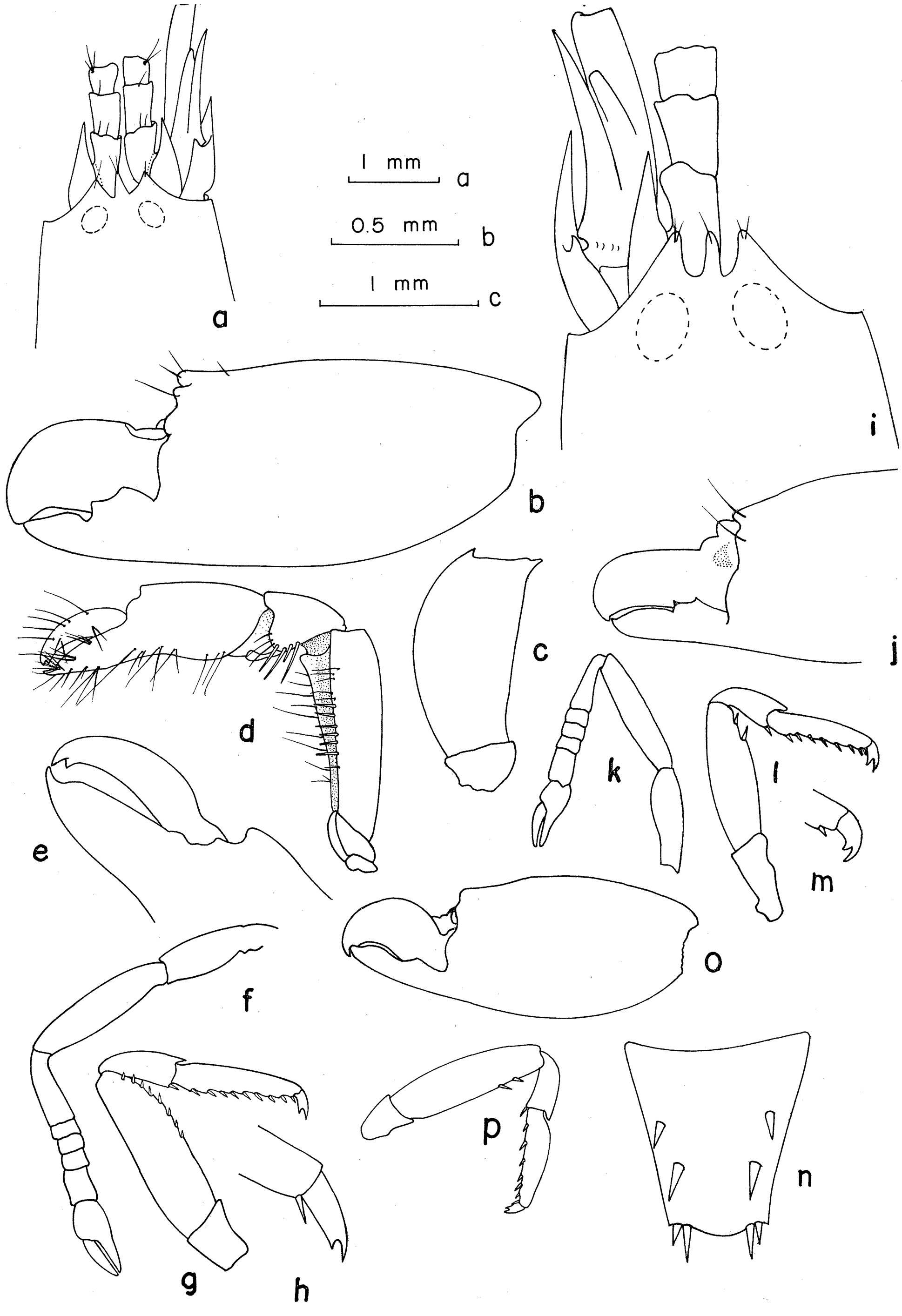
Three specimens collected from Darwin (BAU 57) bear only 1–2 spines on the inferior margin of the third legs (fig. 8p) instead of the 5–6 carried by all other specimens; coupled with this is a lesser development of the two tubercles above the dactylar articulation, with the lateral tubercle less well developed than the medial. This may represent a distinct geographical subspecies, but we are loathe to erect one for so few specimens in a variable species.

We have also three specimens in which the dactyl of the large chela is curved slightly inward, giving the chela a twisted look. We also found this condition in Thai specimens (*loc. cit.*). We attach no significance to this variation.

De Man recognized this species to be closely related to *S. pachymeris* Coutière (originally described as *S. biunguiculatus pachymeris* 1905a: 873, and raised to specific rank by De Man, 1911: 199). He separated the two species by the tubercles above the dactylar articulation of the large chela, by breadth of the meri of both chelipeds, by the relative lengths of the scaphocerites. As we found these characteristics variable we had considerable doubt about the separation of

OPPOSITE

Fig. 8.—*Synalpheus bituberculatus* De Man. 16 mm female from BAU 27: a, anterior region, dorsal view; b, c, large chela, outer face and merus, inner face; d, e, small cheliped, inner face and enlarged dactylus; f, second leg; g, h, third leg and enlarged dactylus. 11 mm male from AM. 334: i, anterior region, dorsal view; j, distal region of large chela; k, second leg; l, m, third leg and enlarged dactylus; n, telson. Specimen from BAU 42: o, large chela. Specimen from BAU 57: p, third leg. a, b, c, d, f, g, j, o, scale a; h, m, scale b; e, i, k, l, n, p, scale c.


a
1 mm a
0.5 mm b
1 mm c
b
c
d
e
f
g
h
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the species. Through the courtesy of the Museé d'Histoire Naturelle of Paris we were able to examine the specimens that Coutière had reported from Cargados and Providence Islands (1921: 417) and now believe that the two species may be firmly separated by the nature of the small chela. In *S. bituberculatus* the dactyl of the small chela is slightly broadened and bears a distal tooth with an accessory tooth medially, while in *S. pachymeris* the tip is tapered and without the accessory tooth; further, on the merus of *S. bituberculatus* the inferoexternal margin bears a row of long fine setae, the inferointernal a series of slender spines, while *S. pachymeris* bears only scattered setae on the merus. While the relative length of the scaphocerite cannot always be relied upon, it is usually definitely longer than the antennular peduncle in *S. bituberculatus* and definitely shorter in *S. pachymeris*. Similarly, on the large cheliped the superior margin of the merus is usually produced into an acute tooth and the palm usually bears the two up-turned tubercles in *S. bituberculatus* while in *S. pachymeris* the meral tooth is always lacking and there is never more than one tubercle which is always directed forward.

No specimens resembling *S. pachymeris* have been found in the Australian collections. While it is incidental to the present study we suggest that if anyone collects specimens similar to the form that Coutière named "variété *cargadosi*" (1921: 417), he carefully consider its specific separation from *pachymeris* (or, as Coutière described it, *S. biunguiculatus*), for the characteristics used to separate it do not fall into the range of variation we have seen.

Biological notes: *S. bituberculatus* is commonly found in sponges, living in pairs. We have also found it in dead coral from all sections of the reef in waters up to 8 metres deep. De Man reported it from sandy bottom at 36 metres. A colour note by John Yaldwyn with the specimen from One Tree Island (AM 334) states "body and appendages pinkish transparent with scattering of red chromatophores; eyes black, fingers orange". Our specimens ranged in size from 10–20 mm.

Australian distribution: This species was collected in Western Australia in the Houtman Abrohlos; in northern Australia from Darwin and the Torres Straits; and in eastern Australia from Green Island, Hayman Island and in the Swain Reefs-Capricorn Group area.

General distribution: Indian Ocean, Singapore, Thailand, Indonesia, Japan, Philippines*.

Synalpheus harpagatrus sp nov.

Fig. 9

Holotype: 38 mm female from sponge in 50 feet of water 5 miles west of North Beach, Perth, Western Australia (WM 86–65) collected by D. Blair, 9/9/61.

Allotype: 28 mm male from a pair taken from a sponge. Cottesloe, near Perth, Western Australia (WM 11129/30) collected by L. Glauert, December, 1924.

Paratypes: 1, 35 mm female from WM 11129/30; 1, 14 mm male and 1, 20 mm female from WM 10380; 1, 14 mm female from WM 4985; 1, 25 mm male from SM 1.

Description: Rostrum awl-shaped, three times as long as broad at base, tip three-quarters length of visible part of first antennular article. Orbital teeth triangular, about two-thirds as broad at the base as long, with inner margin straight and parallel to axis of rostrum. Tips of rostrum and orbital teeth bearing a few setae. Rostral base with orbitorostral process.

Second antennular article 0.8 as long as visible part of first, and 1.5 times as long as wide. Third article a little shorter than second. Stylocerite acute, reaching middle of second antennular article. Lateral tooth of scaphocerite reaching near end of third antennular article. Squamous portion narrow, reaching near middle of third antennular article. Carpocerite a little more than six times as long as broad and reaching well past end of antennular peduncle. Inferior tooth of basicerite almost as long as stylocerite, superior tooth acute, slender, about one-third as long as inferior tooth. Distal end of ultimate article of third maxilliped bearing a cluster of 10–12 short heavy spines.

Large chela sub-cylindrical, 2.4 times as long as broad with fingers occupying distal 0.3. Distal end of superior margin of palm slightly protruding and bearing medially a small acute tooth. Merus thick, 1.8 times as long as broad, inferior margins inermous, but bearing on superodistal margin an acute triangular tooth.

Small cheliped stout. Chela nearly cylindrical, 2.3 times as long as broad, fingers a little less than half as long as palm. Dactylus broadened with rounded tip bearing 4 rounded obtuse teeth. Pollex also broadened, tip bearing 3 triangular acute teeth. Distal half of opposing surfaces of pollex and dactylus deeply excavate, proximal half of pollex convex and fitting into corresponding cavity on dactylus. When fingers are closed, teeth at tip of dactylus mesh with, but extend beyond, those of fixed finger. Carpus cup-shaped, superodistal margin armed towards medial side with a subacute tooth similar to that of large chela. Merus heavy, 1.8 times as long as broad, with superodistal tooth similar to that of large chela.

Carpal articles of second leg with a ratio: 10:1.8:1.8:1.8:4.0.

Merus of third leg 3.2 times as long as broad, bearing on inferointernal margin 5 strong spines, but none distally. Carpus one-third as long as merus, superodistal margin projecting as strong obtuse tooth, inferodistal margin bearing two spines. Propodus about two-thirds length of merus, bearing on its inferior margin 5 strong spines, but none distally. Carpus one-third as long as merus, superodistal margin projecting as strong obtuse tooth, inferodistal margin bearing two spines.

Propodus about two-thirds length of merus, bearing on its inferior margin seven spines and two distally. Dactylus biunguiculate with ungui equal in length; superior unguis 4 times as long as broad at base and following gradual curve of dactylus; inferior unguis about as long as broad at base and at almost a right angle to the axis of propodus. Fourth leg similar to third, but bearing less spinules on merus. Fifth leg without spines on merus.

Telson 1.8 times as long as broad at posterior margin, much shorter than uropods. Posterolateral angles acute and slightly projected. Posterior margin broadly arcuate. Outer uropod with transverse articulation.

Discussion: On the small cheliped of the male allotype the merus was more slender than that of the holotype, the inferodistal tooth was merely a rounded prominence and the small tooth on the superodistal margin of the carpus was absent. However, as another male we examined had a small cheliped that was like that of the holotype, we feel this must be an individual variation. In two specimens the rostrum and orbital teeth are a little longer in relation to the first antennular article than those of the holotype.

This species appears to be related to the Indo-Pacific group of synalpheids that carry broadened and often denticulate fingers on the small chela. The species in the American Gambarelloides (= Laevimanus) group have similarly developed fingers, but according to Coutière (1909, *serratum*) the "Laevimanus" group always has a heavy crest or brush of setae on this dactylus which never appears in the Indo-Pacific forms. The Indo-Pacific group of species include those listed in the key from couplets 6 to 12 (p. 279) and *S. antenor* De Man and *S. laticeps* Coutière. From all these species *S. harpagatrus* is separated by the presence of strong spines on the merus of the third legs and by the very heavy spines on the tip of the third maxilliped. Other characteristics useful for the separation of this species are given in the key.

The specific name is derived from *harpatus* Gr., seizing or holding and *–tros,* Gr., tool or instrument, and refers to the possible use of the small chela in the cavity of the host sponge.

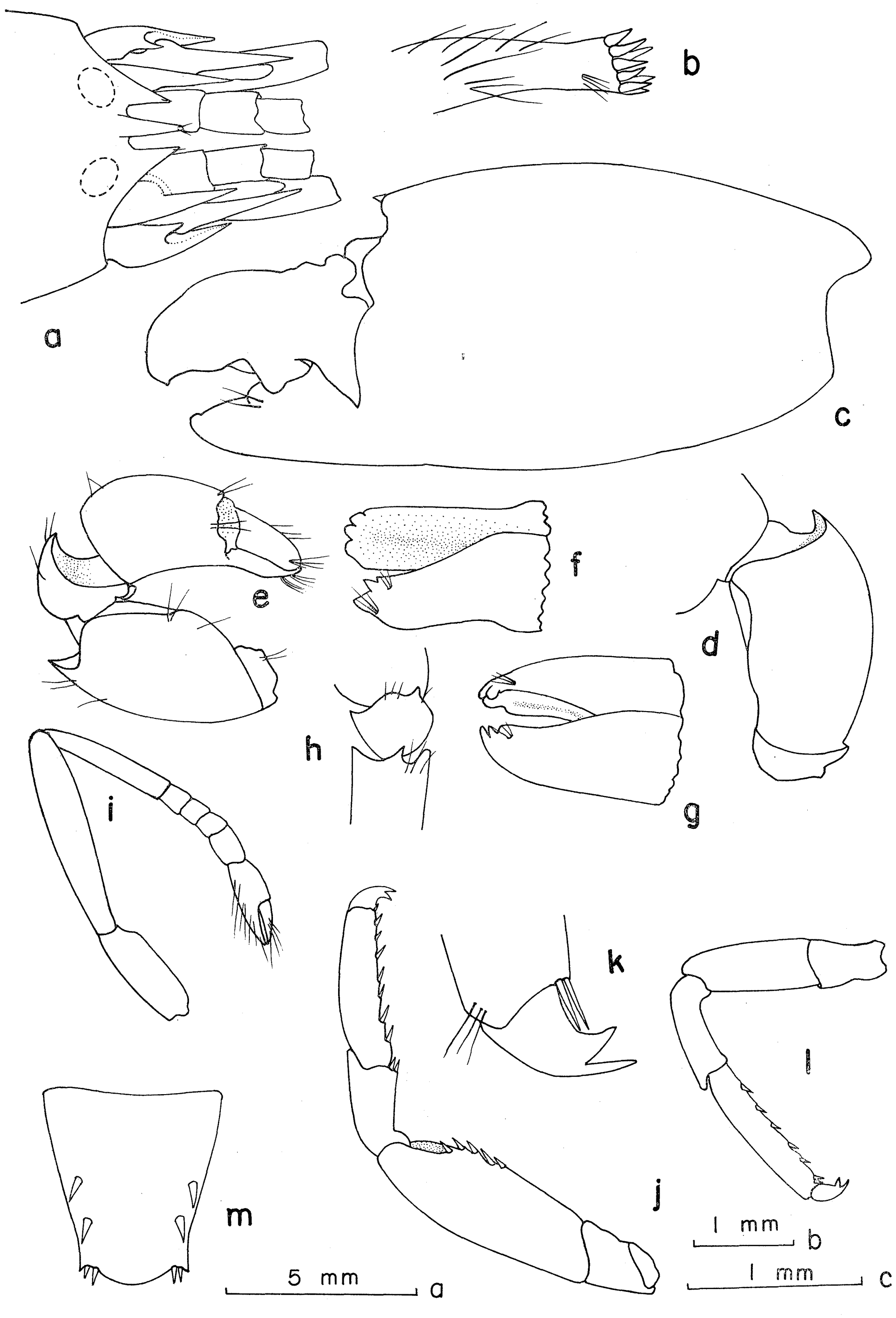
The holotype and allotype will be placed in the Western Australian Museum in Perth.

Biological notes: All of the specimens came from sponges except one that was dredged, but it might have been separated from a sponge in the dredging process. The type was dredged from 50 ft, but all except one of the paratypes were collected from sponges intertidally.

Australian distribution: All specimens with locality data were collected between Fremantle and Geraldton, W.A. A 30 mm male collected by W. Greenwood, August 30, 1909, had no collection data, but as it came from the South Australian Museum, we presume it may have been collected from South Australian waters.

OPPOSITE

Fig. 9.—*Synalpheus harpagatrus* sp. nov. Holotype. a, anterior region, dorsal view; b, distal end of third maxilliped; c, d, large chela and merus, outer face; e, small cheliped; f, g, dactyl and pollex of small chela, ventral and lateral view; h, superior face of carpus and distosuperior section of merus of small cheliped; i, second leg; j, k, third leg and dactylus; l, fifth leg; m, telson. c, d, e, h, i, j, l, m, scale a; a, f, g, scale b; b, k, scale c.


a
b
c
d
e
f
g
h
i
j
k
l
m
5 mm a
1 mm b
1 mm c

Synalpheus theano De Man

Fig. 10

Synalpheus theano De Man, 1910b, Tijdschr. ned. dierk. Vereen 11 (4): 296; 1911, Siboga Exped. 39a[1] (2): 293, fig. 61. Banner & Banner, 1972, Crustaceana 23 (1): 20, fig. 3f [separation from *S. neptunus* (Dana)].

Nec Synalpheus theano Banner & Banner, 1966b, Siam Soc. Mono. 3, p. 69, fig. 24 (= *S. neptunus*).

Specimens examined: 1 specimen from AM 140; 9, AM P 13556; 8, BAU 27; 6, BAU 28; 1, BAU 40; 1, BAU 43; 1 specimen each from CS 2, 10, 15, 16, 17, 23; 2, QM W 1053; 2, UQ 22; 1, WM 268–65; 1, WM 10380; 2, WM 10487; 1, WM 10591/92.

Diagnosis: Rostrum reaching past middle of first antennular article; orbital teeth as long as rostrum, but broader at base. Rostral base with orbitorostral process.

Antennular articles subequal, second article 1.3 times as long as broad. Stylocerite reaching from three-fourths length of first antennular article to end. Lateral spine of scaphocerite reaching from one-half length to end of third article; squamous portion reaching variously from three-fourths the length, to end, of second article. Carpocerite reaching almost the length of third antennular article past that article. Inferior spine of basicerite varying from one-half the length of the second article to end; superior angle rounded.

Middle article of third maxilliped bearing two strong spines in addition to setae, tip of final article bearing a dense tuft of setae but no spines.

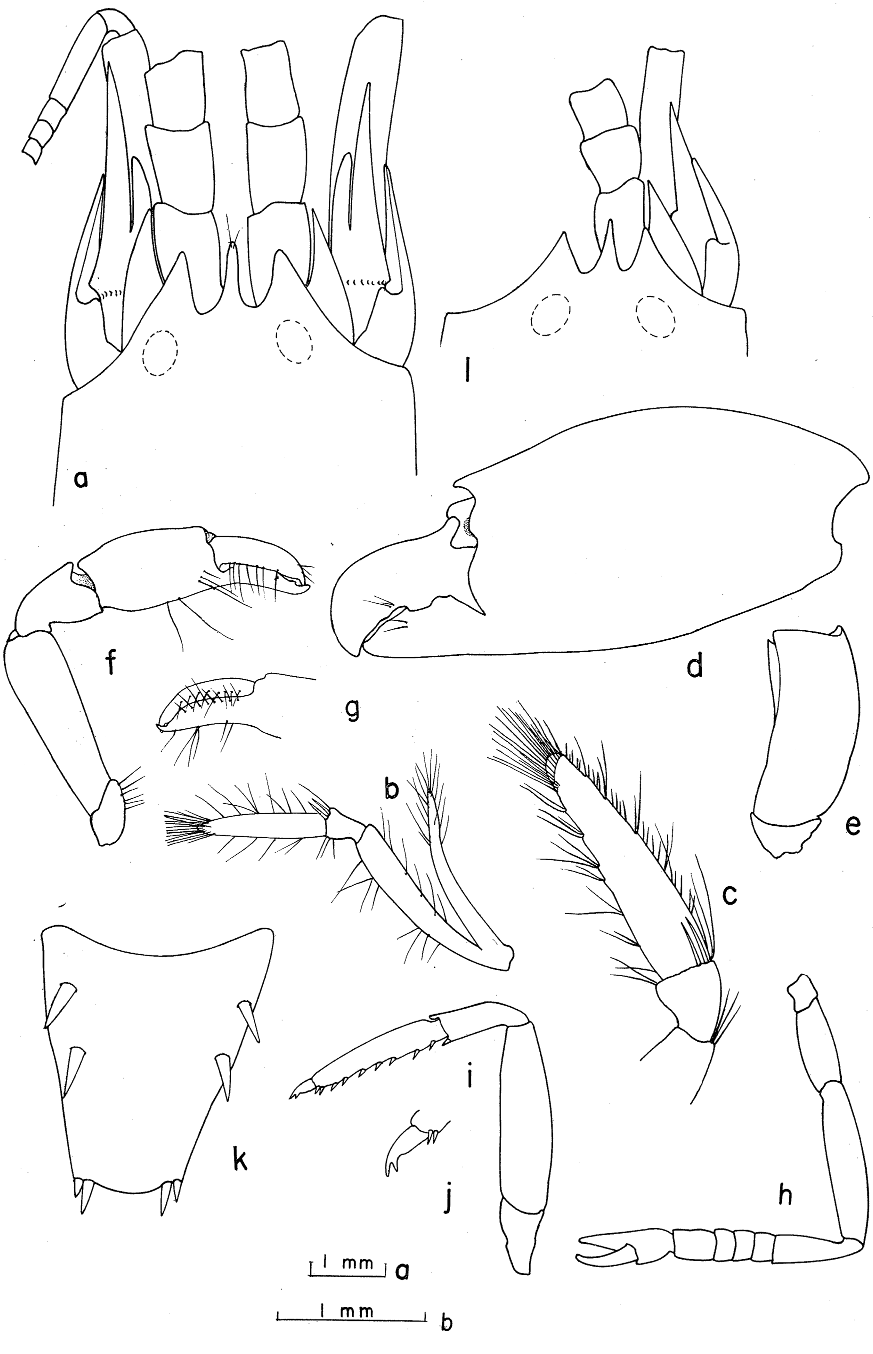
Large chela 2.4 times as long as broad; superior margin terminating in an obtuse tooth above dactylus. Merus 2.6 times as long as broad, superior and inferointernal margin each terminating in small acute tooth. Small chela 2.4 times as long as wide with fingers and palm almost equal in length. Dactylus broadened laterally, opposing surface slightly excavate and terminating in a slender obtuse tooth that crosses a similar tooth on pollex upon closure. Margin of outer face of dactylus armed with 7–9 regularly placed setae; inner face similarly armed with setae which cross in a regular fashion corresponding setae on margin of pollex. Carpus cup-shaped, varying from 0.27–0.33 the length of the chela. Merus 3.2 times as long as broad at the distal end, unarmed.

Carpal articles of second leg with ratio 10:2:2:2:4, sum of four distal articles 1.1–1.3 times length of first.

Merus of third leg inermous, 3.7 times as long as broad. Carpus 0.4 as long as merus, superodistal margin projected as an obtuse tooth, inferodistal margin bearing spine; propodus 0.7 as long as merus bearing seven spines on inferior margin and two distally. Dactylus biunguiculate, two ungui equal in length, inferior unguis slightly thicker at base.

OPPOSITE

Fig. 10.—*Synalpheus theano* De Man. 12 mm male from UQ 22: a, anterior region, dorsal view; b, c, third maxilliped and detail of ultimate article; d, e, large chela and merus; f, small cheliped, outer face; g, distal region of small chela, inner face; h, second leg; i, j, third leg and enlarged dactylus; k, telson. 18 mm female from BAU 25: l, anterior region showing lack of squame. b, e, h, i, l, scale a; a, c, f, g, j, k, scale b.


a
l
f
d
g
b
e
c
k
i
j
h
1 mm a
1 mm b

Telson 2.2 times as long as posterior margin is wide. Posterolateral margins forming right angles; posterior margin slightly convex, spines on dorsal surface prominent and anterior to midline. Outer uropod with transverse articulation.

Discussion: For the separation between this species and *S. n. neptunus* see *Discussion* under that species (p. 318).

The specimen shown in fig. 10m is without a vestige of the squamous portion of the scaphocerite. As it compared well otherwise to the characteristics of this species, and as it was collected from a sponge (BAU 25) with other normal members of the species, it was regarded as a variation. A similar difference, however, was found in the related *S. neptunus germanus*, and there considered as one of the criteria for the erection of a new subspecies (p. 321).

Biological notes: Some of the specimens were collected from dead corals. The specimen figured was collected by A. J. Bruce from a yellow sponge *Psammoaplysilla purpurea* (Carter). De Man's specimen was collected by a dredge at 32 metres. Specimens range in size from 10–22 mm.

Australian distribution: In Western Australia specimens were collected near Perth; in northern Australia, from Darwin and Thursday Island; and in eastern Australia, from Whitsunday Group to Port Jackson, N.S.W.

General distribution: Indonesia and Singapore (it may be that Johnson (1962: 50) in his report of the species from Singapore confused *S. theano* with *S. neptunus* as we did (1966b) in our Thai study).

Synalpheus neptunus neptunus (Dana) [Subspecies designated]

Fig. 11

Alpheus neptunus Dana, 1852, U.S. Explor. Exped. 13: 553, pl. 35, fig. 5.

Synalpheus neptunus Coutière, 1909, Proc, U.S. natn. Mus. 36 (1659): 87, fig. 53. Banner & Banner, 1972, Crustaceana 23 (1): 24 [Neotype established and full synonymy given].

Additional Australian Records: [records questionable, see discussion below]

Bate, 1888, Challenger Rept. 24: 563, pl. 10, fig. 2 (as *Alpheus neptunus*). Arafura Sea.

Coutière, 1900, Bull. Mus. Hist nat., Paris 6 (8): 411. Torres Strait.

Specimens examined: 17 specimens from AM E 4494; 6, AM P 1695; 1, BAU 25; 23, BAU 28; 7, BAU 33; 1, BAU 43; 1, CS 25–28; 1, QM W 1053; 8, WM 34–65; 4, WM 183–65; 3, WM 189–65; 1, WM 243–65; 5, WM 274–65; 6, WM 289–65; 5, WM 10591/92.

Diagnosis: Rostrum with rounded tip reaching well past middle of visible part of first antennular article. Orbital teeth broader than rostrum at base and often slightly shorter. Rostral base with orbitorostral process.

First two antennular articles subequal, third a little shorter than second; second article a little longer than broad. Stylocerite varying from three-fourths length of first antennular article to a little past end. Lateral spine of scaphocerite varying from end of second antennular article to three-fourths length of third article; squamous portion variable, at times reaching to end of second antennular article, and at times vestigial. Carpocerite longer than antennular peduncles, approximately five times as long as wide. Lateral spine of basicerite reaching from end of first antennular article to three-fourths length of second; superior angle rounded, occasionally slightly projecting.

Distal article of third maxilliped 4.5 times as long as broad, bearing on its apex a circlet of 6–7 short heavy spines.

Large chela 2.5 times as long as wide, with fingers occupying distal 0.3. Palm terminating above dactylar articulation in rounded prominence. Merus 3.5 times as long as broad with end of superior margin rounded and with only a blunt prominence on distal end of both inferior margins. Small chela 2.4 times as long as wide with fingers and palm almost equal. Fingers broadened laterally, opposing surfaces excavate, both without auxiliary teeth. Margin of outer face of dactylus armed with a row of 7–9 regularly placed setae; margins on inner face armed with setae which cross in a regular fashion, similar setae on pollex. Both dactyl and pollex terminate in a single tooth. Carpus cup-shaped, varying from 0.20 to 0.50 the length of chela.

Second leg with first carpal articles slightly shorter than sum of four following; length of chela may almost equal length of sum of last four articles. Ratio of carpal articles of second legs: 10:2:2:2:5.

Merus of third leg three times as long as broad, inermis. Carpus 0.4 as long as merus, inferodistal margin armed with a solitary spinule, superodistal margin extended into rounded tooth. Propodus 0.7 as long as merus, inferior margin armed with 6–9 spinules, none distally. Dactylus biunguiculate, 2 ungui often equal in length, but inferior unguis slightly thicker at base.

Telson 2.3 times as long as posterior margin is broad; anterior margin twice as broad as posterior; posterolateral margins forming right angles; posterior margin slightly convex. Dorsal spines prominent; length of anterior dorsal pair one-third, of medial pair of posterior spines one-quarter, breadth of telson tip. Outer uropod with distal articulation in mature forms.

Discussion: In 1972 we established a neotype for this species with a specimen from the Sulu Sea, the type location, and contrasted the species to the closely related *S. theano* De Man. We were able to show that both species exhibited considerable variation in characteristics previously considered to be of value in their separation, especially in their growth patterns. However there was one reliable characteristic: In *S. neptunus* the tip of the third maxilliped bears a circlet of short strong spines (fig. 11h) while in *S. theano* the tip bears a tuft of longer, flexible setae (fig. 10c).

The largest specimens in the Australian collections were those from Exmouth Gulf which reached 26 mm in length; other specimens ranged from 7–18 mm. We have figured the rostral front, small chela and second legs of one specimen from Exmouth Gulf (fig. 11k, 1, m) as these parts were more slender than those of specimens of smaller size. We tentatively suggest that this variation is a further extension of the variation in proportion with size.

Biological notes: In the examination of the collections from Australia and the Philippines we observed a rather perplexing correlation that we had not previously noted. In this species there appears to be two different size ranges which are correlated with habitat, with an exception from the Exmouth Gulf, W.A. In those specimens which in our field notes were recorded as coming from corals or where the specific ecological niches were not noted ("dredged from 10 fathoms"), the size ranged from 18–26 mm and they contained the usual number of ovigerous females. Secondary sexual characteristics were well developed, with the females showing large rounded pleura on the abdomen and large, soft pleopods; the second pleopods of the females carried a well-developd *appendix interna* arising at slightly less than two-thirds the length of the endopod (fig. 11i). In contrast the pleura of the males were smaller, the first with a definite projected posterior tooth, the remaining pleura with the posterior margins angular. In the males of size comparable to the ovigerous females the second pleopods were shorter and apparently stronger; while the pleopods carried only the *appendix interna* as is normal for *Synalpheus*, it was shorter and originated from slightly beyond the end of the basal third of the endopod (fig. 11j). None of these apparently free-living forms was less than 8 mm long.

In contrast, large numbers in the collection were noted as coming from the cavities of sponges; within the spongocoels they occurred in great numbers (in our personal collections we removed up to fifty specimens on one sponge, but we could have collected more from larger sponges). All of these specimens were small, not reaching over 8 mm in length. None were ovigerous, and upon examination all showed a male form of abdominal pleura. In most specimens the endoped of the second pleopod had no endite; in a few of the largest there was a small

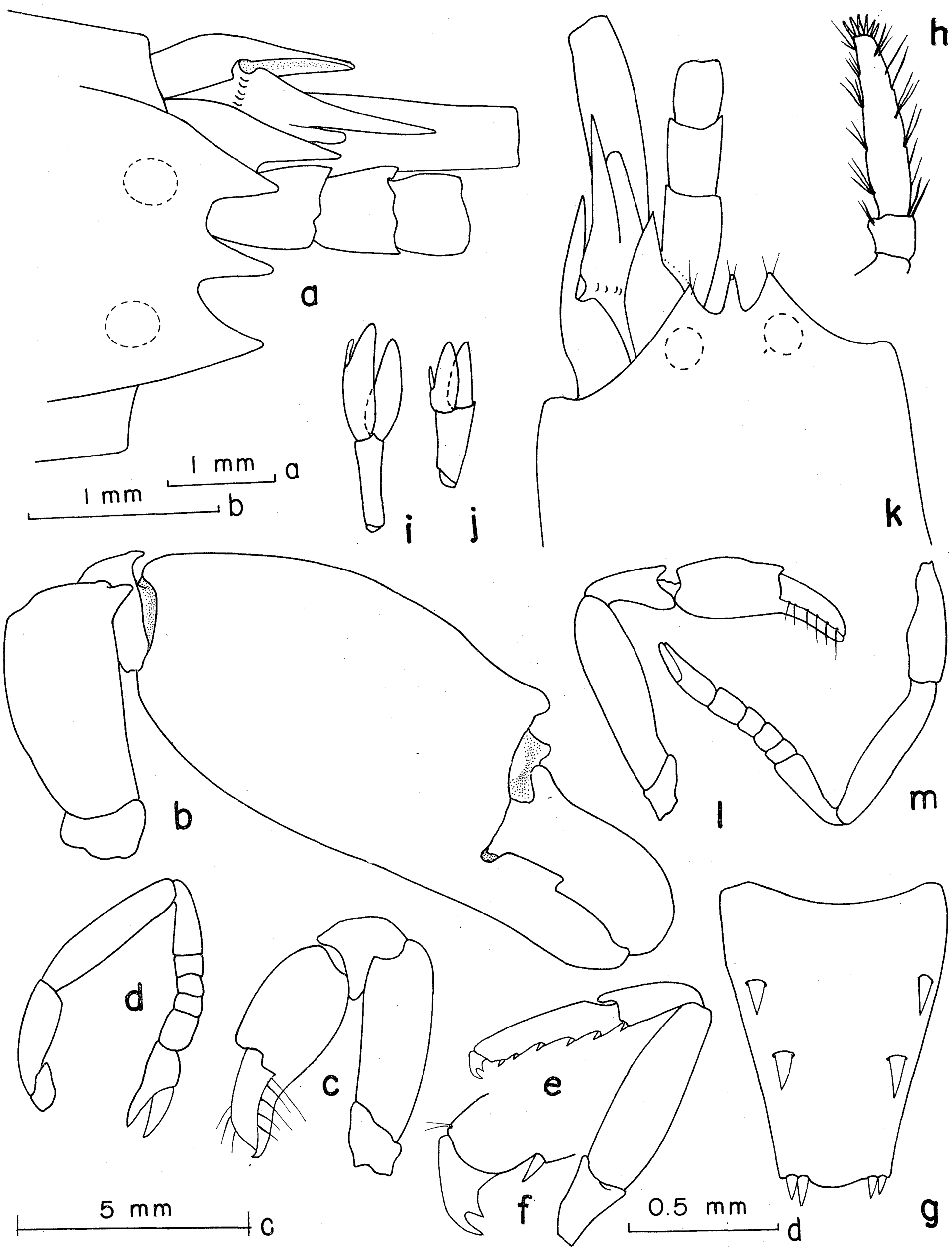


Fig. 11.—*Synalpheus neptunus neptunus* (Dana).—10 mm male from BAU 28: a, anterior region dorsal view; b, large cheliped, inner face; c, small cheliped, outer face; d, second leg; e, f, third leg and enlargement of dactylus; g, telson; h, third maxilliped. 27 mm female from WM 183-65: i, second pleopod. 28 mm male from WM 83-65: j, second pleopod. 30 mm female from WM 34-65: k, anterior region, dorsal view; l, small cheliped; m, second leg. b, c, d, e, h, scale a; a, g, h, scale b; i, j, k, l, m, scale c; f, scale d.

appendix interna in the "male position". Finally, in the smaller of the specimens the outer uropod was without the normal transverse articulation; in the larger the articulation was present but not well formed. It is known that immature synalpheids of both sexes may have abdominal pleura more like adult males (Coutière, 1909: 18). To our knowledge there have been no observations of the male-like *appendix interna* nor of the lack of transverse articulation in immature forms. Other morphological characteristics lie well within the range of variation that we have already reported upon.

The exception lies in two collections from Exmouth Gulf (CS 25–28, WM 60–65). The specimens in both of these were reported as coming from sponges gathered in trawls and both contained sexually mature specimens ranging from 10–25 mm in length (these are not the large specimens mentioned under *Discussion*).

We know of only one other case (Coutière 1909: 17) where there has been reported among the alpheids such difference in habitat with sex and sexual maturity. We suggest two possible interpretations for the observations: First, that the young of *S. n. neptunus* may settle either in the dead coral (or other similar habitats) where it will grow to maturity, or may settle in various sponges where some pheromone-like chemical given off by some species of sponges will inhibit growth and sexual maturity of the individual. This explanation does not account for the lack of the smaller individuals in the "open" habitat. Second, that the species actually uses some species of sponges as a "nursery", probably infesting it in a post-larval stage and staying within the protection of the spongocoel until it reaches the length of about 8 mm when it moves into the "open" habitat. What would cause an individual to leave the spongocoel at a particular stage of development we do not know, but we suggest it may be a change in food habits or too much spatial restriction by the narrow passages of the sponge. In the case of the two Exmouth Gulf collections these food or spatial restrictions had not applied in that particular sponge and the alpheid could reach maturity. While it will take further field observation supplemented with laboratory studies to confirm these conclusions (which are impossible in Hawaii as the species does not occur in the Central Pacific), we believe that the second hypothesis seems the more logical from the data available to us.

The Australian specimens were taken mostly from coral heads collected in shallow water; however, those from Cockburn Sound were taken from sponges dredged from 11 fathoms.

Australian distribution: Specimens from Western Australia came from Perth to Exmouth Gulf; in northern Australia from Thursday Is., in eastern Australia from Port Douglas to Port Jackson.

General distribution: Red Sea; Indian Ocean; Indonesia; China, Japan and Sulu Sea. We have not found it in the islands of the Central Pacific. There is so much confusion about the identity of *S. n. neptunus* that most older locality records cannot be relied upon.

Synalpheus neptunus germanus subsp. nov.

Fig. 12

Holotype: 11 mm specimen collected from sponge by G. Glauert, 14/8/22, at Cottesloe, W.A. (WM 9991), apparently an immature male.

Paratypes: 16 specimens, 10–15 mm from same location as the holotype; eighteen specimens, 10–15 mm from Rottnest, W.A. (WM 32–65); nine specimens 7–14 mm from Cottesloe, W.A. (AM P 12426). [All paratypes apparently immature males.]

Description: Rostrum almost reaching to end of first antennular article. Orbital teeth with tips rounded, almost as long as rostrum, but much broader at base, almost forming an equilateral triangle. Rostral base with orbitorostral process.

Antennular peduncle stout, articles subequal, second antennular article a little broader than long. Stylocerite a little longer than first article. Scaphocerite with lateral spine reaching almost to end of third antennular article; squamous portion absent. Carpocerite reaching well past antennular peduncle, 4.5 times as long as wide in lateral view. Basicerite with superior margin slightly projected but rounded; inferior spine a little longer than stylocerite.

Distal end of third maxilliped armed with a circlet of spinules.

Large cheliped 2.6 times as long as broad, distal end of superior margin proximal to palm produced into an obtuse tooth, tilted slightly upward. Finger 0.3 as long as entire chela. Merus two times as long as broad, distal ends of both inferior margins armed with slightly produced, obtuse teeth; superior margin not produced.

Small chela 3 times as long as broad, palm a little shorter than fingers; fingers laterally expanded and excavate; distal part of pollex on inner face bearing four patches of setae which curve upwards and forwards so that when viewed from the inner face they appear as a fan of setae (fig. 12f). Outer face of dactylus with two rows of setae placed longitudinally; superior row located below crest with evenly spaced follicles, each bearing one or two setae; inferior row located along oppositional margin, similar to that of *S. n. neptunus*. A few setae on the palm close to base of pollex. Carpus one-quarter length of chela, bearing a few setae on inferoexternal margin. Merus 0.8 length of chela and 2.5 times as long as broad.

Carpal articles of the second leg with a ratio: 10:2:2:2:6. Second to fourth articles broader than long; chela twice length of distal article.

Merus of third leg almost 3.5 times as long as broad. Carpus 0.4 as long as merus, distosuperior margin projecting as subacute tooth, inferodistal margin bearing movable spine. Propodus 0.7 as long as merus, bearing on inferior margin five spinules and two distally. Dactylus biunguiculate, ungui almost equal in length, apex between forming a "U".

Telson 2.7 times as long as wide at the posterior margin, anterior margin 2.5 times breadth of posterior; posterolateral margins forming right angles; telsal tip almost straight. Length of anterior pair of dorsal spines over half, of medial pair of posterior spines less than half, breadth of telson tip. Outer uropod without distal articulation.

Discussion: Somewhat similar to the specimens of the nominate subspecies which were also collected from sponges, all forty-four of these specimens appeared to be juvenile, none carried ova. All had the angular corners of the abdominal pleura and all lacked the transverse articulation of the outer uropod. However, possibly because of their slightly larger size, all had an *appendix interna* in the basal third of the endopod of the second pleopod. As in *S. neptunus neptunus,* we have interpreted these characteristics as being those of sexually immature juveniles. Evidently the same factors influence the form of the two subspecies.

This collection shows far less variation than does that of the nominate subspecies and the related *S. theano*; the spines on the end of the third maxilliped shows it definitely to be related to *S. n. neptunus*. The differences between this subspecies and *S. n. neptunus* are small but constant in these collections: 1. In this subspecies the squame is usually absent, and at most a mere vestige, while in the nominate subspecies it usually is of moderate development and only rarely reduced to a vestige. (We differentiate between the vestigial form and the complete absence of the squame by the presence or absence of a slit between the lobe and the lateral tooth). 2. The dactylus of the small chela bears an additional row of setae on the outer face, superior to the marginal row. 3. The tip of the telson is narrower, and the spines are longer, the anterior margin is 2.5 times the breadth of the tip instead of 2.0 times as in *S. n. neptunus*. 4. The tip of the telson is less arcuate. We regard the second point as the most reliable.

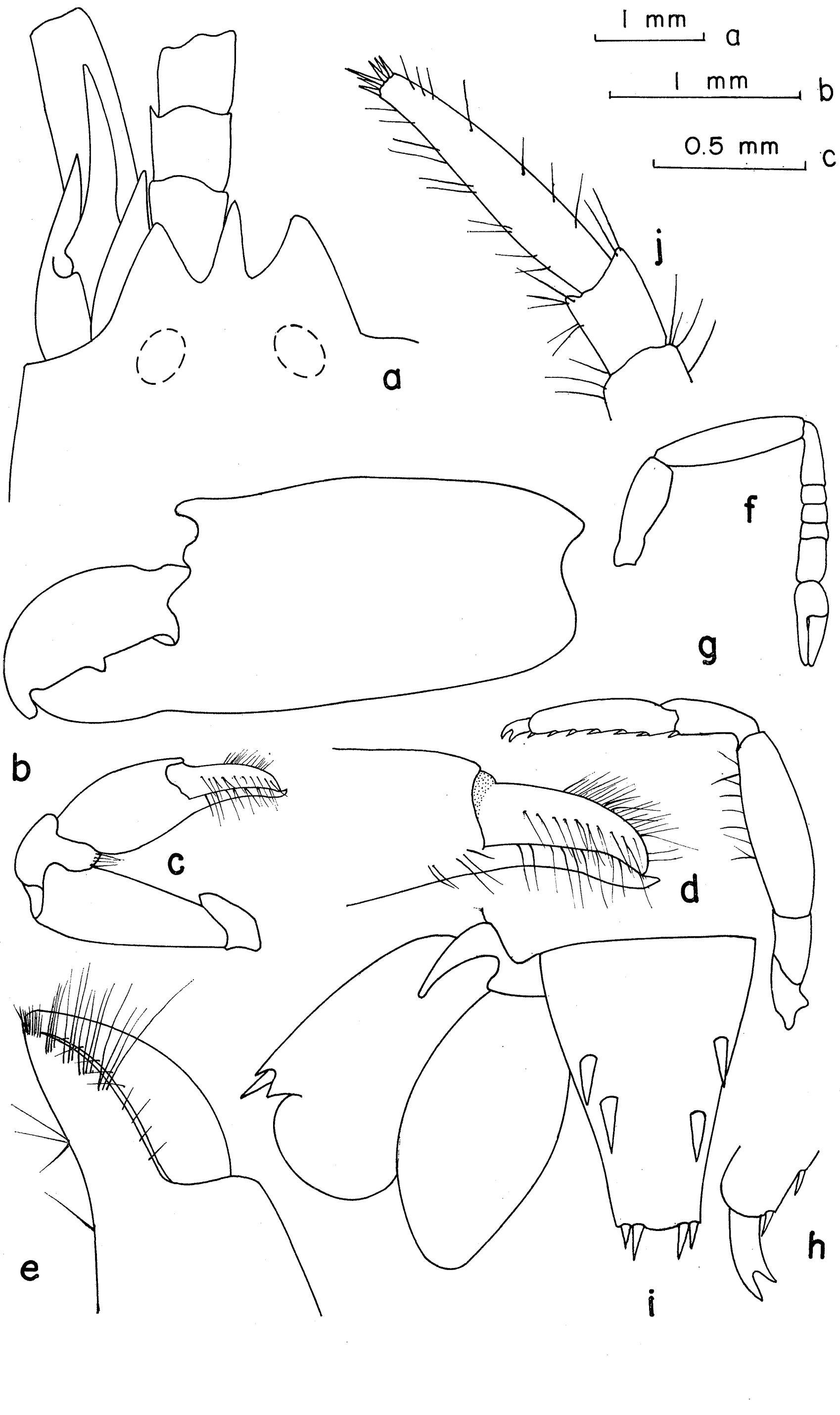
In the consideration of the division of this species into two subspecies it should be noted that all specimens came from the immediate vicinity of Fremantle, W.A., while *S. n. neptunus* is widespread in the Western Pacific and Indian Ocean, as well as in the Fremantle area.

We suggest that this form is a variant of *S. neptunus* which is adapted to live as a juvenile in a particular sponge found in the Fremantle area of Western Australia. We are quite sure that many of the characteristics, like the lack of an articulation in the uropod, will change with maturity, similar to the growth changes we have reported for the nominate subspecies (1972:24, and above). However, we believe these growth changes will not obliterate all the criteria we have established to separate the two subspecies.

The subspecific name is from the Latin word meaning "of the same parent" and was selected to indicate the close relationship of the two subspecies. The holotype will be deposited in the Western Australian Museum.

OPPOSITE

Fig. 12.—*Synalpheus neptunus germanus* subsp. nov. Holotype: a, anterior region, dorsal view; b, large chela, inner face; c, d, small cheliped, outer face and enlargement of distal region; e, enlargement of distal end of small chela, inner face; f, second leg; g, h, third leg and enlargement of dactyl; i, telson. 17 mm male from WM 10591/92: j, distal region of third maxilliped. b, e, f, g, scale a; a, d, e, i, scale b; j, h, scale c.


1 mm a
1 mm b
0.5 mm c
a
b
c
d
e
f
g
h
i
j

Synalpheus demani Borradaile

Fig. 13

Synalpheus demani Borradaile, 1900, Willey's Zool. Res. 4: 416. De Man, 1911, Siboga Exped. 39a[1] (2): 257, fig. 42. Banner & Banner 1968, Micronesica 4 (2): 274. Miya, 1972, Publ. Amakusa Mar. Biol. Lab. 3 (1): 60, pl. 11.

Alpheus triunguiculatus De Man, 1888a, Archiv. Naturgesch. 53: 504, pl. 22, fig. 1 (*nec* Paulson).

Synalpheus spiniger Bate, 1888. Challenger Rept. 24: 560, pl. 100, fig. 3 (*nec* Stimpson).

Synalpheus brockii Nobili, 1901, Ann. del Mus. Zool. Napoli 1 (3): 2.

Specimens examined: Four specimens from AM 177.

Diagnosis: Rostrum slender, over twice as long as broad, reaching to end of first antennular article. Orbital teeth shorter and broader at base than rostrum, but strongly acute. Pterygostomial angle more projecting than usual for the genus. Rostral base with orbitorostral process.

Visible part of first antennular article scarcely 1.5 times as long as second article; second article about 1.5 times as long as broad and 1.5 times as long as third article. Stylocerite acute, reaching to near middle of second antennular article. Squamous portion of scaphocerite reaching to middle of third antennular article, lateral spine reaching to end of same article. Carpocerite, viewed laterally, 4.5 times as long as broad, reaching past end of third antennular article. Lateral margins of distal half of carpocerite beset with setae. Inferior spine of basicerite almost as long as stylocerite and bearing setae on distolateral margin; superior spine acute, a little longer than orbital spines. Superior margin of basicerite bearing third short subacute tooth medial and proximal to superior tooth.

Large chelae missing in all available specimens. (De Man, 1888a, pl. 22, fig. 1 shows the large chela to be three times as long as broad, margin superior to dactylar articulation unarmed and rounded; distal angles of merus not projecting.)

Small chela 3.5 times as long as broad, fingers 0.7 as long as palm. Carpus about one-sixth as long as chela. Merus 2.5 times as long as broad, inermis, but bearing along superior margin groups of short setae and individually placed fine setae along inferior margin.

Carpal articles of second leg with ratio 10:2:2:2:3; second and third articles as broad as long.

Third leg stout. Ischium and merus unarmed; merus 3 times as long as broad. Carpus short, 0.4 as long as merus and heavy, 0.6 as broad as long; inferodistal margin rounded and bearing a few setae; superodistal margin extended as a heavy tooth. Propodus as long as merus, curved, proximal portions unarmed but bearing distally three small spinules and several dense patches of setae. Dactylus heavy, almost one-third as long as prodous, triunguiculate. Middle unguis two or three times length of superior unguis; inferior unguis about 1.5 length of superior; inferior unguis usually slightly broader at base than at middle.

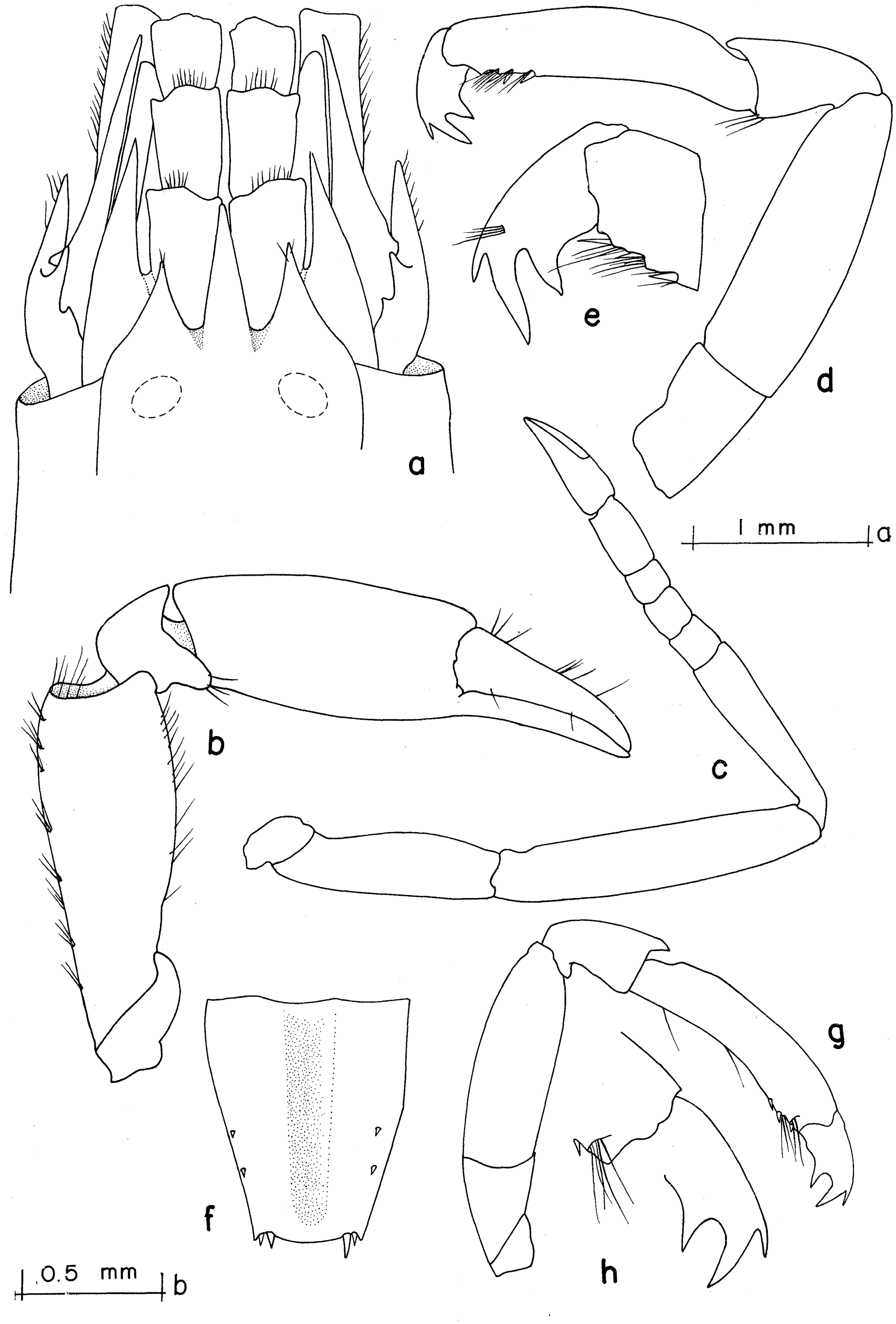


Fig. 13.—*Synalpheus demani* Borradaile. 20 mm male AM 177: a, anterior region of carapace, dorsal view; b, small cheliped; c, second leg; d, e, third leg and enlarged dactylus; f, telson. Bate's specimen from the Challenger Report: g, h, third leg and enlargement of dactylus. All drawings except e and h, scale a; e and h, scale b.

Telson 2.1 times as long as broad at posterior margin, posterolateral margin slightly produced and acute. Dorsal surface slightly concave medially, with spinules small and located posterior to middle and near lateral margins, or absent. Outer uropod with transverse articulation.

Discussion: Our four specimens appear to be two pairs. Both males are 20 mm long while the females which are ovigerous, are 30 mm long. The gastric region of the carapace of the female also has a "humped-up" appearance similar to *S. carinatus* (De Man) while the carapace of the male is flattened. The spines on the upper surface of the telson are variable: the male drawn had four small spines, one female carried one spine and in the other two specimens all spines were lacking. Miya (1972) remarks on two smaller males in his collection that have only four articles in the carpus of the second legs. He stated that these also had a rudimentary *appendix interna* on the second pleopods, a process absent in larger males.

This species is most closely related to *S. triunguiculatus* Paulson, but is separated by at least three characteristics: 1. In *S. triunguiculatus* there is a hooked tubercle at the distal end of the palm of the large chela while *S. demani* has none; 2. the inferior margin of the propodus of the third leg in *S. triunguiculatus* carries eight strong spinules while in *S. demani* there are only three spinules near the distal end; 3. the spines on the dorsal surface of the telson of *S. triunguiculatus* are strong while in *S. demani* they are small and weak or entirely absent.

We were able to examine Spence Bate's specimen that he named *S. spiniger* (Stimpson) from the Challenger Expedition at the British Museum of Natural History and found it to be *S. demani*. *S. spiniger* is described as having only two ungui on the dactyli of the third legs " . . . *unguiculus secundus dactyli minutus ventralis, retrorsum curvatus*" (Stimpson 1861: 31). Bate apparently failed to note the third unguis on his specimen. We have figured the third leg and dactylus of Bate's specimen (fig. 13g, h). The groove he depicted on the large chela (pl. C, fig. 3k) is not a true groove but an artifact.

Some of the synonymy has arisen as De Man applied the name *S. triunguiculatus* to a new species, apparently unaware that Paulson had previously published the name for a different species. Both Borradaile and Nobili corrected this error, but Borradaile's correction has priority.

Biological notes: While these four specimens were collected by dredging without notes on a possible symbiotic association, the species is known often to be in association with crinoids (Banner & Banner, 1968: 274). Miya stated that all of his specimens from Japanese waters were found living in association with *Comanthina schlegeli* (Carpenter). Dr R. U. Gooding also has sent us specimens from off Samarai, Papua, which were collected, together with other comatulid-associated synalpheids, from a dredge haul consisting of almost nothing but crinoids.

Both Miya and ourselves have given colour notes; these differ, and indicate that like other symbionts, the species may change its colour to match that of the host (*see* Appendix, p. 156).

Australian distribution: Our specimens were dredged between Shark Bay and Cape Farquar, Western Australia.

General distributions: Red Sea (as *S. brockii* Nobili); Indonesia: Philippines (Visayan Sea as *S. spiniger* by Bate); Japan; Loyalty Is.; Marshall Is.

Synalpheus nilandensis Coutière

Fig. 14

Synalpheus nilandensis Coutière, 1905a, Fauna and Geog. Mald. and Laccad. 2 (4): 871, fig. 4. De Man, 1911, Siboga Exped. 39a[1] (2): 246, fig. 38.

Synalpheus nilandensis var. *oxyceros* Coutière, 1905a, Fauna and Geog. Mald. and Laccad. 2 (4): 871, fig. 5. De Man, 1911, Siboga Exped. 39a[1] (2): 246, fig. 38c, d.

Synalpheus nilandensis var. *bandaensis* De Man, 1911, Siboga Exped. 39a[1] (2): 249, fig. 38a, b.

Specimens examined: 1 specimen from AC S4; 3, WM 192–65; 1, WM 230–65.

Diagnosis of Australian form: Rostrum narrow, reaching to middle of first antennular article. Orbital teeth as long as rostrum, but broader at base, rostrum and orbital teeth tilted upwards at tips. Rostral base with orbitorostral process.

Visible part of first antennular article twice as long as second article; second article longer than broad, third article shorter than second. Stylocerite reaching to middle of second antennular article. Scaphocerite with narrow squame reaching to first quarter of third antennular article, lateral spine reaching to tip of carpocerite. Carpocerite viewed from below 4.4 times as long as broad, reaching length of third antennular article past that article. Lower spine of basicerite reaching to near end of first antennular article, upper spine prominent, acute.

Large chela three times as long as broad, fingers 0.3 of total length. Palm bearing acute tooth above dactylar articulation. Merus 2.8 times as long as broad, superodistal margin terminating in acute tooth, lower distal margins rounded. Small chela 3.5 times as long as broad, fingers 0.4 as long as palm. Merus 2.6 times as long as broad; superodistal margin with acute tooth.

Carpal articles of second leg with ratio: 10.1:1:1:3.

Merus of third leg 3.5 times as long as broad, inferior margin armed distally with about four strong spines. Carpus 0.4 as long as merus, superodistal margin projecting but rounded, inferodistal margin bearing strong spine. Propodus slender, almost as long as merus, bearing on its inferior margin about 12 spines and a pair distally. Dactylus triunguiculate, 0.2 as long as prodous, middle unguis largest, almost following curvature of dactyl; superior unguis three-fourths as long and much thinner than middle unguis; inferior slender, acute, slightly shorter than superior; notch between middle and superior ungui triangular and acute, between middle and inferior broadly rounded.

Telson 2.7 times as long as broad at posterior margin. Posterolateral angles extending in short, acute teeth, but teeth never shorter than outer pair of posterior spines. Outer uropod with transverse articulation.

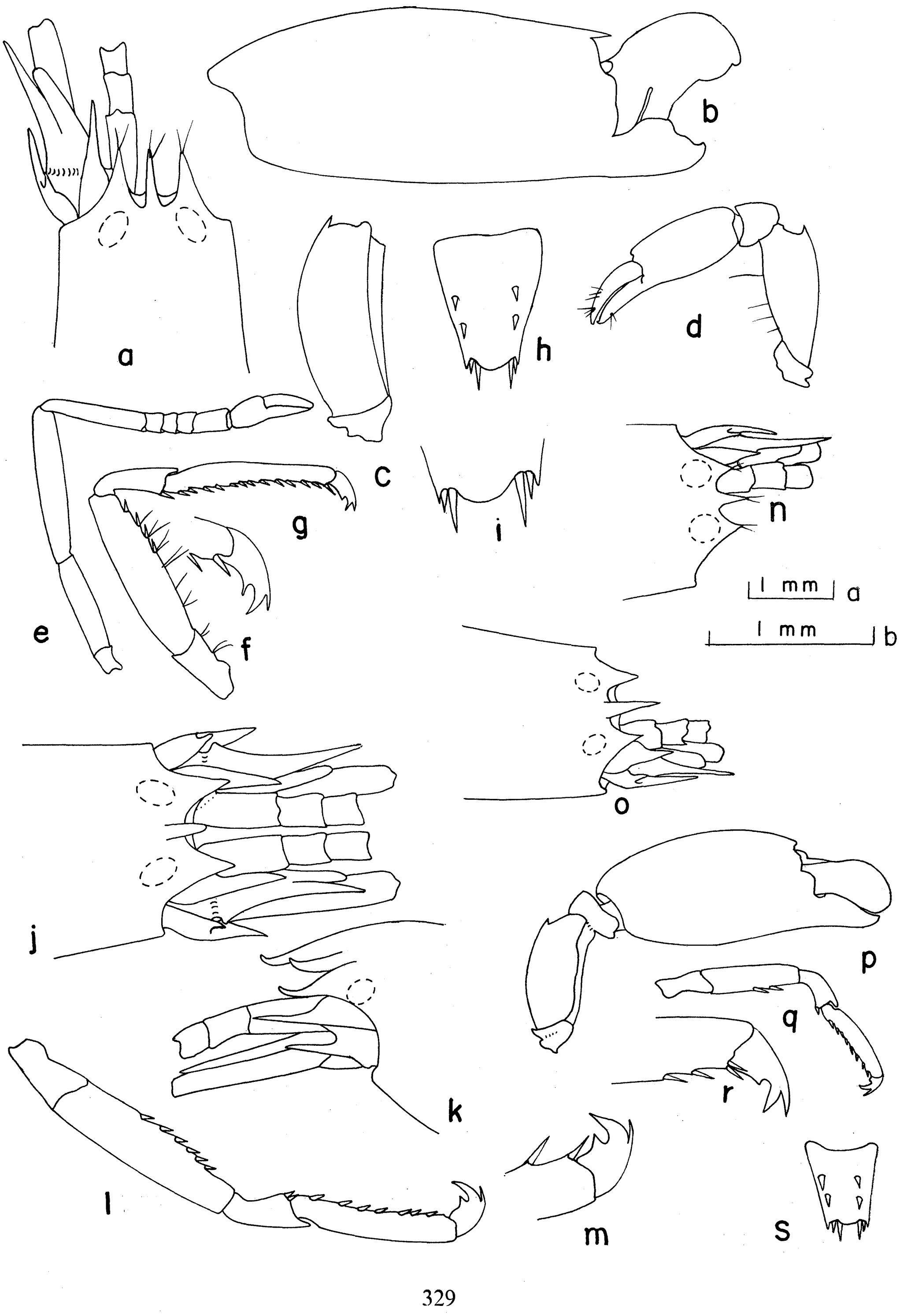
Discussion: We have found it impossible to resolve the *S. nilandensis* complex on the basis of the present collections and past descriptions. Previously described are the parent species and two additional varieties from the Maldives by Coutière and by De Man from the Siboga Expedition. These descriptions are not complete and do not completely agree as De Man's interpretations differ from those of Coutière. Coutière's work was based on six specimens; De Man had a total of seven specimens. Coutière noted that three of his specimens came from gorgonians; none of De Man's were noted to be symbionts. We have before us the listed five specimens from Western Australia; twelve specimens from the Andaman Sea, collected by the International Indian Ocean Expedition; eighteen specimens from near Hong Kong, two from near Borneo loaned by the Fisheries Research Station of Hong Kong; and also two specimens from the Red Sea collected by the University of Israel Red Sea Expedition. We have also re-examined all of De Man's Siboga specimens at the courtesy of the Zoölogisch Museum, Amsterdam. As these specimens fall into five imperfectly separated groups, we are describing both the previously named varieties and our new varieties as "forms", outside the rules of nomenclature (Article I 10 (b) and 45 (e) (i) of the International Code of Zoological Nomenclature, 1961). This device will permit future workers reviewing the complex to raise or eliminate these designations on the basis of parameters of variation found within populations.

S. nilandensis forma *nilandensis* (Coutière, 1905a: 871). This form has a slender rostrum, equal in length to the orbital teeth, reaching about two-thirds the length of the first antennular article. The first antennular article is twice as long as broad; the stylocerite reaches well past the end of the first article. The lateral spine of the scaphocerite reaches to end of carpocerite which is the length of the third antennular article past that article; the squame reaches to the end of the antennular peduncle. The lateral spine of the basicerite reaches to the level of the first antennular article, but is shorter than the stylocerite. The dactylus of the third leg is 1.5 times as long as broad, the superior unguis slender and reduced, the middle unguis heavy and turning at right angles to the axis of the dactyl. The inferior unguis is shortest and forms almost a semicircle where it meets the middle unguis. This combination of characteristics is not found in our collections. Coutière remarked that three of his specimens came from gorgonians.

S. nilandensis forma *oxyceros* (Coutière, 1905a: 871). This form was erected by Coutière in a short paragraph and illustrated by only two drawings. It was separated from the parent form by: 1. the stylocerite reaching the middle of the second antennular article; 2. the inferior tooth of the basicerite reaching the end of the same article; 3. the lateral tooth of the scaphocerite reaching 1.5 times the length of the third antennular article past the end of the carpocerite; 4. the dactylus of the third leg being 2.2 times as long as broad and the superior unguis being heavier and longer than in the nominate form. We do not have this form in our collections.

OPPOSITE

Fig. 14.—*Synalpheus nilandensis* Coutière. *Forma bandaensis*. 14 mm male from WM 192-65: a, anterior region, dorsal view; b, c, large chela and merus, inner face; d, small cheliped; e, second leg; f, g, third leg and enlargement of dactyl; h, i, telson and enlargement of posterior region. *Forma alpha* 15 mm male from *IIOE* Sta. 22A (Andaman Sea): j, k, anterior region, dorsal and lateral view; l, m, third leg and enlargement of dactyl. *Forma beta* 10 mm female from Aabak Is. (Southern Red Sea): n, anterior region, dorsal view. 12 mm ovigerous female from Siboga Sta. 282: o, anterior region, dorsal view; p. large cheliped; q, r, third leg and enlargement of dactylus; s, telson. a, b, c, d, e, f, h, j, k, l, n, o, p, q, s, scale a; g, i, m, r, scale b.


a
b
c
d
e
f
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1 mm a
1 mm b

S. nilandensis forma *alpha*. This form is represented by one of De Man's three specimens that he attributes to the nominate form of *S. nilandensis* (1911: 247, fig. 38). It is represented in our collection by nine specimens from the Andaman Sea, two from near Borneo and four from Hong Kong (see figs 14 j, k, l, m). It is characterized by having the rostrum markedly shorter than the orbital teeth, and having the orbital teeth somewhat divergent; the three are slightly upturned on the ends and they are markedly shorter than the first antennular article. The antennular and antennal articles approach the proportions of the nominate species. The middle unguis of the third leg is at right angles to the axis of the dactylus, but is slightly more slender than one figured by Coutière. One specimen from Hong Kong and one from Borneo were reported as symbiotic with the ophuroid *Gorgonocephalus;* no other associations were commented upon in the collecting notes.

S. nilandensis forma *bandaensis* (De Man, 1911: 248, fig. 38a, b). De Man described this variety on the basis of three specimens; our five Australian specimens as well as three specimens from the Andaman Sea and fourteen specimens from near Hong Kong, we place in this form (fig. 14 a-i). In this the rostrum, orbital teeth and antennular and antennal bases are almost identical to the nominate form; it differs in the form of the dactylus of the third legs. The dactylus here is 2.5 times as long as broad, more slender than in the nominate forms; the superior unguis is half as long to as long as the middle unguis the middle unguis is slender, about twice as long as broad at the base and lies at an angle of 45° to the axis of the article; the inferior unguis usually is a small but slender and acute tooth. Neither the specimens of De Man nor those from Australia were reported in symbiotic association, but the fourteen specimens from Hong Kong came from a "hard sponge".

S. nilandensis forma *beta*. The single specimen described by De Man as *S. n. oxyceros* (*nec* Coutière) belongs to this form, as well as two specimens we have from the Red Sea. The three specimens do not conform, and perhaps should be described as three separate forms. The rostrum in the Red Sea specimens is either as long as or slightly longer than the orbital teeth, but in De Man's specimens it is one third longer than the teeth; in one of the Red Sea specimens the rostrum is markedly shorter than the first antennular article, in the other the rostrum is as long as the article and in De Man's specimen it exceeds the length of the article. However, all are similar in having short, heavy articles of the antennular peduncles, with the second article less than 1.5 times as long as broad, and the first and second articles subequal in length. There are only slight differences among the three specimens in the relative lengths of stylocerite, scaphocerite, carpocerite and basicerite. The dactylus of the third leg is like that of *S. n. bandaensis* (including the specimens De Man labelled as *S. n. oxyceros*) in which we found the upper unguis to be less strongly bent than shown in his drawing. These three specimens had no symbiotic association noted.

Thus the separations between the forms are slight and variable. If any of the forms are obligate symbionts, with each form specializing in a sponge, gorgonian or ophiuroid, they might well be considered as separate species. If, on the other hand, the species is primarily free-living with opportunistic symbiosis which might select or impose certain adaptations within the normal range of variation, the differences could be viewed as without systematic worth as they have been caused by habitat. Finally, it may be that these forms represent isolated breeding populations that should be considered to be of subspecific worth (considering the broad and at times overlapping distribution of the forms, this is not likely). Certainly, the present collections do not indicate which of the three choices is correct.

Biological notes: These Australian specimens were collected between 19 and 73 fathoms. Other specimens reported upon were dredged from similar depths. Specimens from all locations mentioned above ranged from 10–16 mm in length.

Australian distribution: The specimens were only from Western Australia, from Houtman Abrolhos, Exmouth Gulf and Dirk Hartog Island.

General distribution: Red Sea*; Maldives and Laccadives; Andaman Sea*; Indonesia; Borneo*; Hong Kong*; Tuamotus Archipelago (Nobili, 1907:353—it is interesting to note that this one specimen was "commensale dell'ostrica perlifera" from a 25 m depth; to our knowledge this is the only record of an alpheid symbiotic with pearl oysters).

Synalpheus heroni Coutière

Synalpheus heroni Coutière, 1909, Proc. U.S. natn. Mus. 36 (1659): 42, fig. 24. De Man, 1911, Siboga Exped. 39a[1] (2): 256, fig. 41.

Nec Synalpheus heroni Banner & Banner, 1966b, Siam Soc. Mono. 3, p. 55, fig. 16.

Specimens examined: 1 specimen from BAU 30; 3, BAU 32; 2, BAU 33; 1, WM 192–65.

Diagnosis: Rostrum reaching past middle of visible part of first antennular article. Orbital teeth the same length, but forming almost an equilateral triangle. Rostral base with orbitorostral process.

Antennular peduncle stout, antennular articles subequal, second article 1.5 times as long as broad. Stylocerite reaching to near middle of second antennular article. Lateral spine of scaphocerite reaching to end of carpocerite; squamous portion more narrow than tooth, reaching only slightly past end of second antennular article. Carpocerite varying from 3–4 times as long as broad, approaching length of third antennular article past that article. Inferior tooth of basicerite a little longer than stylocerite; superior tooth prominent, acute.

Large chela 2.4 times as long as broad, fingers occupying the distal 0.3. Superior margin of palm terminating in obtuse protusion; inferior margin slightly concave opposite dactylar articulation. Dactylus heavy with normal plunger; oppositional face distal to plunger narrow, proximally developed on outer side as a ridge with a slight longitudinal depression in middle, distally as a single sheering blade; inner face rounded; tip heavy, rounded and crossing tip of pollex. Pollex with a normal "socket" or cavity for plunger; outer face bearing strong, slightly curved ridge that meets exactly with both the longitudinal depression and the blade of dacytlus. Distal to socket, inner face with a rounded transverse depression that reaches almost to outer ridge; demarked distally by low rounded cusp; from cusp to tip, face rounded; tip acute. No structures on dacytlus meet either depression or cusp of pollex. Ridges and tip of both fingers of thick, hard, translucent chitin.

Small chela stout, 2.5 times as long as broad, fingers shorter than palm. Tooth at tip of dactylus and pollex accompanied by a small tooth medial to tip. Outer face of pollex concave. Carpus a little shorter than fingers. Merus as long and almost as broad as chela, distosuperior margin slightly projecting.

Carpal articles of the second leg with a ratio: 10:2:2:2:4.

Merus of third leg stout, inermous, 3.6 times as long as broad. Carpus 0.5 as long as merus; inferodistal margin terminating in spine; superodistal extending as obtuse tooth. Propodus a little shorter than merus, bearing on inferior margin 6 spines and a pair distally. Dactylus triunguiculate. Inferior unguis only slightly

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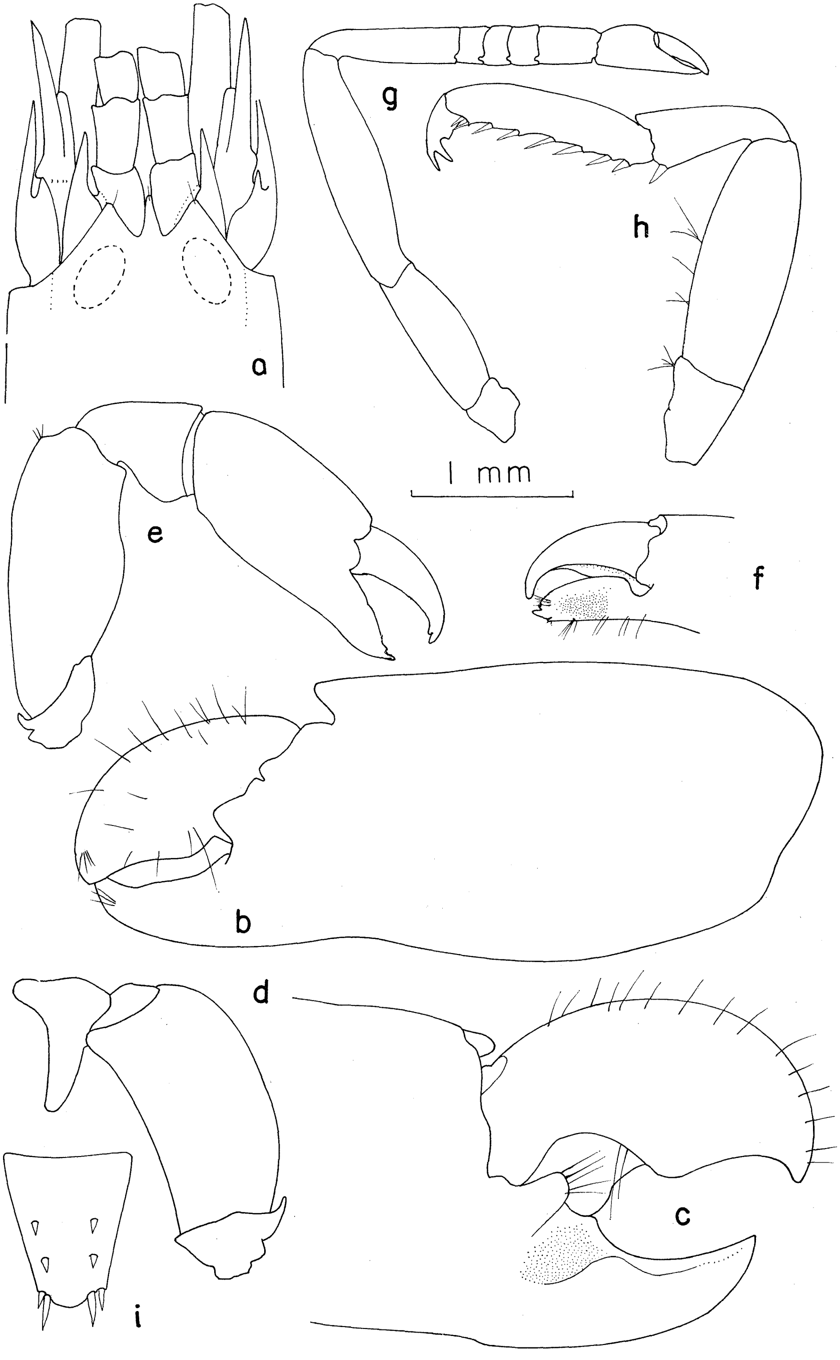
OPPOSITE

Fig. 15.—*Synalpheus heroni* Coutière. 10 mm female from BAU 33: a, anterior region, dorsal view; b, large chela, inner face; c, large cheliped, outer face, distal region; d, merus, large chela, inner face; e, small cheliped, inner face; f, detail of distal region of small chela outer face; g, second leg; h, third leg; i, telson. All figures same scale.


a
g
h
1 mm
e
f
b
d
c
i

projecting to form right angle to proximal inferior margin of dactyl. Superior and middle ungui curved gradually, slightly divergent and equal in length, but middle unguis slightly thicker at base.

Telson 2.2 times as long as posterior margin is broad.

Discussion: This species, described by Coutière from the Red Sea, is remarkably close to *Synalpheus nobili* that Coutière described from Ecuador. We were able to examine the type of *S. heroni* as well as the type of *S. nobili* at the Smithsonian Institution. We also examined 24 specimens of *S. nobili* reported upon by Schmitt (1939: 12) from Clipperton Is. The only consistent differences between *S. nobili* and *S. heroni* are that in *S. nobili*: 1. the squame is less reduced; 2. the lateral spine of the scaphocerite is shorter than the carpocerite; 3. the large chela does not have the depression proximate to the cavity of the plunger; 4. the carpus of the small chela is shorter in relation to the chela; 5. the extra unguis of the inferior margin of the dactylus of the third thoracic leg forms an obtuse angle. These characteristics are known to be variable in other species, but as we could find no overlapping between the specimens from the Eastern Pacific and our specimens from the Great Barrier Reef, we have to consider the species separate and distinct. Certainly the Eastern Pacific Barrier would favour speciation.

We have re-examined the sole specimen from Thailand (Banner & Banner, 1966b: 55, fig. 16) that we identified as *S. heroni*. We do not believe the identification was correct. It does not have the concavity opposite the dactylar articulation of the large chela so characteristic of *S. heroni;* the squame is not reduced and the small chela bears a row of setae on the superior surface of the dactylus similar to *S. hastilicrassus* Coutière. However, unlike *S. hastilicrassus* the posterolateral margins of the telson are not spinose. We will rename the species in a future paper dealing with the Thai alpheids.

Biological notes: Our specimens were taken from dead coral heads in water up to 15 feet deep. They ranged in size from 10–14 mm long.

Australian distribution: Six of the specimens were taken from the Great Barrier Reef east of Port Douglas, Queensland, and one from near Dirk Hartog Island in Western Australia.

General distribution: Red Sea; Indonesia; Fiji; Phoenix and Line Islands: Society Archipelago.

Synalpheus fossor (Paulson)

Fig. 16

Alpheus fossor Paulson, 1875, Invest. Red Sea Crust., p. 103, pl. 13, fig. 5.

Synalpheus fossor Coutière, 1905a, Fauna and Geog. Mald and Laccad. 2 (4): 872, pl. 70, fig. 6. Tattersall, 1921, Trans. Linn. Soc. Lond. 34 (229): 374.

Synalpheus fossor var. *propinqua* De Man, 1911, Siboga Exped. 39a[1] (2): 250, fig. 39.

Synalpheus bakeri Coutière, 1908a, Bull. Soc. philomath. Paris IX, 11 (5): 199 [species described from S. Australia].

Synalpheus bakeri var. *stormi* De Man, 1911, Siboga Exped. 39a[1] (2): 253, fig. 40. Banner & Banner, 1966, Siam Soc. Mono. 3, p. 53, fig. 15.

Alpheus sp. varietas B De Man, 1897, Zool. Jb. Syst. 9:741, pl. 35, figs 62c and 62cc [= *S. bakeri stormi* acc. De Man, 1911, *loc. cit.*].

Additional Australian Records:

Coutière, 1909, Proc. U.S. natn. Mus. 36 (1659): 91 [repeat of Coutière, 1908a, *loc. cit.*].

Hale, 1941, Rep. B.A.N.Z. Antarct. Exped. B, 4 (9): 265 [as *S. bakeri stormi,* off S.W. Australia].

Specimens examined: 1 specimen from AM 63; 1, AM. 140; 20, AM E 4499; 1, AM E 4500; 2, AM P 6107; 3, BAU 25; 5, BAU 27; 2, BAU 28; 2, BAU 30; 7, BAU 40; 2, BAU 43; 9, QM W 2239; 1, WM 108–65.

Diagnosis: Rostrum slender, acute, reaching variously from middle of first antennular article to one-fourth length of second antennular article. Orbital teeth varying from 0.6 as long as rostrum to almost equal. Tip of rostrum and orbital teeth bearing a few short stiff setae and at times tilted upward. Rostral base with orbitorostral process.

Second antennular article 0.8 as long as visible part of first, third antennular article a little more than half as long as second. Stylocerite reaching almost to middle of second antennular article. Scaphocerite with narrow squame reaching variously from end of second antennular article to end of third. Carpocerite 6.0 times as long as broad, reaching from half the length to full length of third antennular article past that article. Inferior tooth of basicerite near length of stylocerite; superior tooth well developed.

Large chela cylindrical, about 2.5 times as long as broad, with fingers occupying the distal 0.3. Palm proximal to dactylus bearing one or two obtuse (rarely acute) tubercles. Merus twice as long as broad, bearing acute tooth on superodistal margin. Small chela varying from 2.4 to 2.6 times as long as broad; merus similar to that of large chela but slightly more slender.

Carpal articles of the second leg with a ratio: 10:2:2:2:5.

Third leg with merus varying from 3.2–4.1 times as long as broad. Carpus with superior margin projecting as rounded tooth, inferior margin armed with spine. Propodus varying from 4.7–7.0 times as long as broad and bearing 6–10 spinules on inferior margin. Dactylus triunguiculate; middle ungius usually wider at base than superior ungius, but about the same length; notch between superior and middle ungius usually "V"-shaped and acute at apex. Inferior unguis less produced, at times not set off from inferior dactylar margin, varying from acute to a right angle. Notch between inferior and middle unguis usually a rounded "U"-shape.

Telson with posterolateral corners usually strongly projecting and acute, often almost as long as outer spinule of posterior pair, but at times with projection minimal. Spines on upper surface varying from large and heavy to small and short.

Discussion: Like many other synalpheids, the specimens in the *S. fossor* complex appear to be variable and the group has been divided into a series of species and subspecies; however, the species, or series of species, has not been common in the collections of previous workers and the references are limited. Below are annotations on all references.

S. fossor was originally described by Paulson from the Red Sea on the basis of sixteen specimens; his description does not emphasize many of the characteristics now considered to be of taxonomic importance, but he supplied seven small but valuable figures. (One point in his descripton needs clarification: he described the dactylus of the third leg as follows: "the internal surface is very concave, and the dactylopodite is spoonlike with prominent edges and has claws" (Por's translation, 1961: 109). This description especially when combined with the specfic name, *fossor,* which also could have reference to an excavate or "spoonlike" condition, might imply that the dactyls were excavate like some species of the Rapax group of the genus *Alpheus.* However, we have obtained some topotypes from the Red Sea which agree with Paulson's description on all other characteristics; these show the dactyls of the third to fifth legs to be compressed, with the only "spoonlike" characteristic to be the outline from the first to third unguis in lateral profile; there is no spoonlike excavation (*see* fig. 16s, t).

The next reference to the complex was that of De Man in 1897 to "*Alpheus* sp. varietas B" based on a single specimen from Atjeh in the Java Sea; in 1911 he placed this species under *S. bakeri stormi.*

In 1905, Coutière made the first report upon *S. fossor,* based on two specimens from the Maldives (p. 872). He remarked on what he thought was a difference between these two specimens and the description of Paulson in the

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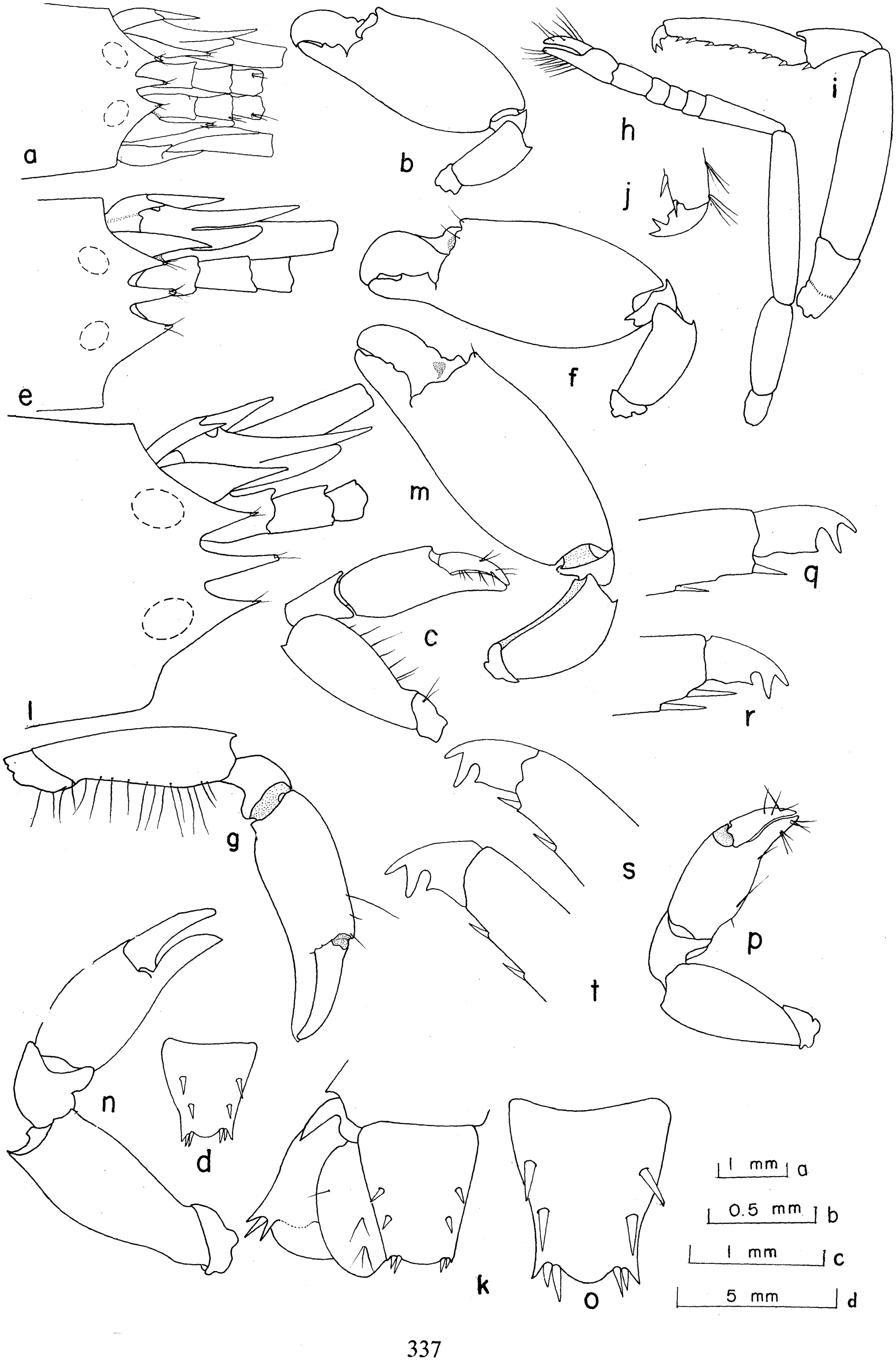
OPPOSITE

Fig. 16.—*Synalpheus fossor* (Paulson). 14 mm female from BAU 25: a, anterior region; b, large cheliped, outer face; c, small cheliped; d, telson. 17 mm male from BAU 40: e, anterior region; f, large cheliped, outer face; g, small cheliped; h, second leg; i, j, third leg and dactylus k, telson. 24 mm male from AME 4499: l, anterior region; m, large cheliped, outer face; n. small cheliped; o, telson. 12 mm male from Naifaro Reef, Maldive archipelago: p. small small cheliped; q, r, dactyls, third and fourth legs. 20 mm male from Naifaro Reef: s, t, dactyls, third and fourth legs. a, c, d, e, g, h, i, k, l, n, o, p, scale a; q, r, s, t, scale b; j, scale c; b, f, m scale d.



a
b
h
i
j
e
f
m
q
c
r
l
g
s
p
t
n
d
k
o
1 mm a
0.5 mm b
1 mm c
5 mm d

curvature of the dactyls of the third legs in the region of the ungui. We have re-examined his two specimens through the courtesy of the Muséum National d'Historire Naturelle, Paris and have figured the dactyli of the third and fourth legs of both of his specimens (fig. 16 q, r, s, t); we find no great differences between these specimens and the topotypes referred to above. We should add that his specimens did not have the fringe of setae on the margins of the rostrum shown in his fig. 6; instead there were a few setae on the tip. Coutière in 1908 (*op. cit.,* p. 197) gives some proportions (presumably from the Maldive specimens) in his description of *S. trionyx.*

In 1908, Coutière (*op. cit.*) described *S. bakeri* from South Adelaide on the basis of two specimens (the description, also without figures, was republished in a condensed form in 1909:91). Unfortunately Courtière compared the specimens to *S. triunguiculatus* (Paulson) instead of *S. fossor,* to which they were more plainly related. Since the original description no specimens have been assigned to this species.

In 1911 De Man erected the variety, *S. fossor* var. *propinqua* (p. 250) on the basis of eight specimens from Indonesia and one from Pearl Banks, Sulu Archipelago. Those he compared to Coutière's two specimens which he had borrowed and separated the two forms "by the more slender shape of the meri and propodi of the three posterior legs and by the larger number of propodal spines." He also created *S. bakeri stormi* (*op. cit.* p. 253) on the basis of six other specimens which he separated from *S. bakeri* by "slight differences".

Tattersall in 1921 (*loc. cit.*) reported on 14 specimens from the Sudanese Red Sea as *S. fossor* and suggested that his specimens were intermediate between Paulson's species and De Man's variety *propinqua.*

In 1938, Lebour (Proc. Zool. Soc. Lond. B, 108: 651) described a species from Madras "associated" with the ascidian *Herdmania pallida* (Michaelson) (now *H. momus* (Savigny)) under the name of *S. herdmanae.* This species is plainly related to the *S. fossor* complex, but can be separated by "a small extra protuberance dorsally beside the three hooks" on the dactylus of the third to fifth legs. In view of this difference and its unique symbiotic relationship, this species is accepted and not further discussed.

S. fossor was recorded without comment by Coutière in 1921 (Trans. Linn. Soc. Lond. 17 (4): 416) from Chagos and similarly by Calman in 1939 (British Mus. John Murray Exped. Sci Rep. 6 (4): 208) from the Red Sea.

For our review of this complex we have a moderate sized collection: fifty-six specimens from various parts of Australia, thirteen from the southern Philippines, two from Thailand, and eleven from the Red Sea; the species did not appear in any of our central Pacific collections. Some of these specimens were reported as coming from sponges, others as free living in coral heads. These specimens we have compared to criteria used to separate the nominal species and subspecies as derived from both the various descriptions and characteristics taken from the figures. The results are given in Table III. with a comparison to the variation found in Australian specimens.

Table 3. *Variation in nominal species of the* Synalpheus fossor (*Paulson*) *complex*

Characteristic	*S. fossor*	*S. fossor propinqua*	*S. bakeri*	*S. bakeri stormi*	Australian specimens
Length of rostrum to antennular articles.	Past middle of first.	Same as *S. fossor*.	Middle of second	End of first ..	Middle of first to first quarter of second.
Length, of orbital teeth to rostrum.	Equal	Slightly shorter.	0·7 length ..	0·66–0·75 length.	0·66 to equal.
Length, of squame to antennular articles.	To end of second.	To middle of third.	Not given ..	Almost to end of third.	From end of second to end of third.
Length, of lateral spine of scaphocerite to antennular articles.	To end of third.	Just past end of third.	Slightly past end of third.	Same as *S. bakeri*.	From end of third to length of third beyond.
Length/breadth large chela ..	2·7 (from plate).	3·2 (from plate).	2·5	2·75	2·5–2·8.
Tubercle above datylar articulation, large chela.	One	One acute tooth and one obtuse tubercle.	Unarmed ..	Solitary small conical tooth.	From completely lacking to two small tubercles.
Length/breadth small chela ..	Not figured or given.	3·0 (from plate).	Not figured or given.	4·0	2·4–3·6.
Length/breadth merus third leg ..	3·5 (from De Man).	2·8–3·6	3·5	4·0	3·2–4·1.
Length/breadth propodus third leg	5·6 (from plate)	4·4–5·2	Not figured or given.	6·5–7·0	4·7–6·0.
Spines on propodus, third leg ..	7..	9 (from plate) ..	Not given ..	7..	6–10.
Size of outer angles, telson ..	Long	Short	Like *S. fossor* ..	Short	From short to long.
Size of dorsal spines, telson ..	Large	Medium ..	Not given ..	Small	From small to large.

Most of the characteristics used in the separation of the named members of the complex are those found to be variable in so many other species of *Synalpheus;* here too they were also found to be variable. In most cases the variation noted encompassed the differences that had been used to separate the members of the complex. In a few cases, as the rostral length in *S. bakeri* or the propodal breadth of the third legs in *S. bakeri stormi,* the proportions exceeded the range that we found. However, in these cases our ranges was so great that the significance of this further extension was questionable (for example in the propodus we found variation in the length-breadth ratio from 4.7–6.0, and De Man reported variation from 6.5–7.0). We therefore put all of the nominal species and subspecies except *S. herdmaniae* into synonymy under *S. fossor*. We should remark that the broad patterns in variation that we report are not found in all geographically separated poullations. Thus the sample we obtained from Thursday Island showed rather restricted variation, and could be separated from the samples we obtained from the Whitsunday Group by the two processes above the dactylar articulation, and large spines on the telson. Because of this regionality we originally considered the erection of geographically separated subspecies, but discarded the idea when we found that the Torres Straits specimens were quite like those from the Red Sea and the Whitsunday specimens approached De Man's variety *propinqua* from Indonesia; moreover, the specimens from other areas of Australia varied in more inconstant patterns. Perhaps further study with much more extensive collections will indicate reliable subspecific differences; they are not so indicated by these collections.

Biological notes: Most specimens were apparently collected from dead coral, although undoubtedly some were within sponges in the dead coral. The pair of specimens from BAU 40 were found living in an orange-red membranous sponge and were salmon pink, their colour close to that of their host. Our specimens ranged in size from 10–25 mm.

Australian distribution: From off southwest West Australia to Shark Bay; Darwin and Thursday Island on the North Coast and on the East Coast from Port Douglas to Southport, southern Queensland; in South Australia from Spencer's Gulf and Kangaroo Island.

General distribution: Red Sea; Maldive Archipelago; Indonesia; Thailand: Philippines.

Synalpheus haddoni Coutière

Fig. 17

Synalpheus laevimanus haddoni Coutière, 1900, Bull. Mus. Hist. nat., Paris 6 (8): 411, figs.

Synalpheus haddoni Coutière, 1909, Proc. U.S. natn Mus. 36 (1659): 10.

Original description, our translation: "This is the first mention that has been made of the presence of *Synalpheus laevimanus* in the Pacific, the species that has long been known as peculiar to the Mediterranean. I have remarked previously that *S. spinifrons* (H.–M. Edwards) from the coasts of Chile was very probably this species, that *S. laevimanus longicarpus* Herrick, extremely common on the Atlantic coast of America, was slightly different, and finally, I have described a new variety of *S. laevimanus parfaiti* coming from Annobon [Dutch Guiana, Bull. Soc. ent. Fr. 1898 (8): 189]. There is no doubt about the close relationship which unites the Mediterannean species with two specimens from the Torres Straits I have examined. The tridentation of the frontal margin, whose tips are short and close together, the form and proportions of the stylocerite, the strong spiny armature of the antenna, the total absence of the antennular scale, the form of the large chela, whose anterior palmar border carries a strong spine, the proportions of the segments of the carpus of the second legs [the proportions] of the third, fourth and fifth legs, the form of their dactylopodites, are many of the identical characteristics of specimens from the two regions. The differences which one can bring up are the following: the antennular peduncle, on the typical specimens and also in the preceding varieties always passes markedly the antennular peduncle (in general by the length of the distal article past that article). On the two specimens in question this length does not exceed one-third of the length of the distal antennular article. Of the two ungui which terminate the dactyl, the posterior is scarcely stronger than the anterior, whereas in the typical specimens one observes a rather notable difference between the two hooks. Finally the distal spines of the telson are practically equidistant, and those of the superior face are longer than ordinary. But these are characters subject to quite extensive variations, however in the typical *S. laevimanus* as well as the varieties *longicarpus* and *parfaiti* they justify at most the establishment of a new varity *haddoni*. Finally it is necessary to remark that the two specimens examined are young (the larger, a female carrying 6–7 eggs, is not more than 10 mm in length) and the differences here observed will be diminished without doubt by the examination of a larger series of specimens. 1 sp. female, 1 sp., male (?) (the latter is only 4 mm long).—Sabai Channel, Torres Straits."

We are at loss as to how to handle Coutière's change of status in his 1909 publication, for the name was merely listed in a table without comment but with a (?). However, he did not only remove the species from *S. laevimanus* itself, but also from his Laevimanus Group, placing it in the Biunguiculatus Group. We believe that the raising of the name *haddoni* to specific rank, and the change of group is logical, for no members of the Laevimanus Group have penetrated into the Indo-Pacific faunal realm, and *S. laevimanus* is, as Coutière has stated, a species typical of the Mediterranean. Therefore we are tentatively accepting the 1909 designation of the form as an independent species.

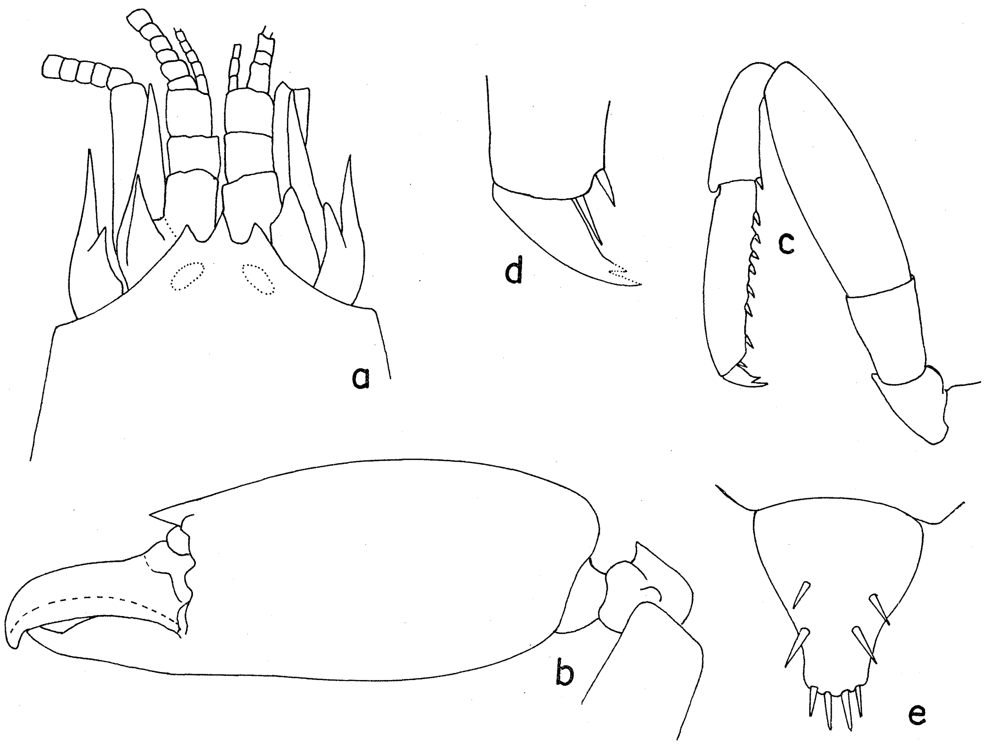


FIG. 17.—*Synalpheus haddoni* Coutière (after Coutière). 10 mm ovigerous female from Torres Straits. a, anterior region, dorsal view; b, large cheliped, outer face; c, d, third leg and dactylus; e, telson.

We have no specimens approaching this species, but we list it as there could be no doubt about the authenticity of the record and characteristics of the species, in particular, the reduction of the rostrum, orbital teeth and antennal squame, and the unique character of the telson and its armature. These characteristics insure that it has not been confused with any other Australian species so far reported.

Synalpheus coutierei Banner

Fig. 18 a–i

Synalpheus coutierei Banner, 1953, Pacif. Sci. 7 (1): 36; Banner & Banner, 1966b, Siam Soc. Mono. 3, p. 62, fig. 20.

Alpheus biunguiculatus De Man, 1888a, Arch. Naturgesch. 53 (1): 502, pl. 21, fig. 6. Bate, 1888, Challenger Rept. 24: 562, pl. 101, fig. 4.

Synalpheus biunguiculatus Coutière, 1898g, Bull. Soc. ent. Fr. 1898 (11): 232, figs 1–4 [Arafura Sea, N. W. Australia]; 1905a Fauna and Geog. Mald. and Laccad. 2 (4): 873, pl. 71, fig. 8.

Synalpheus biunguiculatus var. *exilipes* Coutière, 1905a, Fauna and Geog. Mald. and Laccad. 2 (4): 874, fig. 10. Balss, 1921, K. Svenska Vetensk. Akad. Handl. 61 (10): 9 [Cape Jaubert].

Synalpheus exilipes Johnson, 1962a, Bull. natn. Mus. St. Singapore 30: 51.

[*Nec*: *Synalpheus biunguiculatus* (Stimpson), 1861, Proc. Acad. nat. Sci. Philad. 1860: 31.]

Additional Australian Records (older records as *S. biunguiculatus*):
Ortmann, 1894, Denkschr. med. naturw. Ges. Jena 8: 14. Thursday Is.
Coutière, 1900, Bull. Mus. Hist. nat., Paris 6 (8): 411. Torres Straits.
McNeill, 1968, Gt Barrier Reef Exped. Sci. Rept 7 (1): 17; Low Isles.

Specimens examined: 1 specimen from AM 85; 4, AM 140; 1, BAU 10; 1, BAU 37.

Diagnosis: Rostrum narrow with tip reaching to near middle of first antennular article. Orbital teeth more than twice as broad at base as rostrum; length almost equal to rostrum. Tips of rostrum and orbital teeth rounded, bearing one or two setae. Rostral base with orbitorostral process.

Visible part of first antennular article 1.5 times longer than second; second article 1.5 times as long as broad and a little longer than third. Stylocerite reaching to middle of second antennular article. Scaphocerite with squamous portion narrow, and reaching to middle of third antennular article; lateral tooth reaching to past end of antennular peduncle. Carpocerite 4.2 times as long as wide when viewed ventrally, reaching length of third antennular article past that article. Inferior spine of basicerite subequal in length to stylocerite, superior tooth acute and prominent.

Large chela 2.5 times as long as broad, with fingers occupying distal 0.3 Superior margin of palm terminating in subacute tooth above dactylar articulation, second shorter tubercle adjacent medially. Dactylus heavy, longer than fixed finger. Merus two times as long as broad with angular superodistal tooth. Small chela 2.7 times as long as broad, fingers shorter than palm. Margin of outer face of dactylus carrying 8–10 follicles with one or two stiff setae. Lateral face of palm near dactylar articulation also bearing patch of stiff setae. On inner face, margins of both dactylus and pollex bearing stiff setae that cross in regular fashion. Carpus varying from 0.2–0.4 times as long as chela, inferodistal margin bearing 3–4 stiff setae. The inferoexternal margin of merus bearing fine setae placed at random along its entire margin. The inferointernal margin glabrous. The inferior margin of the ischium bearing a row of evenly spaced fine setae.

Carpal articles of the second leg with a ratio 10:2:2:2:4; articles 2–4 broader than long.

Merus of third leg 3.3 times as long as broad, inermous. Carpus 0.4 as long as merus; superior margin extended into an obtuse tooth; inferior margin with short distal spine. Propodus almost as long as merus, bearing on inferior margin seven spines and a pair distally. Dactylus biunguiculate, superior unguis a little longer than inferior unguis, region between ungui "U"-shaped.

Telson 2.4 times as long as broad at the posterior margin, posterolateral angles right angles.

Discussion: This species was considered by De Man (1888a *et seq.*) and Coutière (1898g *et seq.*) to be the same species that Stimpson described as *S. biunguiculatus* from the Hawaiian Islands. As the species they recognized did not occur in Hawaii, in 1953 we described a neotype for *S. biunguiculatus* and conferred the name *S. coutierei* upon the species described by De Man and Coutière. At that time we did not consider the two varieties that Coutière described in 1905, *S. biunguiculatus exilipes* and *pachymeris*. The latter form was subsequently raised to specific rank by De Man (1911: 199) and has been accepted. In 1956, we identified some specimens from the Marianas as *S. coutierei exilipes,* but with doubts as to the validity of the subspecies for even in that small collection we found variation in the proportions considered by Coutière to be of value in the separation of the subspecies. Johnson (1962a) working with Malayan specimens raised Coutière's variety *S. biunguiculatus* [*sic*] *exilipes* to specific rank, without further comment.

We have reviewed not only the Australian specimens but also specimens from other collections for the validity of the separation of the variety *exilipes* from the parent species. As has often been found, the characteristics used by Coutière for the separation of his five specimens from the Maldives into two subspecies are variable and the subtle differences in proportions used by Coutière, unreliable. We also question the separation of *S. bispinosus* De Man from this species (*see* p. 180).

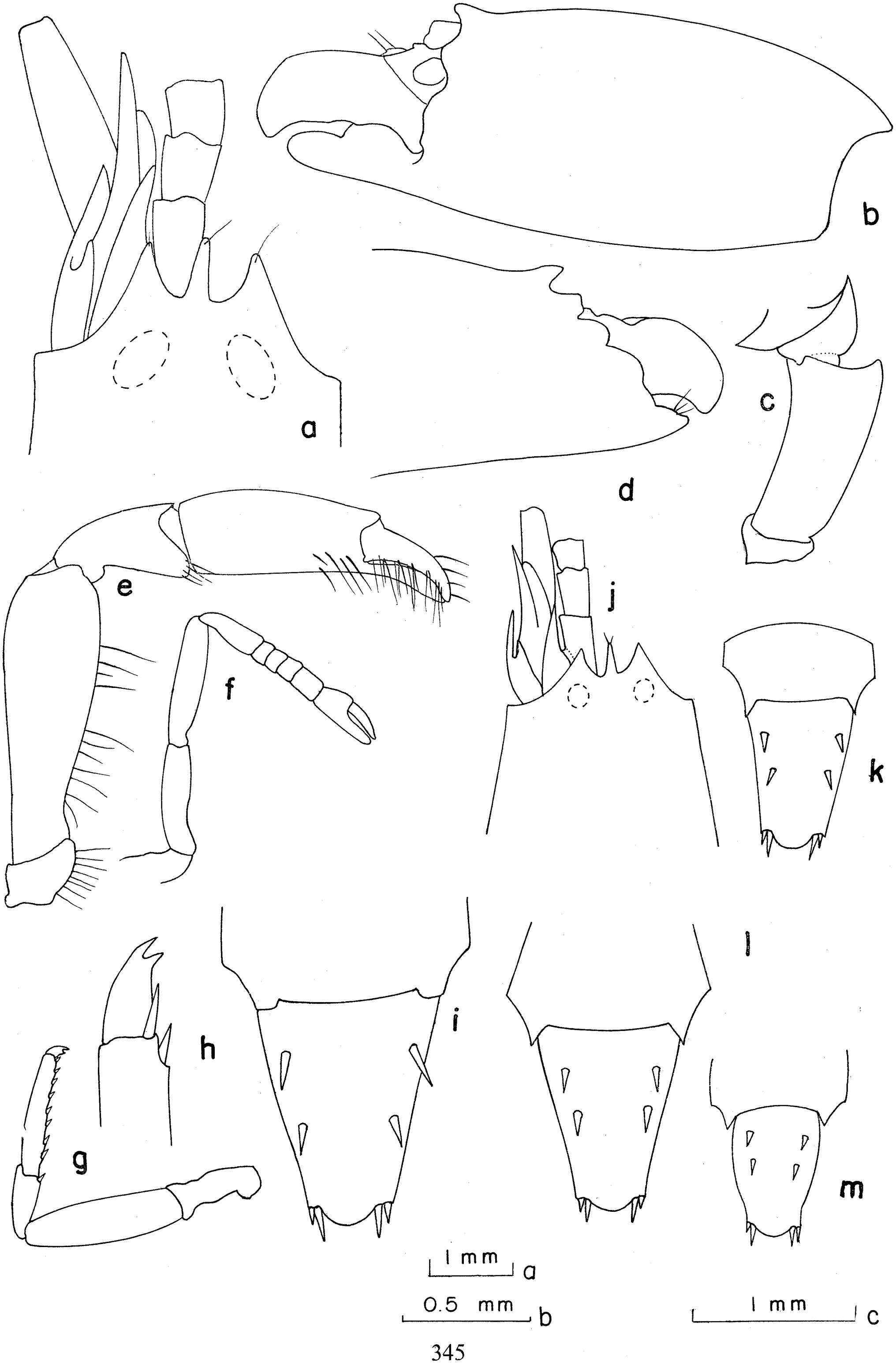
Biological notes: This species has been collected in shallow water from heads of dead coral. Coutière reported sixty specimens from Djibouti collected from heads of the coral *Stylophora* spp. in which it was living in company with *S. triunguiculatus* (Paulson). He also reported many specimens were found living among the settling growth on buoys (1898g: 232). In Thailand we found it living in a sponge. We also have on hand some large speimens from the Indian Ocean that were dredged at 77 metres. The Australian specimens range from 9–23 mm.

Australian distribution: The specimens in the present collection came from the northwest of Western Australia, Darwin, Torres Straits and north and central Queensland, a range that includes those previously reported.

General distribution: From the Suez Canal and Persian Gulf south to Mozambique and eastward across the Indo-Pacific, occurring in most investigated archipelagoes, but not in Hawaii or the Societies. It has not been reported from Japanese waters; however, it has passed the Eastern Pacific barrier to Clipperton Island.

OPPOSITE

Fig. 18.—*Synalpheus coutierei* Banner. 11 mm male from BAU 37: a, Anterior region, dorsal view; b, c, large chela and merus, outer face; d, distal region of chela, inner face; e, small cheliped; f, second leg; g, h, third leg and dactylus enlarged; i, telson. *Synalpheus bispinosus* De Man. 10 mm male from AM. 140: j, Anterior region, dorsal view; k, telson. 20 mm female from AM 85: l, telson. 12 mm female from BAU 25: m, telson. b, c, d, e, f, g, j, k, l, m, scale a; h, scale b; a, i, scale c.


a
b
c
d
e
f
j
k
g
h
i
l
m
1 mm a
0.5 mm b
1 mm c

Synalpheus bispinosus De Man

Fig. 18 j-m

Synalpheus bispinosus De Man, 1910b, Tijdschr. ned. dierk. Vereen. 11 (4): 302; 1911, Siboga Exped. 39a[1] (2): 280, fig. 54.

Specimens examined: 1 specimen from AM 140; 1, BAU, 25; 1, WM 30–65.

Diagnosis: Characteristics fall within the range of variation of *S. coutierei* Banner (p. 343) except that the posterior margin of the sixth abdominal segment is produce into acute teeth, one on either side of the articulation of the telson.

Discussion: We are reporting these specimens as *S. bispinosus* with considerable doubt, for in all characteristics except the lateral teeth on the posterior margin of the sixth abdominal segment they are indistinguishable from *S. coutierei.* Even De Man in his original description remarked on the similarity of *S. biunguiculatus exilipes* Coutière (=*S. coutierei*). However, of all specimens available of the latter species none showed other than the normal rounded condition of the posterior margin of the sixth abdominal tergum, and none of these showed other than well-developed and acute teeth. Moreover, the two forms were not collected together. Therefore we accept the separation at least until further collections are available.

Biological notes: This species has been collected at depths between 6 and 100 feet. They ranged in sizes up to 15 mm in length.

Australian distribution: Our specimens were collected in the Dampier Archipelago, Darwin and the Torres Straits.

General distribution: De Man's specimens were from Indonesia; we have some as yet unreported specimens from the Red Sea and the Southern Philippines.

Synalpheus ancistrorhynchus De Man

Fig. 19

Synalpheus ancistrorhynchus De Man, 1909a, Tijdsch. ned. dierk. Vereen. 11 (2): 124; 1911, Siboga Exped. 39a[1] (2): 267, fig. 47.

Specimens examined: 2 specimens from AC S2; 6, AM 3; 5, AM 85; 2, AM 123; 5, AM 137; 1, AM P 2577; 2, BAU 53; 1, BAU 54; 1, WM 77–65.

Diagnosis: Rostrum and orbital teeth short, equal in length; reaching to first quarter of visible part of first antennular article; wide at their bases, curved upwards at their tips, tips bearing short stiff setae. Rostral base with orbitorostral process.

Visible part of first antennular article and second article subequal, third article a little shorter than second. Stylocerite reaching first quarter of second antennular article. Squamous portion of scaphoceute narrow, reaching to end of second antennular article, lateral spine reaching to near end of third antennular article; cleft between lateral spine and squamous portion deep, reaching proximtiy to first antennular article. Carpocerite the length of third article past that article. Inferior spine of basicerite almost as long as stylocerite, superior spine acute, about one-third as long as inferior spine.

Large chela 2.5 times as long as broad, superior margin projecting as rounded tooth above dactylar articulation, fingers half as long as palm. Merus two times as long as broad, distosuperior margin slightly projected, subacute, other distal margins rounded. Small chela 3.6 times as long as broad, fingers a little shorter than palm. Superior margin of palm slightly projecting distally. Dactylus slightly broadened, bearing a row of curved setae, usually two hairs per follicle, placed laterally. Lateral margins of dactylus being short stiff setae. Merus 1.4 times as long as broad, superodistal margin rounded.

Second leg stout, carpal articles with a ratio 10:2:2:2:5; three middle articles each broader than long.

Merus of third leg 3.5 times as long as wide, usually bearing on distal portion of inferior margin 2-3 small spines. Carpus 0.3 as long as merus, armed with inferodistal spine. Propodus half as long as merus and bearing eight spines on its inferior border, two distally. Dactylus biunguiculate, superior unguis about 1.5 times longer than inferior unguis, but thinner at base.

Telson, varying, usually about twice as long as broad at posterior margin. Laterial margins may have subterminal constriction. Posterolateral angles produced into strong teeth which are much longer than the slightly arcuate posterior margin, but shorter than the adjacent spines. Spines of posterior margin large, almost equal in length. Spines on dorsal surface of telson large, as long as, but heavier than spines on tip. Outer uropod with partial, non-functional distal articulation.

Discussion: We found some variation in our 20 specimens. The spines may be lacking on the merus of the third legs, but in those the usual place of the spines carried small patches of setae. The ungui of the dactyli of the third legs varied in relative lengths (fig. 19 g, m). The telson was variable in the subterminal constriction, in the size of the posterolateral teeth and in the proportions of both the dorsal and terminal spines (compare figs 19h-k). In some specimens the articulaton on the outer uropod was visible, but did not constitute a line of flexion.

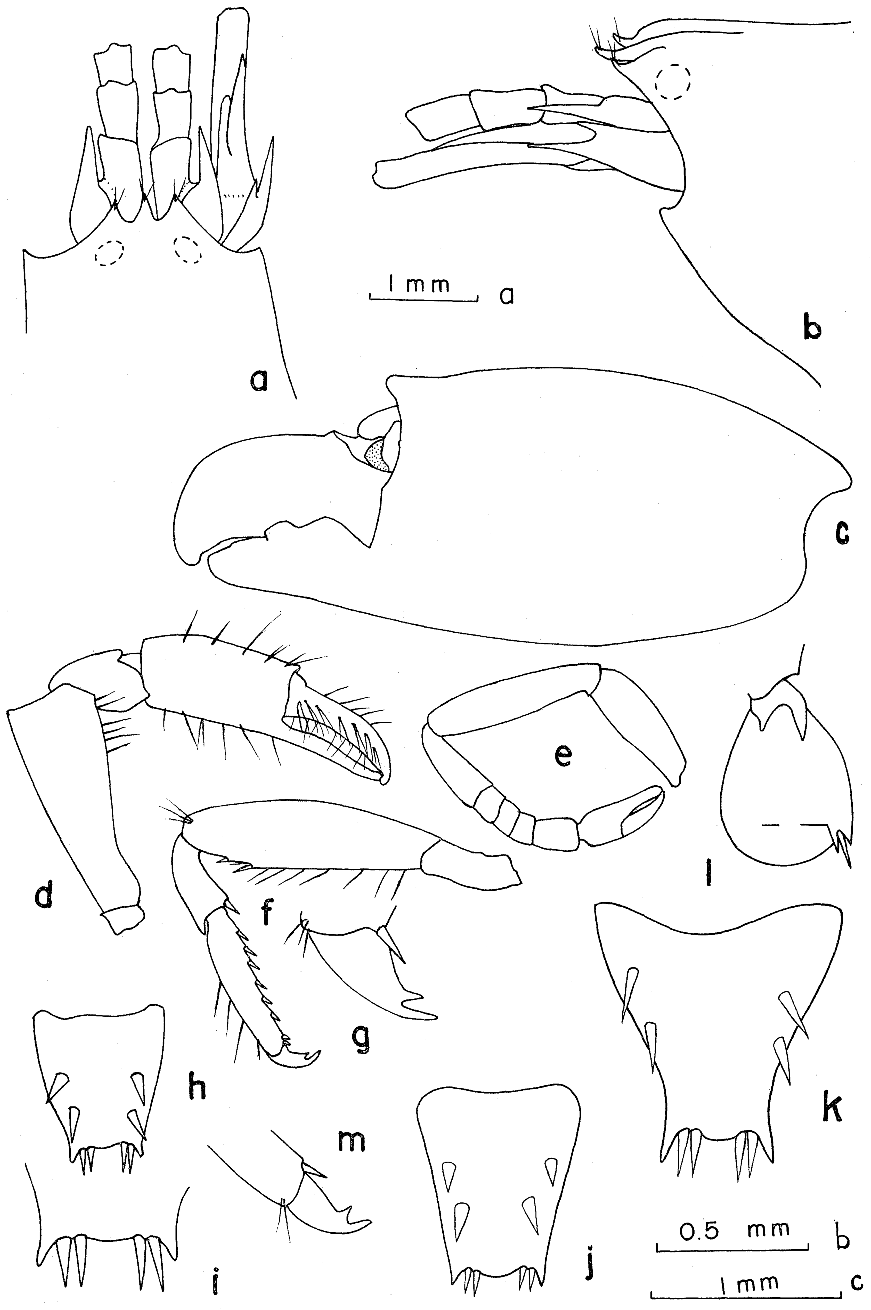
As De Man pointed out, this species very closely resembles *S. hastilicrassus* Coutière. However, the much shorter orbital teeth, the stouter thoracic legs, and usually the spines on the meri of the third legs clearly separated the two. De Man states (without a figure) that there is a small tooth on the superior margin of the merus of the large chela; in these specimens it is a minor projection.

Biological Notes: This is not a large species, the largest one in our collection being 15 mm long. The species has been dredged from 21 fathoms in Western Australia and has been found in coral heads in Queensland.

Australian Distribution: This species has been collected in Western Australia between 18° and 30° S., at Darwin and at Heron and Masthead Island off Queensland.

General Distribution: This is the first report of the species since De Man's original report of his two specimens from Indonesia.

Fig. 19.—*Synalpheus ancistrorhynchus* De Man. 14 mm male from AM3: a, b, anterior region, dorsal and lateral view; c, large chela, inner face; d, small cheliped, outer face; e, second leg; f, g, third leg and enlargement of dactylus; h, i, telson and enlargement of posterior region. 12 mm male from BAU 54: j, telson. 11 mm female from WM 77-65: k, telson. 10 mm male from BAU 54: l, uropod. 12 mm female from AM 137: m, dactyl of third leg. a, b, c, d, e, f, h, l, scale a; g, m, scale b; i, j, k, scale c.


a
1 mm a
b
c
d
e
f
g
h
i
j
k
l
m
0.5 mm b
1 mm c

Synalpheus lophodactylus Coutière

Fig. 20

Synalpheus lophodactylus Coutière, 1908a, Bull. Soc. Philomath, Parish IX, 11 (5): 197; 1921, Trans. Linn. Soc. Lond., Zool. Lond. II, Zool. 14, 17: 417, pl. 61, fig. 11. Banner, 1957, Pacif. Sci. 11 (2): 195.

Specimens Examined: 12 specimens from AM 419: 18, AM P 12426; 1, BAU 33; 2, BAU 43; 2, BAU 44; 1 specimen each from CS 1, 3, 4, 11, 12, 18; 3, WM 82-65; 3, WM 140-65; 1, WM 175-65; 11, WM 267-65; 9, WM 251-78-32; 13, WM 9991; 10, WM 10380; 1, WM 10410; 40, WM 10467; 35, WM 10472; 51, WM 10481; 4, WM 10487; 34, WM 10591/92.

Diagnosis: The normal form of rostrum twice as long as broad at base, reaching end of visible part of first antennular article. Orbital teeth not as long as rostrum, but broader at base. Rostral base with orbitorostral process.

Visible part of first antennular article and second antennular article almost equal, third article a little shorter than second. Stylocerite reaching to end of first antennular article. Squamous portion of scaphocerite reaching past middle of third antennular article, lateral tooth reaching beyond antennular peduncle. Carpocerite 3.4 times as long as wide, reaching almost the length of third article past that article. Inferior tooth of basicerite reaching to middle of second antennular article, superior margin without projection.

Large chela 2.7 times as long as broad, distal end of superior margin of palm terminating into an obtuse tooth, tilted slightly upward. Merus three times as long as broad, distal angles inermous. Small chela three times as long as broad; superior surface of dactyl bearing a longitudinal brush of hairs, placed slightly laterally, extending almost full length. Carpus ranging from 0.25-0.50 times length of chela. Merus similar to that of large chela.

Carpal articles of second leg with a ratio 10:2:2:2:6, middle articles broader than long.

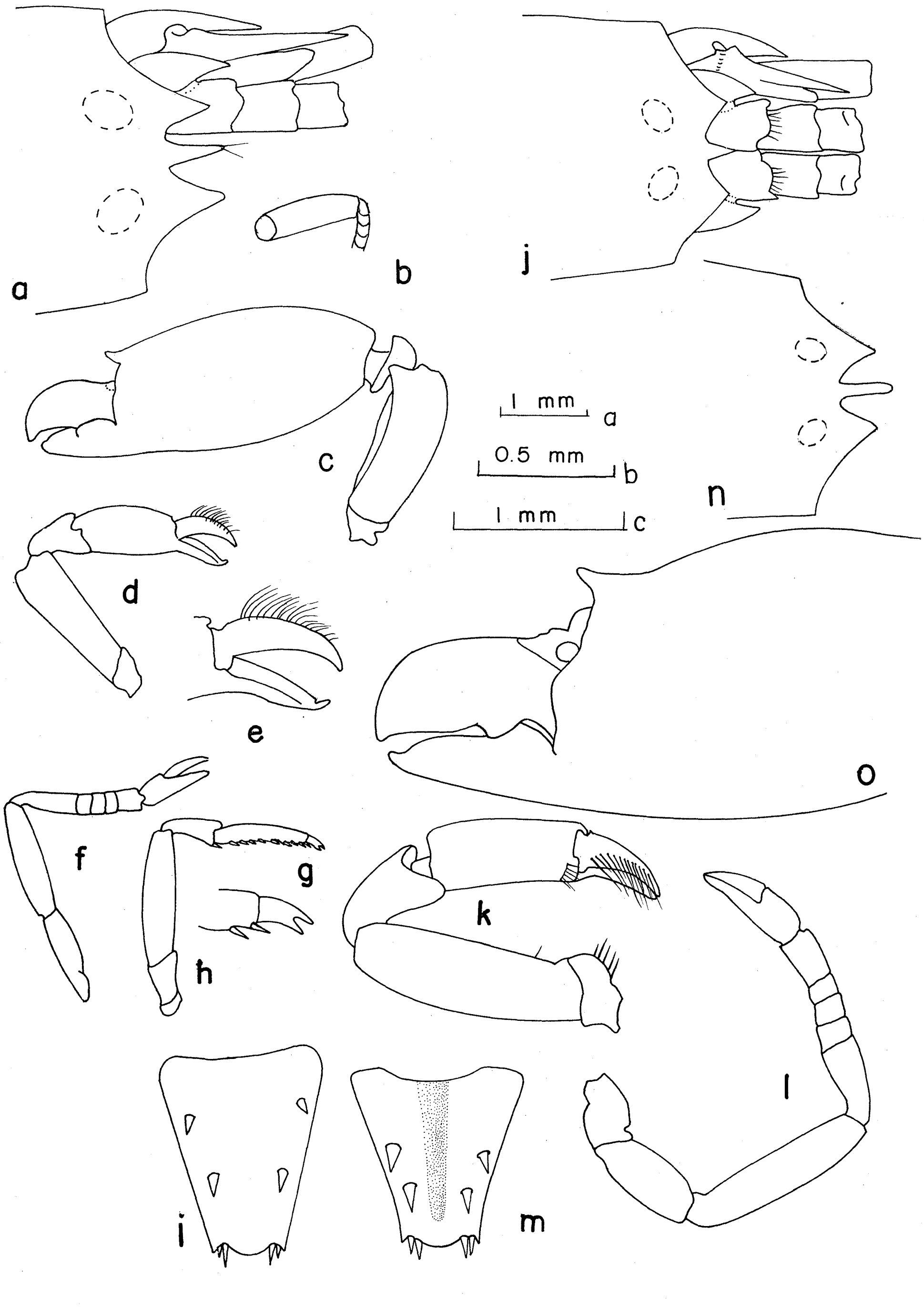
Merus of third leg inermous, 4.5 times as long as broad. Carpus 0.36 as long as merus; distal end of superior margin projected into a blunt tooth, inferior margin terminating in single spine. Propodus 0.6 times as long as merus, bearing on its inferior margin 9 movable spines and two distally. Dactylus biunguiculate, ungui of equal length, apex between ungui "U"-shaped.

Telson 2.2 times as long as broad at posterior margin. Posterolateral angles acute, about half as long as short lateral spine of distal pair. Tip of telson between spines slightly convex. Outer uropod without transverse articulation.

Discussion: We have examined the type at the Muséum d'Histoire Naturelle in Paris; Coutière figure (1921: pl. 61, fig. 11) is an excellent likeness, however, the small cheliped was missing. Our specimens agree well with Coutière's with a few exceptions. The inferior spine of the basicerite reaches

OPPOSITE

Fig. 20.—*Synalpheus lophodactylus* Coutière. 11 mm ovigerous female from BAU 44: a, anterior region, dorsal view; b, carpocerite; c, large cheliped; d, e, small cheliped, enlarged view of fingers; f, second leg; g, h, third leg and enlarged view of dactylus; i, telson. 12 mm male from AMP 12426: j, anterior region; k, small cheliped; l, second leg.; m, telson. 10 mm male from WM 275-65: n, anterior region, dorsal view. 22 mm male from CS 9: o, distal section of large chela. b, c, d, f, g, j, m, n, scale a; h, scale b; a, e, i, k, l, o, scale c.


a
b
j
c
1 mm a
0.5 mm b
1 mm c
n
d
e
o
f
g
h
k
l
i
m

to the middle of the second antennular article instead to the end of the first; in one specimen from BAU 44 it reaches to end of second antennular article. The brush of hairs on the superior surface of the dactyl of the small chela in our specimens extend from almost the articulation of the dactylus instead of appearing only in the distal section as in Coutière's specimen.

We found this also true for our specimen from Arno Atoll (1957: 196). We found variation in the length of the carpus of the small cheliped as mentioned above.

In collections from sponges in Western Australia we found notable variation. The extreme condition in the anterior region is shown in fig. 20j. In this form the rostrum and the orbital teeth were markedly shortened, the orbital teeth were relatively broader at the base; the antennules were stouter; the carpocerite was 3.0 times as long as broad instead of 4.0 as found in normal specimens. The first article of the carpus of the second leg was only 0.7 as long as the four following (fig. 20 l) while in the normal form the first article was almost equal to the four following. These characteristics were not constant in any geographical area, for example, in a single collection of fifty-one specimens from a single sponge the normal form, the extreme form and intermediates occurred. This does not appear to be more than the normal variations which are found so often in symbiotic synalpheids.

The differences between this species and its nearest relative, *S. hastilicrassus,* are subtle and the separation of the two species is difficult. The principle difference is that *S. lophodactylus* is a stouter species than *S. hastilicrassus*. In *S. lophodactylus* the stylocerite is always shorter than both the first antennular article and the outer tooth of the basicerite, while in *S. hastilicrassus* it reaches the middle of the second antennular article and is equal to the outer tooth of the basicerite. In *S. lophodactylus* the carpocerite is less than 4.0 times as long as broad while in *S. hastilicrassus* it is more than 4.0 times as long as wide. The tooth on the distosuperior margin of the palm of the large chela is tilted upwards in *S. lophodactylus,* but in *S. hastilicrassus* it is not. The second leg is stouter in this species, the first article being 2.5 times as long as wide at its distal end, while in *S. hastilicrassus* it is 3.5. Finally the posterior lateral angles of the telson in *S. lophodactylus* are not as strong as those for *S. hastilicrassus*. The outer uropod has a transverse articulation in *S. hastilicrassus*.

Biological notes: Of the 208 specimens in the collection all except 7 were taken from sponges, with a large number from sponges which has been carried to the beaches by storm waves in Western Australia. Of those not reported to be from sponges, 3 were dredged from 2 fathoms and 4 were taken from dead coral between 2–6 feet deep. The specimens ranged in size from 7–22 mm.

Australian distribution: In Western Australia specimens came from as far north as Dirk Hartog Is., but the majority were found in storm-carried sponges at Cottesloe, near Perth. One specimen came from Chinamans Reef, off Port Douglas, Queensland, and others came from the Whitsunday Group off Queensland.

General distribution: Chagos Archipelago, Indian Ocean; Marshall Islands.

Synalpheus hastilicrassus Coutière

Fig. 21

Synalpheus hastilicrassus Coutière, 1905a, Fauna and Geog. Mald. and Laccad, 2 (4): 875, pl. 72, fig. 12. De Man, 1911, Siboga Exped. 39a[1] (2): 263, fig. 45 [*partim*].

Synalpheus hastilicrassus (Coutière var.? De Man, 1911, Siboga Exped. 39a[1] (2): 264, fig. 45b [*partim*].

Synalpheus hastilicrassus acanthitelsoniformis De Man, 1920, Zoöl. Meded., Leiden, 5 (3): 108; 1922, Siboga Exped. 39a[4] (5): 29, fig. 14.

Synalpheus acanthitelsonis Coutière, 1905a, *loc. cit.* 2 (4): 875, fig. 13. De Man, 1911, *loc. cit.*: 256, fig. 46. Gravely, 1930, Bull. Madras Govt Mus. new ser. (nat. Hist.) 1 (2): 77, pl. 1, fig. 1. Banner & Banner, 1966b, Siam Soc. Mono. 3, p. 58, fig. 18.

Specimens examined: 1 specimen from AM 137; 1, AM 258; 1, AM P 1966; 1, AM P 3566; 6, BAU 25; 2, BAU 27; 3, BAU 37; 4, BAU 38; 3, BAU 40; 1, BAU 42; 4, BAU 44; 3, BAU 48; 3, BAU 53.

Diagnosis: Rostrum slender, three to four times as long as broad at base, reaching variously from end of first antennular article to near end of second article. Orbital teeth directed straight forward, about 0.6 as long as rostrum, but much broader at base. Rostral base with orbitorostral process. Visible part of first antennular article subequal to second article; third article from half to almost equal length of second. Stylocerite reaching near middle of second antennular article. Scaphocerite with squamous portion reaching variously from middle to end of third antennular article. Lateral tooth of scaphocerite much longer, equal to or longer than carpocerite, carpocerite reaching past antennular peduncle by length of third article. Superior margin of basicerite usually truncate, inferior tooth subequal in length to stylocerite.

Large chela cylindrical, 2.7 times as long as broad; fingers about half length of palm. Palm terminating in subacute to acute tooth above the dactylar articulation, not upturned. Merus 2.2 times as long as broad, distosuperior margin usually without tooth. Small chela three times as long as broad, finger 0.4 as long as entire chela. Superolateral surface of dactylus bearing single row of inwardly curving setae, with one or two setae emerging from each follicle. Merus 3.8 times as long as broad; superodistal angle at times produced into acute tooth; inferointernal margin bearing row of setae.

Carpal articles of second leg with a ratio: 10:1:6:1:6:1:6:4.

Merus of third leg 4.5 times as long as broad, unarmed, carpus 0.6 as long as merus with superodistal margin projecting and subacute; inferodistal margin bearing small spine. Propodus 0.7 as long as merus, bearing eight spines on its inferior margin and two distally. Dactylus biunguiculate, 0.2 as long as propodus, ungui almost equal in length, superior unguis a little broader at base than inferior.

Telson 1.8 times as long as wide at arcuate posterior margin. Posterolateral angles produced into acute teeth, usually long, reaching half or more than the length of the adjacent spine. Outer uropod with transverse articulation.

Discussion: Five nominal species and one subspecies of the Paulsoni group of *Synalpheus* have the posterolateral angles of the telson developed into large teeth. These are (in order of date of original description):

S. tumidomanus (Paulson)
S. hastilicrassus Coutière
S. acanthitelsonis Coutière

S. ancistrorhynchus De Man
S. hastilicrassus acanthitelsoniformis De Man
S. thai Banner & Banner

Also closely related is *S. lophodactylus* which Coutière (1909: 10) placed in the Biunguiculatus Group. For the separation of these two species see page 184.

Of the species listed above, three seem to be distinct: *S. tumidomanus* has only slight projections of the posterolateral angles (see p. 111); *S. ancistrorhynchus* has a much shorter rostrum and orbital teeth than the others, and usually bears 2–3 spines on the merus of the third legs; *S. thai* has extremely long posterolateral teeth, almost half as long as the telson proper. In the earlier paper (Banner & Banner, 1966b: 60) we questioned the validity of the separation of the other three species and subspecies. We now have more extensive collections so that we are better able to review their separation.

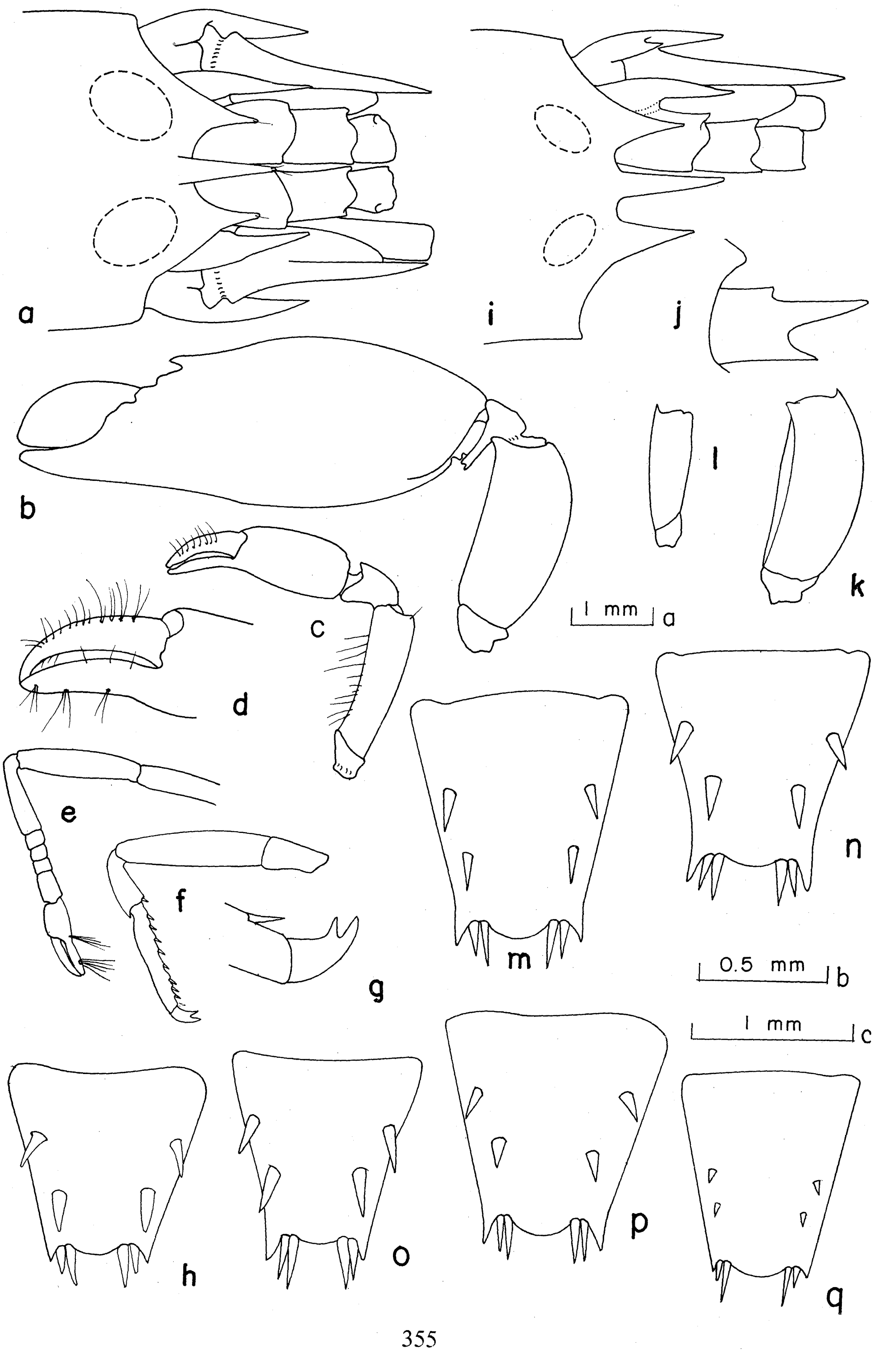
From these collections we have selected sixty specimens from our Malayo-Thai collection, twenty-one specimens from Queensland and twenty-nine specimens from the Sulu Sea in the southern Philippines. In the latter two collections, these were all the specimens in the collection that were completely intact and reasonably mature. We have assessed the variation of the five principal characteristics that have been used in the separation of the three nominal forms. The characteristics and the variations are given in table IV; it should be noted that we have,

Table 4. *Variation in* S. hastilicrassus

Characteristic	As described for			Percentage of specimens with characteristic		
	S. hastilicrassus	*S. h. acanthitelsoniformis*	*S. acanthitelsonis*	Malayo–Thai Collection 60 specimens	Queensland Collection 21 specimens	Sulu Sea Collection 29 specimens
				per cent	per cent	per cent
Superior tooth on basicerite	no	no	yes	45	5	0
Tooth on superodistal angle of merus, large cheliped.	no	missing	yes	94	19	78
Tooth on superodistal angle of merus, small cheliped.	no	no	yes	98	41	85
Posterolateral teeth of telson longer than midposterior arc.	no	yes	yes	10	43	96
Posterolateral teeth of telson longer than adjacent spines.	no	no	yes	0	0	0

OPPOSITE

Fig. 21.—*Synalpheus hastilicrassus* Coutière. 12 mm male from BAU 44: a, anterior region, dorsal view; b, large cheliped; c, d, small cheliped and enlarged distal section; e, second leg; f, g, third leg and dactylus; h, telson; 14 mm male from BAU 37: i, anterior region, dorsal aspect; j, basicerite of specimen; k, l, meri of large and small chelipeds; 14 mm male from Hong Kong: m, telson; 14 mm female from AMP 3566: n, telson. 11 mm female from Hong Kong: o, telson. 14 mm female from BAU 37: p. telson. 12 mm male from Hong Kong: q, telson. b, c, e, f, i, k, l, scale a; g, scale b; a, d, h, j, m, n, o, p, q, scale c.


a
i
j
b
l
k
c
d
1 mm a
e
f
g
m
n
0.5 mm b
1 mm c
h
o
p
q

for our tabulation, recorded each characteristic as all-or-none, but that in actuality the characteristic showed wide variation. Thus the tooth on the basicerite would be recorded as absent or present, but if present it would vary from a strong tooth to one almost non-discernible.

Supplementing the table are the drawings in figure 21. As can be seen from the wide variation both tabulated and depicted, none of the criteria used in separation, with a single exception, appear to be valid. The exception is the length relationship of the posterolateral teeth of the telson to the adjacent spines. In none of our specimens were the posterolateral teeth as long as the adjacent spines, a condition that characterizes *S. acanthitelsonis*, but there again was enough variation in the relative lengths that we believe with a larger collection this too would be within the range of variation. We therefore combine the three taxa under the name *S. hastilicrassus*.

There is some question about subspecific races of the species. Certainly the differences in percentages of specimens which bear any one characteristic in these three widely separated collections would indicate geographic and genetic isolation. However, to erect new subspecies, detailed studies on specimens from various parts of Indonesian waters (the Indo-Malayan subregion of Ekman, 1953: 18) would be desirable to determine the extent of variation in this probable center of distribution. Then the other possible geographic subspecies could be defined on their differences, not from one another, but from the presumable nominate stock. If so, then Coutière's species and De Man's variety may both be revived and given well-defined subspecific status. At present, the erection of new subspecies and the retention of the older names is not justified.

Two more variant forms of this species should be noted here to complete the discussion, although the specimens are from our Philippine collections. The first is similar to the form described by De Man as *S. hastilicrassus* Coutière var.? which he separated from the nominate form on the basis of the fingers of the large chela which are one-half, instead of one-third the length of the palm. We have two small females from the Sulu Sea with similar proportions in the large chela. We do not consider this difference in proportion to be specific or subspecific importance. It will be figured in our Philippine paper.

The second form is more perplexing, for in a male and a female collected from near Zamboanga almost all characteristics were those of *S. hastilicrassus*, but one has three, and other one, spine on the merus of the third legs. In this character, then, they are similar to *S. ancistrorhynchus* De Man. We at present regard the separation of *S. hastilicrassus* and *S. ancistrorhynchus* as firm, but these two specimens raise doubts. We will defer action until some future worker has larger and more adequate collections upon which to base his decision. These will also be figured in the Philippine paper.

Biological notes: This is not a large species, our largest specimen from Australia being 20 mm long. It has been dredged as deep as 90 metres and is found commonly inside coral heads in waters up to 5 metres. It has been found in sponges.

Australian distribution: Darwin, from Torres Straits in the north to Great Sandy Strait, south of Bundaberg, Queensland, on the east coast.

General distribution: Maldive Archipelago; Gulf of Manaar; Indonesia; Philippines*, Caroline and Marshall Islands; Fiji.

Synalpheus neomeris (De Man)

Fig. 22

Alpheus minor neptunus De Man, 1888b, J. Linn. Soc. Lond. 22: 272 [*nec A. minor* Rankin = *A. minus* Say; *nec A. neptunus* Dana].

Alpheus neomeris De Man, 1897, Zool. Jb. Syst. 9: 734, fig. 61 a, d, e [*partim*].

Synalpheus neomeris Coutière, 1905a, Fauna and Geog. Mald. and Laccad. 2 (4): 869, fig. 1. De Man, 1911, Siboga Exped 39a[1] (2): 212, fig. 24.

Synalpheus gravieri Coutière, 1905a, Fauna and Geog. Mald. and Laccad. 2 (4): 870, fig. 2. Pearson, 1905, Rep. Govt. Ceylon Pearl Oyster Fish. Gulf Manaar 4 (24): 82. De Man, 1911, Siboga Exped. 39a[1] (2): 216, fig. 25. Gurney, 1927, Trans. Zool. Soc. Lond. 22: 261, fig. 64 [larval development]. Banner & Banner, 1966b, Siam Soc. Mono. 3, p. 48, fig. 13. Miya, 1972, Publ. Amakusa Biol. Lab. 3 (1): 66, pl. 13.

Alpheus prolificus Ortmann, 1890, Zool. Jb. Syst. 5: 484 [*nec* Bate].

Alpheus neptunus Bate, 1888, Challenger Rept. 24: 563, pl. 101, fig. 2 [*nec A. neptunus* Dana].

Additional Australian Records:

Coutière, 1900, Bull. Mus. Hist. nat., Paris 6 (8): 411. Torres Straits.

Specimens examined: 2 specimens from AC S3; 1, AM 26; 2, AM 82; 2, AM 85; 7, AM 109; 1, AM 136; 1, AM 145; 2, AM 163; 2, AM 236; 2, AM 252; 1, AM 278; 1, AM 286; 1, AM 305; 1, AM 307; 2, AM 439; 1, AM G 1789; 1, AM P 3566; 1, AM P 3574; 1, AM P 11763; 2, MM 176; 1, WM 91–65; 1, WM 129–65; WM 304–65.

Diagnosis: Rostrum narrow, reaching to past middle of first antennular article. Orbital teeth triangular, a little shorter than rostrum, not tilted upward, bearing a few setae. Rostral base bearing orbitorostral process.

Second antennular article a little shorter than first, third a little shorter than second. Stylocerite reaching to middle of second antennular article. Squame of scaphocerite reaching to middle of third antennular article. Carpocerite reaching at least length of third article past that article. Inferior tooth of basicerite almost as long as stylocerite, superior tooth acute, nearly as long as orbital teeth.

Large chela 2.6 times as long as broad, bearing a tooth above the dactylar articulation that varies from a slight rounded projection to acute tooth. Fingers occupying 0.3 length of entire chela. Merus 2.0 times as long as broad with small projections terminally on both superior and internal margins. Small chela varying from 3.4–4.4 times as long as broad with fingers a little shorter than palm. Merus similar to that of large chela, but almost three times as long as broad.

Carpal articles of second leg with ratio: 10:1.6:1.6:1.6:3.0.

Third leg with ischium unarmed. Merus of third legs three times as long as broad, inner margin armed with 3–7 heavy movable spines.

Carpus 0.4 as long as merus, terminating on superior margin with heavy rounded tooth, on inferior margin with single spine. Propodus 0.8 as long as merus, slightly curved, and bearing nine spines on inferior margin and two distally. Dactylus biunguiculate. Superior unguis small, varying from one-fourth to one-third as thick at base, and from about one-third to one-half as long as inferior unguis.

Telson about 3.0 times as long as posterior margin is wide. Posterior angles not acute. Anterior pair of dorsal spines located posterior to middle.

Discussion: In 1897 De Man described *Alpheus neomeris* based on two specimens from the Mergui Archipelago, which in 1888 he called *A. minor neptunus* Dana, and on nine specimens from Atjeh, Sumatra. In 1905, Coutière with thirty-eight specimens from the Maldive Archipelago created a new subspecies, *S. neomeris streptodactylus* on the basis of the differences in the dactylus of the third leg. In 1911 De Man reexamined his previous specimens and decided: (1) that his Mergui specimens were the true *S. neomeris* which he re-described, and (2) that the specimens from Atjeh were of Coutière's subspecies, which he then raised to specific rank of *S. streptodactylus*. We accept De Man's differentiation between the two species and discuss the criteria for the separation under *S. streptodactylus*; the erection of a new species, *S. metaneomeris streptodactylus,* by Coutière in 1921 is also discussed there.

Through the kindness of Dr Pinkster of the Zoölogisch Museum, Amsterdam, we were able to examine the two specimens De Man had studied from the Mergui Archipelago; both were female. These carried the label *A. minor neptunus,* evidently applied by De Man prior to his 1888 publication. These were part of the syntypic series in 1897 when he established *A. neomeris* and, on Dr Pinkster's recommendation, we designate one of these specimens as a lectotype (Museum number: ZMA De. 102.333).

We found De Man's description to be correct and adequate; we append drawings of the anterior region and of the dactyli of the third and fourth legs from the lectotype and paratype to supplement the 1897 and 1911 drawings of De Man.

However, in 1905 Coutière described another new species *S. gravieri* based on fourteen specimens which he considered closely related to De Man's *S. neomeris,* basing his comparison upon De Man's 1897 description. For the separation of the two species, Coutière pointed out a difference in the anterior region of the carapace ("Les deux épines orbitaires sont fréquement plus divergentes que chez le *S. neomeris*") and a series of minor differences in length in the antennular and antennal peduncles, in the proportion of the small chela, and in the proportions of the third, fourth and fifth thoracic legs. He also emphasized differences in the ungui of the dactylus of the third leg, stating it was characterized ". . . surtout par la réduction de la griffe dorsale, très grêle, n'ayant guère que 1/6 de l'épaisseur et 1/3 de la longeur de la griffe principale."

Two of these criteria were dismissed by De Man in his review of the three species in 1911. He pointed out that the drawing of the third leg (1897: 61b) was of *S. streptodactylus;* this was evidently the figure Coutière used for comparison of the proportions of the third leg. De Man, in a series of measurements of his specimens, showed that the range in proportions of the small chela encompassed the differences dwelt upon by Coutière. However, De Man accepted

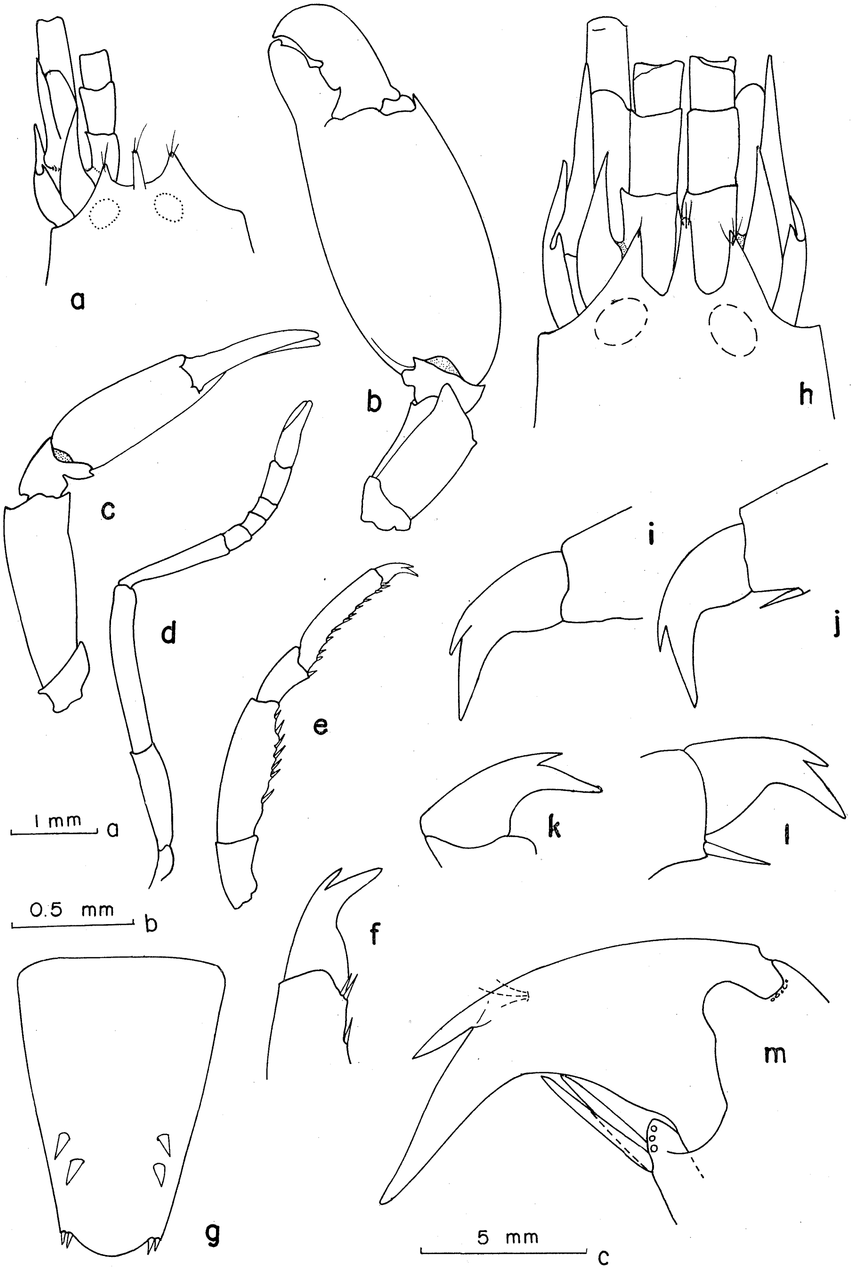


Fig. 22.—*Synalpheus neomeris* (De Man). Australian specimen, 28 mm male from AM 136: a, anterior region, dorsal view; b, large cheliped, outer face; c, small cheliped, superior face; d, second leg; e, f, third leg and dactyl; g, telson. Lectotype and paratype of *S. neomeris* (De Man) from the Mergui Archipelago: 18 mm female, lectotype; h, anterior region; i, j, dactylus of third and fourth legs. 17 mm female, paratype: k, l, dactylus of third and fourth legs. *S. gravieri* Coutière, holotype from Maldive Archipelago: m, dactylus of third leg drawn by J. Forest of the Nat. Mus. nat. Hist., Paris, g, h, scale a; f, i, j, k, l, scale b; a, b, c, d, e, scale c

the species and in the 44 specimens from the Siboga Station 258, placed nineteen specimens in *S. gravieri* and 25 in *S. neomeris*. He noted that the superior unguis reached one-third, not one-sixth the basal thickness of the major unguis.

We were given the opportunity to look at some specimens labelled by Coutière himself as *S. neomeris* and *S. gravieri* at the Muséum National d'Histoire Naturelle in Paris; we also examined at the Zoölogisch Museum in Amsterdam the specimens from Siboga Station 258 that De Man had identified. In none of these could we detect consistent differences. It is true that De Man's specimens of *S. gravieri* were smaller, the largest being 16 mm long, than the specimens of *S. neomeris,* with the largest 28 mm long. Most of the differences we saw appeared to be related to maturity.

From our Australian and other collections from the Pacific and Indian Oceans we have examined about eighty specimens. In this group we found the rostral front and the proportions of the antennular and antennal articles to be quite variable, as is often found in this genus, and that these variations encompassed the differences pointed out by Coutière. We ignored Coutière's supposed differences in the proportions of the third legs for if the comparison was made with De Man's 1897 figure 61b (the true *S. neomeris*) instead of 61d, no differences are apparent. We also paid no attention to the slight differences which ranged from 1–3 per cent in the ratio of lengths of merus, carpus and propodus of the fourth and fifth legs, for we have found that even if articles can be measured with such accuracy, the variation from left side to right side of one specimen may be greater than the percentage cited. The variation in this collection, then, destroyed all of the criteria for the separation of *S. gravieri* from *S. neomeris* except for the "très grêle" condition of the superior unguis of the third legs.

However, in none of our specimens did the superior unguis attain proportions set forth by Coutière. We found minor variations in the proportion and curvature, but these were interpreted to be within the range for *S. neomeris*. Our re-examination of specimens identified by both Coutière and De Man as *S. gravieri* showed that even these did not approach the proportions given by Coutière. We appealed to Dr Forest of the Muséum National d'Histoire Naturelle in Paris to re-examine Coutière's holotype for *S. gravieri*. He kindly did so, and forwarded to us a drawing of the unguis in question (fig. 22m). The drawing shows Coutière's type to have the superior unguis slightly more than one-third (0.36) the basal breadth, and slightly more than one-third the length (0.36), of the principal unguis. The proportions of the superior unguis thus falls within the range for *S. neomeris*. We therefore place *S. gravieri* as a junior synonym of *S. neomeris*.

To clarify previous records we find our two specimens reported from Thailand (1966b: 48) as *S. gravieri* to be also *S. neomeris*.

We were able to examine at the British Museum (Natural History) the specimen that Bate had identified in the Challenger Reports as *S. neptunus*; it was plainly *S. neomeris*. *S. prolificus* Ortmann (*nec* Bate) was placed in synonymy to *S. gravieri* by De Man (1911: 216) who was able to examine Ortmann's specimens from Kagoshima, Japan; thus it too should be recorded as *S. neomeris*.

Biological notes: This species has been collected commonly in association with alcyonarians. It has also been found associated with sponges. One specimen from Western Australia, collected in 23 fms, was reported to have been associated with a bryozoan. It has been collected from dead coral heads in fairly shallow water, and has been dredged as deep as 129 metres in Western Australia. Our specimens range in size from 12–25 mm.

The following colour notes were made by J. C. Yaldwyn on a pair of symbiotic specimens collected on the Swains Reefs (AM 163):

"To naked eye appears white, not transparent, with viscera very slightly pink. Through lens: Virtually no chromatophores on entire animal; nothing on bulk of carapace, abdomen, tail fan, anterior appendages, hands, legs, pleopods; eyes appear silver-grey through carapace; about four small and insignificant simple red chromatophores in approximate line between eyes; eggs completely colourless with dark eyes showing through."

Australian distribution: This species has been collected in Western Australia from Busselton to Cape Carnarvon and Houtman Abrolhos; in northern Australia at the Gulf of Carpentaria and the Torres Straits; in eastern Australia from Princess Charlotte Bay to Great Sandy Strait, south of Bundaberg, Queensland, and also from the Herald Group, Coral Sea.

General distribution (including reports for *S. gravieri*): Suez Canal; Red Sea; Persian Gulf; Ceylon; Maldive and Laccadive Archipelago; Singapore; Indonesia; Thailand; Shanghai; Japan and Sulu Sea*.

Synalpheus streptodactylus Coutière

Fig. 23

Synalpheus neomeris streptodactylus Coutière, 1905a, Fauna and Geog. Mald. and Laccad. 2 (4): 870, fig. 1.

Alpheus neomeris De Man, 1897, Zool. Jb. Syst. 9: 734 [*partim*]. Coutière, 1905a. *op. cit.*: 869, fig. 1.

Synalpheus streptodactylus De Man, 1911, Siboga Exped. 39a[1] (2): 226, pl. 7, fig. 29.

Synalpheus metaneomeris streptodactylus Coutière, 1921, Trans. Linn. Soc. Lond. II, 17 (4): 414, pl. 60, fig. 4.

Synalpheus streptodactylus streptodactylus Banner & Banner, 1966a, Pacif. Sci. 20 (2): 157; 1966b, Siam Soc. Mono. 3, p. 50, fig. 14. Miya, 1972, Publ. Amakusa Mar. Biol. Lab 3 (1): 69, pl. 14.

Synalpheus streptodactylus hadrungus Banner & Banner 1966a, Pacif. Sci. 20 (2): 158.

Synalpheus jedanensis Barnard, 1950, Ann. S. Afr. Mus. 38: 738, fig. 139e–i [*nec* De Man]. Fourmanoir, 1958, Naturaliste malgache, 10 (1–2): 115, fig. 3 [*nec* De Man].

Additional Australian Records:

McNeil, 1968, Sci. Rept. Gt Barrier Reef Exped. 7 (1): 18. Lookout Point, N. E. Queensland.

Specimens examined: 2 specimens from AM 11; 6, AM 13; 1, AM 35; 3, AM 67; 1, AM 116; 9, AM 173; 1, AM 199; 6, AM 251; 1, AM 429; 1, AME 3180; 3, AME 4494; 4, AM E 4495; 7, AM E 4499; 2, AM E 6667; 1, AM P 8793; 2, AM P 10038; 5, AM P 13559; 1, AM P 13585; 1, BAU 14; 1, BAU 15; 1, BAU 17; 3, BAU 21; 75, BAU 25; 34, BAU 27; 20, BAU 28; 1, BAU 33; 3, BAU 40; 1, BAU 43; 4, BAU 44; 2, BAU 57; 1 specimen each from CS 13, 14, 18, 22; 1, UQ 14; 1, VM 32; 3, WM 24–65; 1, WM 29–65; 1, WM 34–65; 1, WM 38–65; 3, WM 94–65; 1, WM 107–65; 1, WM 182–65; 1, WM 250–65; 16, WM 268–65; 1, WM 288–65; 1, WM 290–65.

Diagnosis: Rostrum three times as long as broad at base, reaching variously from the middle to the last quarter of the visible part of the first antennular article. Orbital teeth broader at base and a little shorter than rostrum. Rostral base with orbitorostral process.

Visible part of first antennular article at least 1.5 times as long as second antennular article, third article a little shorter. Stylocerite reaching to middle of second antennular article. Scaphocerite with lateral tooth reaching well past antennular peduncle and almost as long as carpocerite. Squamous portion reaching near end of antennular peduncle. Inferior tooth of basicerite almost as long as stylocerite, superior tooth well developed and acute.

Large chela 2.7 times as long as broad, with fingers occupying slightly more than distal quarter. Superior margin of palm bearing acute tooth proximal to dactylus. Merus two times as long as broad with superior margin projecting as an acute tooth. Small chela 3.2 times as long as broad with fingers 0.8 length of palm. Merus similar in form to that of large cheliped.

Carpal articles of the second leg with a ratio: 10:1:1:1:3.

Merus of third leg varying from 3.8–4.4 times as long as broad, with inferior margin bearing 2–5 spines centred beyond middle, but none terminally. Carpus terminating in rounded superior tooth and two inferior spines. Propodus 6.2 times as long as wide, slightly curved, and bearing eight spines on inferior margin and two terminally. Dactylus biunguiculate, 0.2 as long as propodus and strongly hooked; superior unguis 0.3–0.5 as thick, and 0.5 to almost 1.0 as long as inferior unguis. Merus of fourth leg usually bearing one or two spinules; merus of fifth leg unarmed.

Telson 2.8 times as long as posterior margin is wide. Lateral distal corners extended into small but acute teeth. Anterior pair of dorsal spines sometimes slightly posterior, but more often slightly anterior to middle.

Discussion: As discussed under *S. neomeris*, specimens of this species were confused by De Man with those of *S. neomeris* when he described that species originally in 1897. Coutière (1905a) separated the two forms, creating *S. neomeris streptodactylus*. De Man (1911) accepted the separation, but raised the subspecies to specific rank. An examination of 138 specimens from Australia and 58 specimens from the Philippines as well as specimens of *S. neomeris* already cited, allows us to agree with Coutière and De Man that the two species are closely related but specifically separate. Probably the most important characteristic lies in the dactyli of the third legs as mentioned by previous authors. In *S. streptodactylus* the superior unguis is half or more than half as long as the inferior, and usually half as thick at its base; in *S. neomeris* the superior unguis is about one-third as long (rarely reaching half as long) and one-third as thick at its base. We also have discovered several other characteristics useful for separation: In both species the carpocerite is much longer than the antennular peduncles, but in *S. streptodactylus* the lateral tooth of the scaphocerite is nearly equal in length to the carpocerite, while in *S. neomeris* it is equal to the antennular peduncles. In *S. streptodactylus* the posterolateral angles on the telson project as small acute teeth, and the anterior pair of dorsal spinules are wide apart and located near the middle of the anterior-posterior axis; in *S. neomeris* the posterolateral angles are not projecting and the anterior pair of dorsal spinules are close together and posterior to the middle (compare fig. 22g with 23g). Finally there may be an ecological difference, for the only noted symbiotic relationship of *S. streptodactylus* has been with sponges, while *S. neomeris* came from alcyonarians and bryozoans as well as sponges.

Both Barnard (1950: 738) and Fourmanoir (1958: 115) have pictured the dactylus of the third legs of specimens they have named *S. jedanensis*. When they are compared to De Man's original figure for that species (1911, fig. 27c) and to this species, one is convinced that the African specimens are actually *S. streptodactylus*. Further supporting this contention is that these specimens came from sponges, a common habitat for *S. streptodactylus*.

The separation of the species into two subspecies is questionable. As we discussed before (1966a: 157) it is not clear whether the intent of Coutière when he applied the name *S. metaneomeris streptodactylus* in 1921 (p. 414) was to merely rename an existing species, plainly in conflict with rules of nomenclature, or to create a new subspecies on the basis of the subtle differences between the ungui of the dactyls of the third legs. In 1966a we presumed the latter and named the nominate species *S. streptodactylus streptodactylus* and the form with the heavier ventral unguis *S. streptodactylus hadrungus* (=*S. metaneomeris streptodactylus* Coutière). We found that all of our central Pacific specimens were *S. s. streptodactylus.* Since then we have examined six specimens from the collections of the Muséum National d'Histoire Naturelle in Paris that had been identified by Coutière as *S. streptodactylus,* and we found their ungui to be variable. This point, together with the variation found in this extensive collection, has convinced us that the separation between the subspecies is invalid and that only the nominate species should be recognized.

Biological notes: This is not a large species. Our mature specimens range in length from 10–15 mm with the exception of eighteen specimens from South Australia and one from Fremantle which are 20 mm in length. The species has been found from intertidal zone to as deep as 70 fathoms.

While it has been reported from heads of "dead coral" it is often found in large numbers in the spongocoel of various sponges. We suggest that perhaps it is almost always associated with sponges. Those reported from "dead coral" may have been actually living in sponges that so often invade dead portions of coral, and fell out, not of the coral, but of the sponges, when the coral was broken apart. Those reported as taken from "the growth on a pearl oyster shell" could also have come from sponges growing on the shell.

The only colour notes on this species are ours: We found three salmon pink specimens from an orange-red membranous sponge in Western Australia (BAU 4), however, specimens from the brownish sponge *Zygomycale parishii* (Bowerbank) in Hawaii are of a brown colour similar to the sponge.

Australian distribution: This species has been found on all the coasts of Australia.

General distribution: Red Sea, Ghardaqa, South Africa, Maldive and Laccadive Archipelagoes, Sumatra, Thailand, Philippines*, Japan, Tonga, Samoa, Canton Islands, Hawaii.

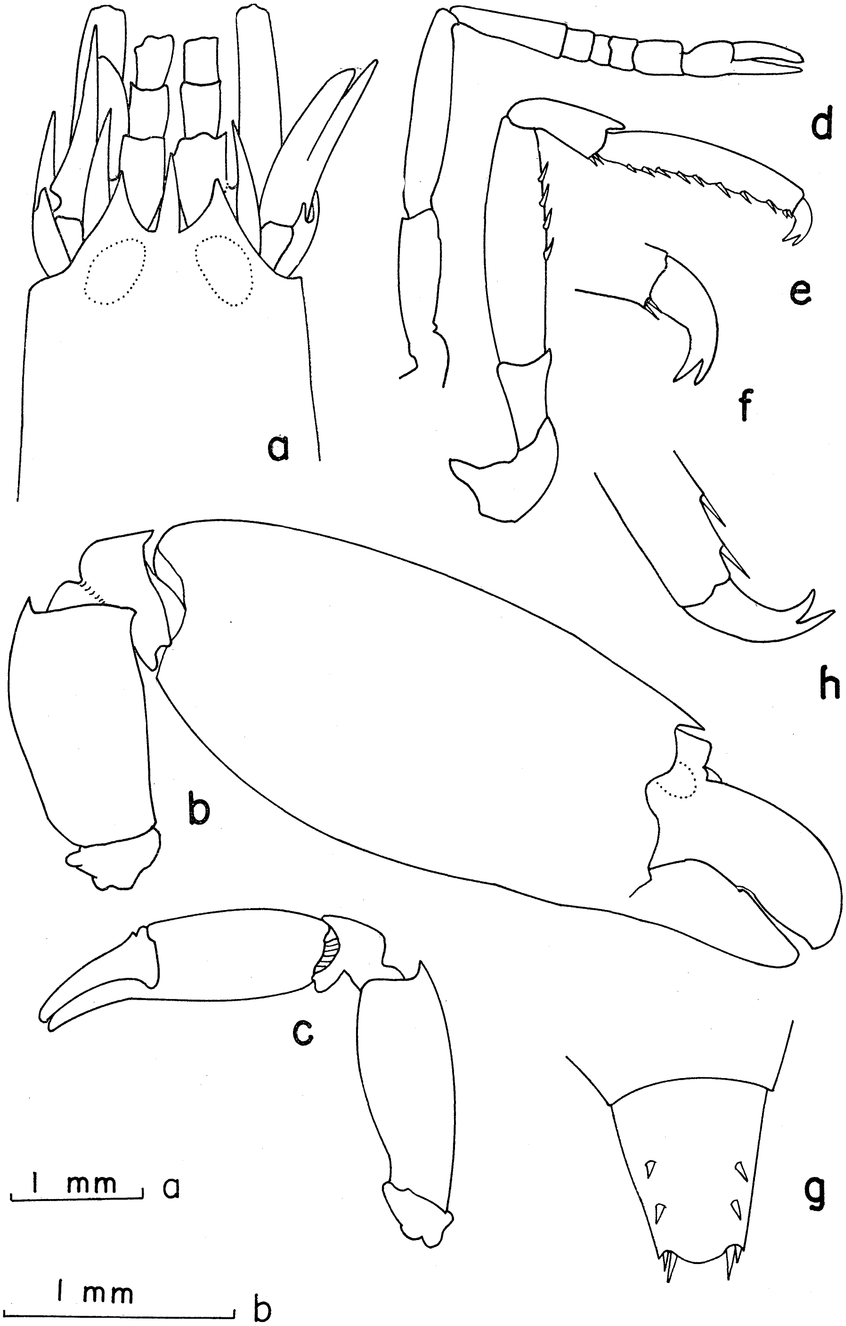


Fig. 23.—*Synalpheus streptodactylus* Coutière. 15 mm male from BAU 38: a, Anterior region; b, large cheliped; c, small cheliped; d, second leg; e, f, third leg and dactylus; g, telson. 17 mm female from WM 288-65: h, dactylus of third leg. a, b, c, d, e, g, scale a; f, h, scale b.

Synalpheus pococki Coutière

Fig. 24 a–h

Synalpheus neomeris var. *pococki* Coutière, 1898d, Bull. Soc. Ent. France 1898 (7): 167, fig. 2 [Holothuria Bank, N. W. Australia, Macclesfield Bank, Arafura Sea].

Synalpheus pococki De Man, 1911, Siboga Exped. 39a[1] (2): 234, fig. 32.

Additional Australian Records:

Coutière, 1900, Bull. Mus. Hist. nat., Paris 6 (8): 411, Albany Passage, Torres Straits.

Specimens examined: 1, 19 mm female from AM 67 (near Darwin).

Diagnosis: Rostrum slender, 3.5 times as long as broad at base, reaching to end of first antennular article. Orbital teeth a little shorter with outer margins straight, inner margins concave. Rostral base with orbitorostral process.

Visible part of first antennular article a little longer than second; third a little shorter than second. Stylocerite reaching middle of second antennular article. Squamous portion of scaphocerite not reduced, reaching near end of antennular peduncle; lateral tooth longer than peduncle. Carpocerite 4.0 times as long as broad when viewed from below, slightly longer than antennular peduncle. Inferior spine of basicerite a little shorter than stylocerite, superior spine prominent, acute.

Large chela 2.6 times as long as broad, fingers occupying almost the distal one-third, with acute tooth above dactylar articulation. Merus three times as long as broad, superodistal margin terminating in an acute tooth, inferior margins inermis. Small chela 4.0 times as long as broad, fingers 0.38 the total length. Carpus 0.6 as long as broad, with superodistal margins armed with acute tooth.

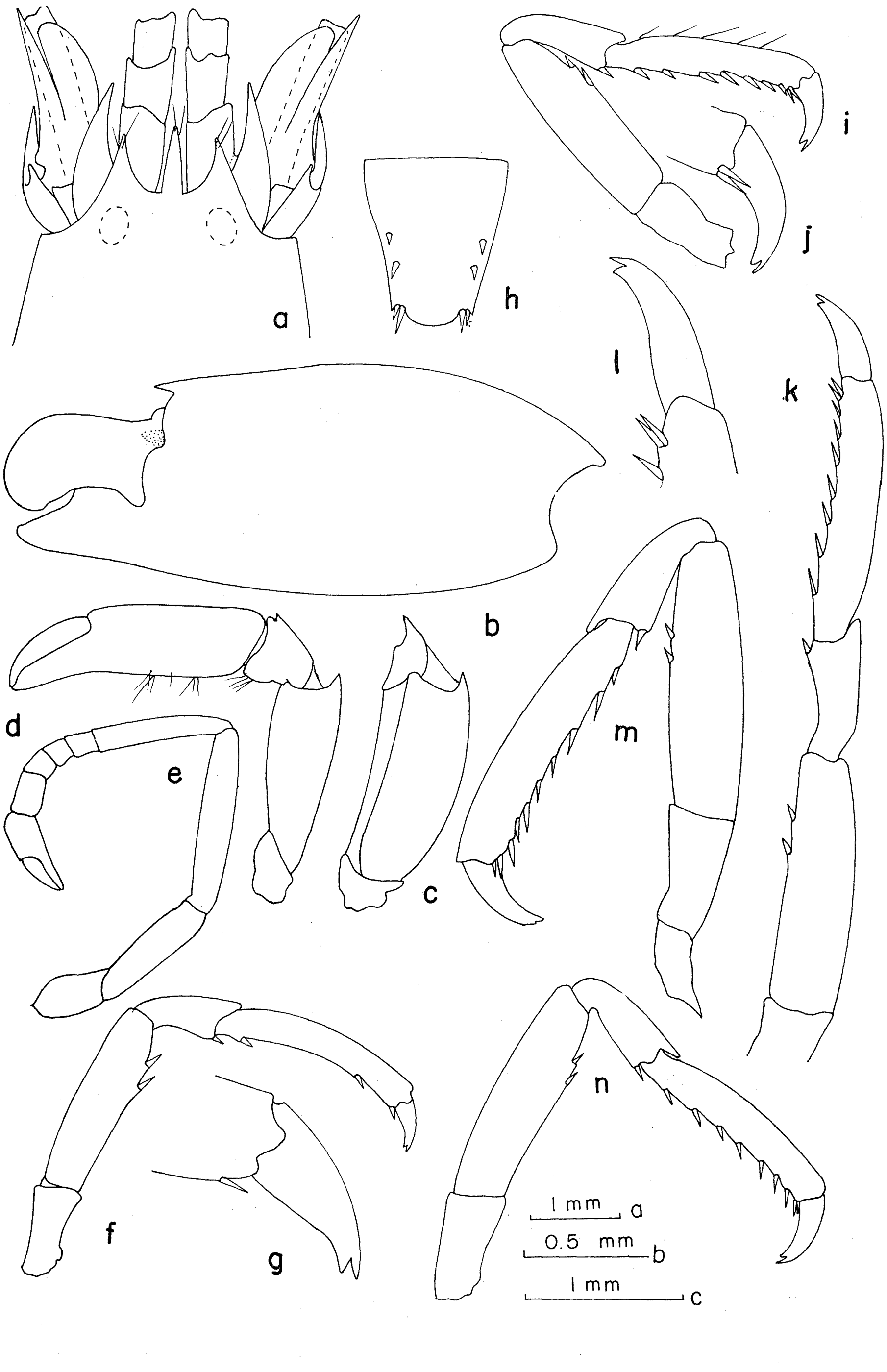
Carpal articles of the second leg with a ratio: 10:1:1:1:3; third article about as long as broad.

Merus of third leg four times as long as broad, bearing two short strong spines on distal half, but distal margins unarmed. Carpus 0.4 as long as merus, distosuperior margin terminating in obtuse projection, distoinferior margin with spine. Propodus distinctly curved, bearing one spine proximally and one at about three-quarters length along inferior margin; one distal spine. Dactylus one-fourth as long as propodus, unguis about one-eighth as long as entire dactyl; inferior unguis thicker at base and a little shorter than superior unguis.

Telson 2 times as long as wide, posterolateral angles slightly projecting and acute.

OPPOSITE

Fig. 24.—*Synalpheus pococki* Coutière and *Synalpheus iocosta* De Man. *Synalpheus pococki*: 11 mm male from AM 67; a, Anterior region, dorsal view; b, c, large chela and merus, inner face; d, small cheliped; e, second leg; f, g, third leg and enlarged dactylus; h, telson. *Synalpheus iocosta*, 14 mm male from AM 13: i, j, third leg and dactylus. 13 mm female from WM 94–65: k, 1, third leg and dactylus. 13 mm female from WM 290–65: m, third leg. Superior unguis. In reduction the roughness where the unguis was attached no longer may be seen. 12 mm female from WM 69-65: n, third leg. a, b, c, d, e, f, h, scale a; g, j, l, scale b; i, k, m, n, scale c.


a
b
c
d
e
f
g
h
i
j
k
l
m
n
1 mm a
0.5 mm b
1 mm c

Discussion: The only difference between this species and *S. iocosta* De Man is the nature of the third leg (*see below*). Our specimen agrees well with Coutière's original description as well as De Man's specimen from Indonesia.

Biological notes: Our specimen was taken from a "growth on a pearl shell", and that of De Man's was captured in a dredge at 13 metres. Coutière did not make any remarks about possible habitats of his specimens, but his specimens from Albany Passage were dredged at 10 fathoms. We suggest that the unique propodus of this species may be an adaptation for a special environment, similar to the hooked dactylus of the small chela of *S. comatularum,* and the strange ungui of the third legs of *S. charon*; however, no available data suggests what this habitat might be.

Australian distribution: Darwin, Arafura Sea and Torres Straits.

General distribution: De Man's specimen from the east coast of Aru Islands in Indonesia is the only record from other than Australia.

Synalpheus iocosta

De Man

Fig. 24 i–n

Synalpheus iocosta De Man, 1909a, Tijdschr. ned. dierk. Vereen. II, 11 (2): 119; 1911 Siboga Exped. 39a[1] (2): 235, fig. 33.

Specimens examined: 1 specimen from AM 13; 1 specimen each from CS 19, 20, 21; 1, WM 69–65; 1, WM 94–65; 1, WM 290–65.

Discussion: As this species is almost exactly the same as *S. pococki* Coutière (p. 366) except in the propodus of the third leg we are not offering a separate description. In the propodi, that of *S. pococki* is distinctly curved, more curved than any other synalpheid, and bears but three spines while in this species it is almost straight and bears 7–8 spines along the inferior margin. We have pictured the legs from four specimens and show how consistent they are in proportion and armature. De Man in his original description of this species, with a series of 42 specimens, points out that the dactylus of the third leg is longer, less heavy and has smaller ungui than in *S. pococki,* but that these characteristics are variable. Our specimens of the two species are in excellent agreement with the original descriptions. One might question the separation of the two species, but certainly nothing in the present collections nor from those previously reported would indicate that the separation of the species is other than valid.

Biological notes: This species has only been collected in dredges from many types of bottoms in water up to 72 fathoms. The three specimens dredged from Cockburn Sound were found associated with sponges and bryozoans. Our specimens ranged from 9–12 mm in length.

Australian distribution: From Cape Naturaliste to Carnarvon in Western Australia and one specimen from the Gulf of Carpentaria.

General distribution: This species has not been reported since De Man's original specimens from the Aru Islands.

Synalpheus charon (Heller)

Fig. 25

Alpheus charon Heller, 1861, Sbr. Akad. Wiss. Wien 44 (1): 272, pl. 3, fig. 21, 22; 1865, Reise Novara Crust. 2 (3): 107. Paulson, 1874, Invest. Red Sea Crust., 1: 104, pl. 8, fig. 4.

Synalpheus charon De Man, 1911. Siboga Exped. 39a[1] (2): 245, figs. 37. Banner, 1953, Pacif. Sci. 7 (1): 37, fig. 11. Banner & Banner, 1967, Bishop Mus. Occ. Pap. 23 (12): 262.

Synalpheus charon charon Banner, 1956, Pacif. Sci. 10 (3): 331.

Synalpheus charon obscurus Banner, 1956, Pacif. Sci. 10 (3): 329, fig. 5.

Synalpheus prolificus Bate, 1888, Challenger Rept. 24: 556, pl. 99, fig. 4.

Synalpheus helleri De Man, 1911, Siboga Exped. 39a[1] (2): 245, fig. 37.

Additional Australia Records: Patton, 1966, Crustaceana 10 (3): 281, 289. Willis, I., Coral Sea and Wistari Reef, Queensland.

Specimens examined: 1 specimen from AM 123; 1, BAU 33.

Diagnosis: Rostrum with margins of proximal section usually parallel, distal section forming an acute triangle, not reaching to end of visible part of first antennular article. Orbital teeth acute, a little shorter and much broader at base than rostrum. Rostral base with orbitorostral process.

Antennular peduncles stout, articles subequal. Stylocerite reaching slightly past middle of second antennular article. Squamous portion of scaphocerite reaching end of antennular peduncle, lateral spine longer, reaching to end of carpocerite which is at least half the length of the third article past that article. Carpocerite 3.5 times as long as broad. Inferior spine of basicerite not quite as long as stylocerite, superior margin rounded.

Large chela 2.6 times as long as broad, fingers occupying the distal third; slight protrusion above dactylar articulation. Merus 2.3 times as long as broad; superodistal margin terminating in acute tooth, distal ends of inferior margins inermous. Small chela almost three times as long as wide, finger 0.4 of total length. Merus 2.3 times as long as broad, superodistal margin terminating in small acute tooth.

Carpal articles of the second leg with a ratio 10:1.7:1.7:1.7:5. First article as long as four following; second to fourth article broader than long.

Merus of third leg inermis, three times as long as broad, carpus 0.4 as long as merus with superior margin projecting as tooth, inferior bearing heavy spine. Propodus 0.8 as long as merus, bearing on its inferior margin 3–4 short heavy spines, with a pair distally. Dactylus stout, ungui about a third of total length. Inferior unguis obtuse, only slightly curved, inferior surface with excavate "pocket". Superior unguis thin and composed of an acute tip and a lateral flange. (*See* Banner, 1956, fig. 5.)

Telson as usual for *Synalpheus*, 2.3 times as long as posterior margin is broad; distolateral margins not projecting, nor acute. Posterior margin arcuate. Anterior pair of dorsal spines located in the middle.

Discussion: This species is readily recognized by the dactyli of the thoracic legs which have the heavy inferior unguis with the pocket-like cavity in the lower side and the smaller acute upper unguis with the lateral flange. No other species of the genus *Synalpheus* bears a similar dactylus.

The great variation in the rostral front has lead to the separation of one new species and one new subspecies, *S. helleri* De Man and *S. charon obscurus* Banner. We placed these in synonymy in 1967 (Banner & Banner, 1967: 262). We have figured the rostral front of both of our specimens because they show the range of variation (figs 25 a and h). The rostrum in the specimen from AM 123 is of the type with the straight proximal portion which was considered as characteristic of *S. helleri* and *S. charon obscurus*. The rostrum of the specimen from BAU 33 is the more typical.

The review of the Hawaiian alpheids (Banner, 1953) discussed *S. prolificus* (Bate), known only from a single specimen from "Off Honolulu, Sandwich Islands". We suggested that if the ungui of the third legs were similar to *S. charon,* then the two species were closely related. However, we remarked that "the nature of the second legs and of the stylocerite would be valid characteristics for the separation of the two species". The British Museum (Natural History) afforded us the opportunity to re-examine the type specimen of Bate's species. None of the supposed differences between *S. prolificus* and *S. charon* are valid. The rostrum is of the type with parallel sides proximally; the stylocerite reaches the middle of the second antennular article; the first carpal article of the second legs is only slightly longer than the sum of the four following, therefore within the range of variation; and, most important, the ungui of the dactyli of the third legs have development characteristic of *S. charon*. *S. prolificus*, a species unreported since it was described in 1888, is plainly a synonym of *S. charon*. We have added figures of Bates's holotype to our figures of Australian specimens.

Biological notes: This species appears to live largely, if not entirely, on living coral. It has been commonly collected from heads of *Pocillopora meandrina* Verrill in association with *Alpheus lottini* Guérin, and crabs of the genus *Trapezia* (Banner, 1953: 38). All three crustaceans are orange-red in colour. In Australia it has also been found in *Stylophora pistillata* (Esper) and *Seriatopora* sp. (Patton, 1966). The specimen from BAU 33 was taken from a living *Porites* sp. In non-Australian waters, it has been collected from dead coral heads in shallow water and Bate's specimen was dredged from 33 metres. The Australian specimens are small, 10–13 mm in length, but it has been reported up to 22 mm in length.

Australian distribution: Heron Island and Wistari Reef in the Capricorn Group, Rudder Reef, off Port Douglas, and Willis I., Coral Sea.

General distribution: This species has been reported from the Red Sea to Mexico, and from Japan to the Great Barrier Reef. We have seen specimens in the American Museum of Natural History in New York from Ecuador and Columbia, South America.

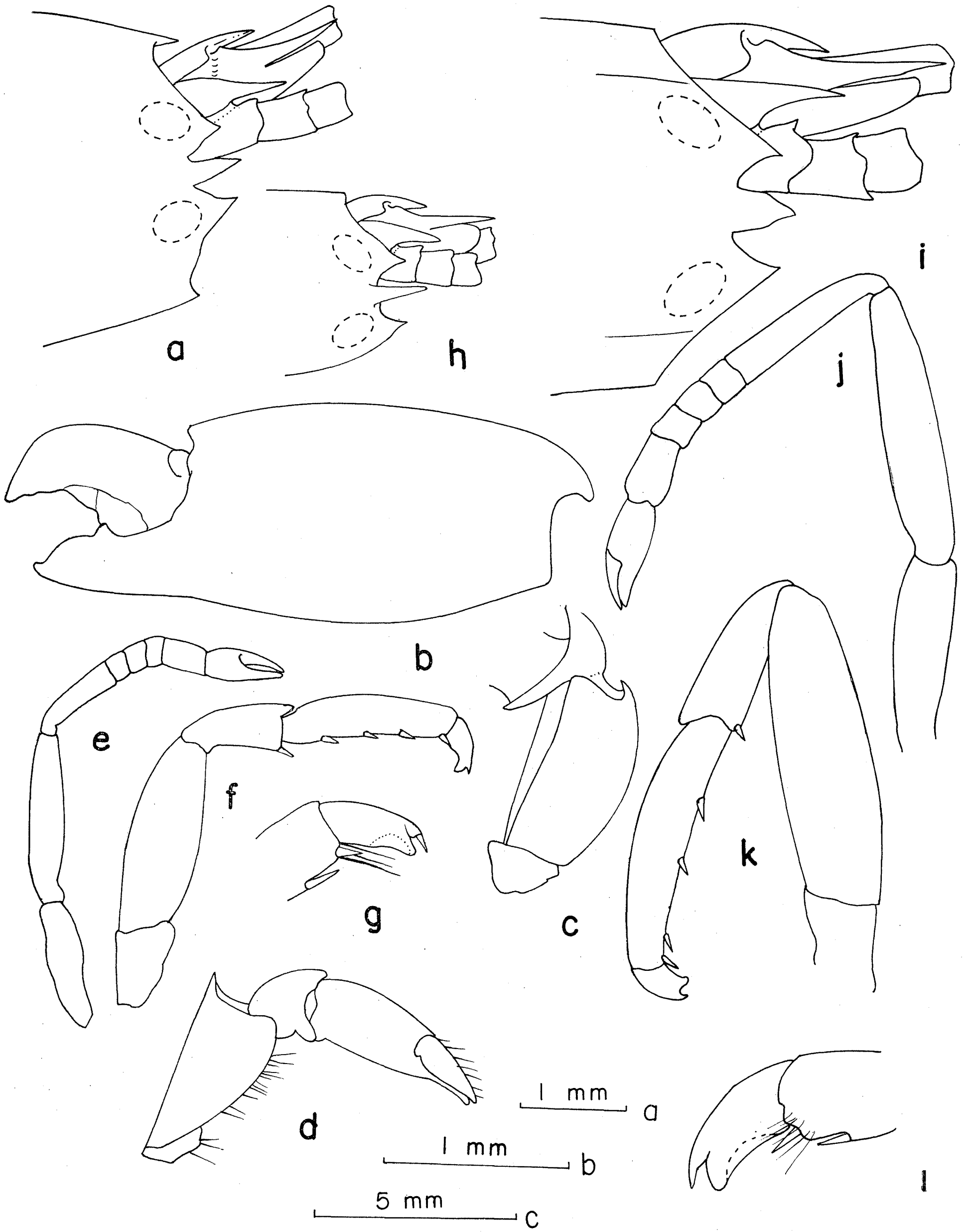


Fig. 25.—*Synalpheus charon* (Heller). 13 mm female from AM 123: a, anterior region, dorsal view; b, c, large chela and merus; d, small cheliped; e, second leg; f, g, third leg and dactylus. 10 mm female from BAU 33: h, anterior region, dorsal view. *Alpheus* (=*Synalpheus*) *prolificus* Bate, from "Off Honolulu". Holotype: i, anterior region, dorsal view; j, second leg; k, l, third leg and dactylus. a, b, c, d, e, f, h, j, k, scale a; g, l, scale b; i, scale c.

Synalpheus gracilirostris De Man

Fig. 26

Synalpheus gracilirostris De Man, 1910b. Tijdschr. ned. dierk. Vereen: 11 (4): 291; 1911, Siboga Exped. 39a[1] (2): 269, fig. 49.

Specimens examined: 1, 11 mm male from BAU 44.

Diagnosis: Rostrum awl-shaped, reaching to middle of second antennular article. Orbital teeth narrow and acute, reaching to middle of visible part of first antennular article. Rostral base with orbitorostral process.

Visible part of first antennular article 1.5 times longer than second, second and third articles equal. Second antennular article as broad as long. Stylocerite reaching to last quarter of second antennular article. Squamous portion of scaphocerite narrow, reaching to end of third antennular article, lateral spine much longer reaching about length of third article past that article. Carpocerite 4.0 times as long as broad, reaching about half way from end of third article to end of squame. Basicerite with inferior spine as long as stylocerite, superior spine acute and prominent.

Large chela 2.8 times as long as wide with fingers one-third total length, with acute tooth above dactylar articulation. Merus 2.7 times as long as broad, superior margin terminating in an acute tooth, other margins inermous. Small chela three times as long as broad, fingers shorter than palm. Carpus cup-shaped, 0.2 as long as chela, merus similar to that of large chela.

Carpal articles of second leg with a ratio: 10:1:1:1:5.

Merus of third leg five times as long as broad. Carpus 0.5 as long as merus, with superior margin terminating in an obtuse tooth, inferior margin terminating in a heavy spine. Propodus as long as merus and bearing on inferior margin seven spines and a pair distally. Dactylus biunguiculate, superior unguis a little longer but equal in thickness at base to inferior unguis.

Telson 2.6 times as long as posterior margin is broad. Posterolateral angles slightly projecting and acute, about half as long as outer posterior spine.

Discussion: De Man based his description on two specimens. We have one specimen from Australia and two from Zamboanga, Philippines; the species has not otherwise been reported. Our three specimens are similar to each other, and differ from De Man's description in four ways: 1) the inferior spine of the basicerite is almost equal in length to the stylocerite instead of "much shorter than the stylocerite". 2) The superior spine of the basicerite of our specimen is prominent and acute while De Man states "upper angle subacute, but not spiniform". 3) The anterior margin of the chela terminates in an acute tooth rather than a "small, rather obtuse tubercle". 4) The lateral angles of the telson in our specimens are more produced.

All four characteristics are known to be somewhat variable in the genus, but in combination, especially with the marked difference in the inferior spine of the basicerite, they may indicate a new species. However, with a total of five specimens known and with variability so common among many species of synalpheids, we are deferring the application of a new name.

Biological notes: De Man's specimens were dredged from 54 metres, but our three specimens have come from dead coral in waters up to 2 metres deep. It is a small species with none of the known specimens longer than 11 mm.

Australian distribution: Our specimen came from Hayman Island in the Whitsunday Group, Queensland.

General distribution: Timor in Indonesia; southern Philippines.*

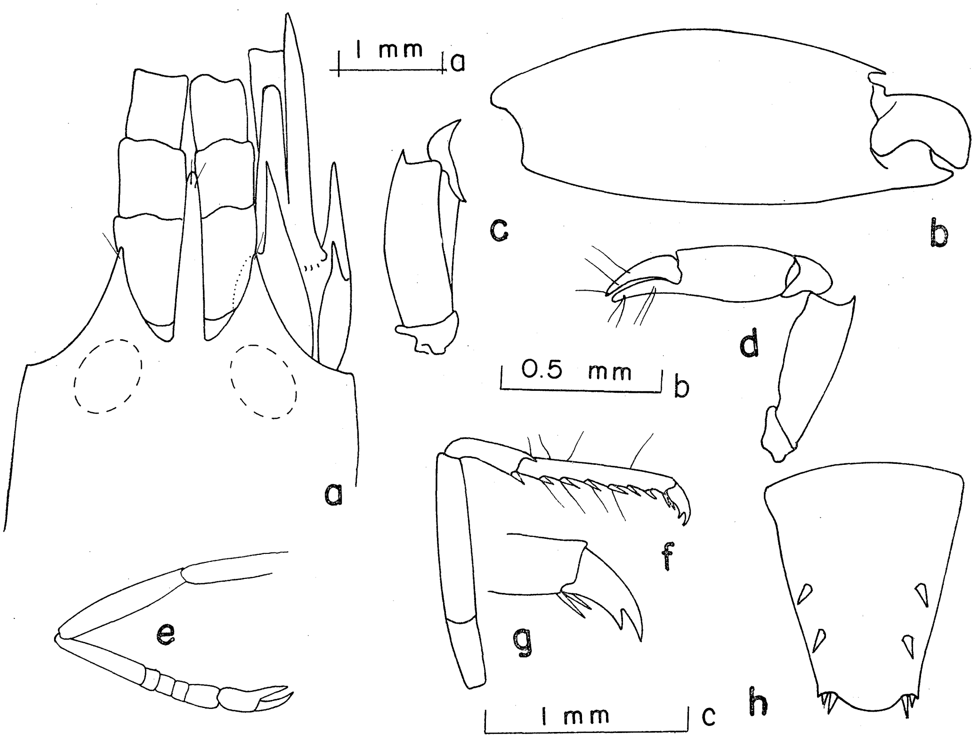


Fig. 26.—*Synalpheus gracilirostris* De Man. 11 mm male from BAU 44: a, anterior region, dorsal view; b, c, large chela and merus; d, small cheliped; e, second leg; f, g, third leg and enlargement of dactylus; h, telson. b, c, d, e, f, scale a; g, scale b; a, h, scale c.

Synalpheus echinus sp. nov.

Fig. 27

Holotype: 17 mm female from Trigg Island, near Perth, Western Australia, collected by W. H. Butler, 20/14/61 (WM 92–65).

Paratypes: 1, 14 mm incomplete female from same location as type; 1, 28 mm ovigerous female from Carnac Is. collected by E. P. Hodgkin (WM 51–65); 1, 17 mm male and 1 large mutilated female from Rottnest Is. (WM 12822/12823); 3 males and 3 females, 16–20 mm from Lancelin Is., (BAU 3 and BAU 4). All localities are near Perth, Western Australia.

Diagnosis: Rostrum narrow almost 3 times as long as broad at base, reaching to end of first antennular article. Orbital teeth also slender, but slightly more than half as long as rostrum; teeth divergent. Rostral base with orbitorostral process.

Visible part of first antennular article 1.7 times as long as second article; second and third article of same length. Stylocerite reaching to near middle of second antennular article. Squamous portion of scaphocerite narrow, as long as antennular peduncle, outer spine longer than carpocerite. Carpocerite subequal to antennular peduncle, 4.0 times as long as broad. Inferior spine of basicerite as long as stylocerite, superior spine reaching to level of tips of orbital teeth.

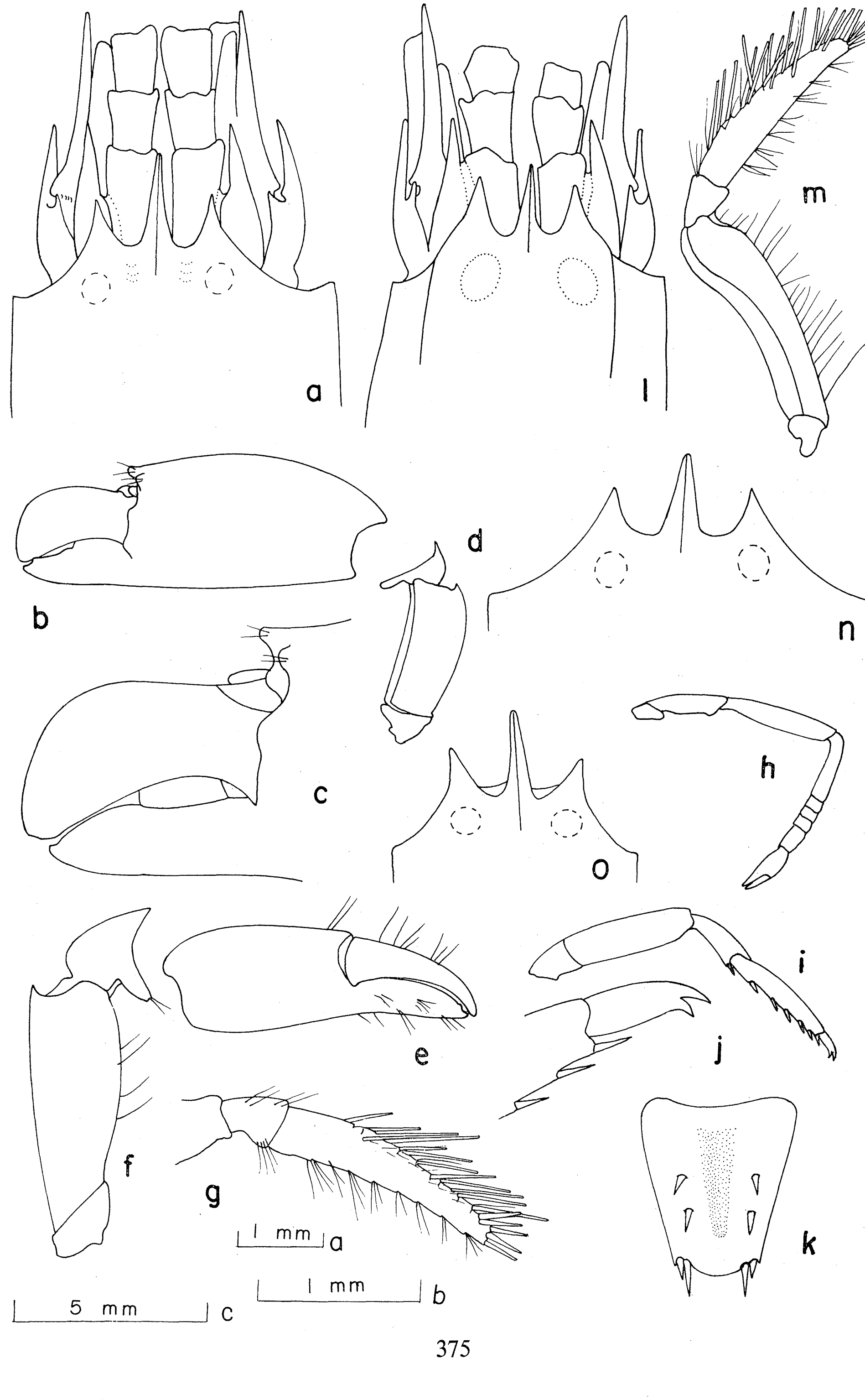
Distal article of third maxilliped bearing on distal two-thirds of superomedial face an armature of 10–20 strong but elongate spines with blunt or acute tips (the spines with blunt tips may represent longer spines that have been broken). Tip of article carrying a circlet of five spines, shorter and heavier than those of face.

Large chela stout, 2.8 times as long as broad, fingers occupying the distal third. Margin of palm above dactylar articulation terminating in two rounded projections, the superior larger. Merus 2.6 times as long as broad, fingers a little shorter than palm; fingers with random setae only; tips of both dactyl and pollex bearing two low cusps. Merus 2.7 times as long as broad, distosuperior margin bearing triangular tooth.

Carpal article of second leg with a ratio: 10:2.0:1.5:1.5:4.0, middle articles broader than long.

OPPOSITE

Fig. 27.—*Synalpheus echinus* sp. nov. Holotype, 17 mm female from WM 92-65: a, anterior region, dorsal view; b, c, large chela and enlargement of distal section; d, merus large chela; e, f, small chela, merus and carpus; g, distal article of third maxilliped of holotype, lateral view (setae on medial face omitted); h, second leg; i, j, third leg and enlargement of dactyl; k, telson. Paratype, 17 mm male from BAU 44: l, anterior region, dorsal view; m, third maxilliped of specimen from BAU 4 (setae on medial face omitted). Paratype, 27 mm female from WM 51-56: n, anterior region, dorsal view. 14 mm female from BAU 4: o, anterior region of carapace, dorsal view. a, e, f, g, h, l, m, n, o, scale a; c, j, scale b; b, d, h, i, scale c.


a
l
m
b
d
n
c
h
o
e
i
j
f
g
k
1 mm a
1 mm b
5 mm c

Merus of third leg 3.7 times as long as broad, inermous. Carpus 0.4 as long as merus, superodistal margin extending as obtuse tooth, inferodistal margin terminating in strong spine. Propodus subequal in length to merus, bearing on its inferior margin five strong spines and a pair distally. Dactylus biunguiculate, ungui equally thick at bases, but with superior unguis a little longer than inferior. Apex between ungui "V"-shaped.

Telson 1.6 times as long as posterior margin is broad; posterolateral angles acute and projecting, but much shorter than adjacent spine. Dorsal surface of telson slightly concave along midline.

Discussion: If Coutière's groups are to be used, this species would probably best be placed in the Paulsoni Group.

As far as we can determine this species differs from all other species of *Synalpheus* in the armature of the third maxilliped. While most synalpheids have spines on the tip of the maxillipeds, they have short bristles or long hairs on the inner face, but this species has spines also on the inner face. Unfortunately, the maxillipeds are usually not mentioned in specific descriptions, so we cannot state conclusively that this is a unique characteristic in the genus. Certainly no condition like this was reported by Coutière in his thesis (1899: 171) or in any species description that we have seen; moreover, we have examined all those species in our collections and in the collections of the Smithsonian Institution and found no parallel development. The species has two other characteristics which, while not unique, are rare enough to be noteworthy: the narrowness of the rostrum, and the shortness of the carpocerite. The plate illustrates some of the differences we have noted in the development of the rostral front.

The specific name is from the Greek *echinos* and refers to the spines on the maxillipeds. The holotype and four paratypes will be deposited at the Western Australian Museum. Six paratypes will be placed at the Australian Museum.

Biological notes: There are no notes in the collection which indicate any unique habitat; all came from coral heads from 3 metres or less deep; the specimen from Carnac Island came from "reef platform". The specimens range from 17–28 mm.

Australian distribution: All specimens in the collection came from near Perth, Western Australia.

Synalpheus tumidomanus (Paulson)

Fig. 28

Alpheus tumidomanus Paulson, 1875, Invest. Crust. Red Sea (1): 101, pl. 13, fig. 2.

Synalpheus tumidomanus Coutière, 1905a, Fauna and Geog. Mald. and Laccad. 2 (4): 876, pl. 73, fig. 14; 1909, Proc. U.S. natn. Mus. 36: 24, fig. 5. Banner & Banner, 1968, Micronesica 4 (2): 275.

Synalpheus tumidomanus exilimanus Coutière, 1909, Proc. U.S. natn. Mus. 36: 10 [note: the combination was proposed by Coutière without explanation, and the name "*exilimanus* Paulson" evidently was substituted in error for Paulson's *gracilimanus*, 1875: 102].

Synalpheus hululensis Coutière, 1908a. Bull. Soc. Philomath., Paris 11 (5): 202.

Synalpheus hululensis hululensis Crosnier & Forest, 1966, Rés. Sci. Camp. Calypso 27 (19): 297, fig. 30.

Synalpheus mac-cullochi Coutière, 1908a, Bull. Soc. Philomath., Paris IX, 11 (5): 203. Hale, 1927b, Trans. R. Soc. S. Aust. 51: 308.

Synalpheus theophane De Man, 1911, Siboga Exped. 39a[1] (2): 261, pl. 10, fig. 44.

Synalpheus anisocheir Stebbing, 1915, Ann. S. Afr. Mus. 15: 86, pl. 23. Barnard, 1950, Ann. S. Afr. Mus. 38: 736, figs 139 a–d.

Synalpheus japonicus Yokoya, 1936, Jap. J. Zool. 7: 133, fig. 3.

Nec. Synalpheus tumidomanus Kubo, 1940a, J. Imp. Fish. Inst., Tokyo 34 (1): 90, text fig. 11, 12 (= *S. hastilicrassus* Coutière).

Nec Synalpheus anisocheir Fourmanoir, 1958, Naturaliste malgache 10 (1–2): 116, fig. 4 (identity unknown).

Additional Australian Records: McNeill, 1968, Gt Barrier Reef Exped. Sci. Rep. 7 (1): 17. Low Isles.

Specimens examined: 3 specimens from AC 29; 1, AC 30; 2, AC 35; 4, AM 1; 1, AM 16; 1, AM, 31; 4, AM 35; 1, AM 60; 1, AM 65; 7, AM 75; 1, AM 101; 2, AM 115; 6, AM 122; 1, AM 131; 2, AM 158; 2, AM 187; 4, AM 189; 2, AM 210; 2, AM 220; 2, AM 251; 1, AM 253; 1, AM 255; 1, AM 256; 1, AM 264; 2, AM 273; 1, AM 305; 2, AM 396; 1, AME 4495; 14, AM P 858; 2, AM P 2149; 1, AM P 3956; 2, AM P 4837; 1, AM P 4863; 2, AM P 5491; 1, AM P 6308; 1, AM P 6353; 1, AM P 6488; 3, AM P 6527; 1, AM P 6825; 6, AM P 8266; 2, AM P 8701; 2, AM P 8970; 1, AM P 9072; 2, AM P 11187; 1, AM P 11272; 3, AM P 13562; 3, AM P 13565; 3, AM P 13582; 6, SMC 805; 17, VM 33; 17, VM 35; 1, WM 47–65; 1, WM 52–65; 3, 76–65; 3, WM 99–65; 2, WM 105–65; 3, WM 112–65; 2, WM 117–65; 1, WM 125–65; 4, WM 141–65; 1, WM 155–65; 3, WM 164–65; 11, WM 175–65; 2, WM 177–65; 8, WM 181–65; 2, WM 240–65; 4, WM 268–65; 3, WM 297–65; 1, WM 173–60.

Table 5. Variations in Synalpheus tumidomanus *(Paulson)*

Characteristic	*S. tumidomanus* (from Paulson's description and figures)	9 specimens from Torres Straits, BAU 27	27 specimens from around Australia
Length, rostrum to antennular articles	Approaching end of first	Three-fourths first to one-fourth second.	From one-half first to one-quarter second.
Length, orbital teeth to rostrum	0·7 length, (from plate)	From 0·5 to 0·8 length.	From 0·5 to 0·9 length.
Length, stylocerite to antennular articles	Middle of second	Middle to near end of second.	Middle to near end of second.
Length, squame to antennular articles	End of second (from plate)	Base to three-fourths length of third.	Base to end of third.
Length, lateral spine of scaphocerite to antennular articles.	End of third	Slightly shorter to slightly longer than third.	Slightly shorter to slightly longer than third.
Length, carpocerite to antennular articles	End of third	Surpasses by one-fourth to one-half length of third.	Surpasses by entire length of third.
Length/breadth ratio of carpocerite (viewed laterally).	5·2 (from plate)	4·5–6·0.	4·0–6·0.
Length, inferior tooth basicerite to antennular articles.	(Not clear from plate)	Three-fourths length to end first.	From three-fourths length first to middle second.
Superior tooth, basicerite	Short, acute	Acute angle, slightly projecting.	From rounded to projecting acute tooth.
Length/breadth ratio of large chela	2·7 (from plate)	2·5–2·8.	2·3–3·0.
Nature of protrusion above dactylus, large chela.	Strong, rounded	From no protrusion to acute tooth.	From no protrusion to acute tooth.
Length/breadth ratio of small chela	Not given	3·0–3·4.	2·7–3·4.
Second leg carpus, ratio of first article to 4 following.	First longer than sum of four following.	First article from slightly shorter to slightly longer than sum of four following.	First article from slightly shorter to slightly longer than sum of four following.
Length/breadth ratio of merus of third leg.	Not stated	4·0–4·8.	3·5–5·0.
Posterolateral angles of telson	Angular teeth half length of adjacent spines.	Acute angle only slightly projecting.	From almost a right angle to acute projecting teeth.

Diagnosis: Table V sets forth the major diagnostic characters of *S. tumidomanus* with three exceptions: 1. The rostral base has an orbitorostral process. 2. The meri of the large and small chela are characterized by an acute tooth on the distosuperior margin. 3. The biunguiculate dactyli of the third legs have the superior unguis a little longer and thicker at the base than the inferior, and the notch between the ungui is "V"-shaped, almost acute.

Discussion: The long and rather confused application of names to specimens of this species or species complex had been discussed originally by Coutière in several papers (1899, 1905, 1909), reviewed by De Man (1911), Holthuis (1952), Crosnier and Forest (1966), Banner & Banner (1968) and Miya (1972). The problem appears to resolve itself at this time to the consideration of the appropriate name for, and extent of variation in populations of, three possibly separate species found in three separate faunal realms: The Indo-Pacific, the tropical eastern Atlantic, and the tropical and subtropical eastern Pacific. Holthuis has discussed the eastern Pacific form and has applied the name *S. spinifrons* (H. Milne-Edwards) to the species that Coutière had once lumped under the name *S. tumidomanus* and later named *S. latastei*. Holthuis did not discuss *S. lockingtoni* which may be related. Crosnier and Forest, considering the tropical Atlantic specimens, established two subspecies of *S. hululensis* Coutière and established a lectotype for the parent species from Coutière's Maldive and Laccadive specimens. We, working with twenty-two specimens from the Marshall Islands and other central Pacific collections, pointed out the wide range of variation in characteristics previously considered to be of worth for specific identification and placed *S. hululensis* and *S. theophane* De Man in synonymy under *S. tumidomanus* (Banner & Banner, 1968: 275).

Because of the difficulties that have been found in this group of nominal species, we have decided to use this large Australian collection to determine if our conclusions from the Marshall Islands were correct. We have augmented the study with a collection of twenty specimens from the Red Sea, Paulson's type locality. However, as we have no specimens from either the Atlantic or eastern Pacific, we do not extend our conclusions to the species complexes of these other realms.

In our 1968 paper, we reported on the variation in six characteristics. Here we have considered 15 characteristics and selected nine specimens each from New South Wales, northern Australia, West Australia and southern Australia. The nine specimens from northern Australia were taken from a single collection from the Torres Straits to determine variation within a limited population; the others were to determine if there were enough differences in geographically separated populations to warrant their consideration as subspecies. The results are given in Table V.

The specimens from the Red Sea conformed well to Paulson's description in all points and did not show variation as great as did the specimens from Australia. Most had a strong superior tooth on the basicerite above the dactylar articulation of the large chela, and relatively strong posterolateral teeth on the telson. However, in this small collection variation was noted—for example, the posterolateral teeth on the telson varied from as long as Paulson depicted to as short as the longest from Australia. Thus, we believe that the population in the Red Sea shows the potential of variation we are reporting, but the variation is more muted.

These results confirm our earlier opinion that the species is very variable, and that *S. hululensis* is a synonym of *S. tumidomanus*. The variation easily encompasses the lectotype established for *S. hululensis hululensis* by Crosnier and Forest. We will leave to those authors the decision on the best way to treat their two Atlantic subspecies, whether they should be continued as subspecies of *S. tumidomanus* or raised to specific rank. (We regret we were unable to refer to the important paper of Crosnier and Forest in our 1968 study, for we received our copy of their work when our paper was at the publisher in Japan.)

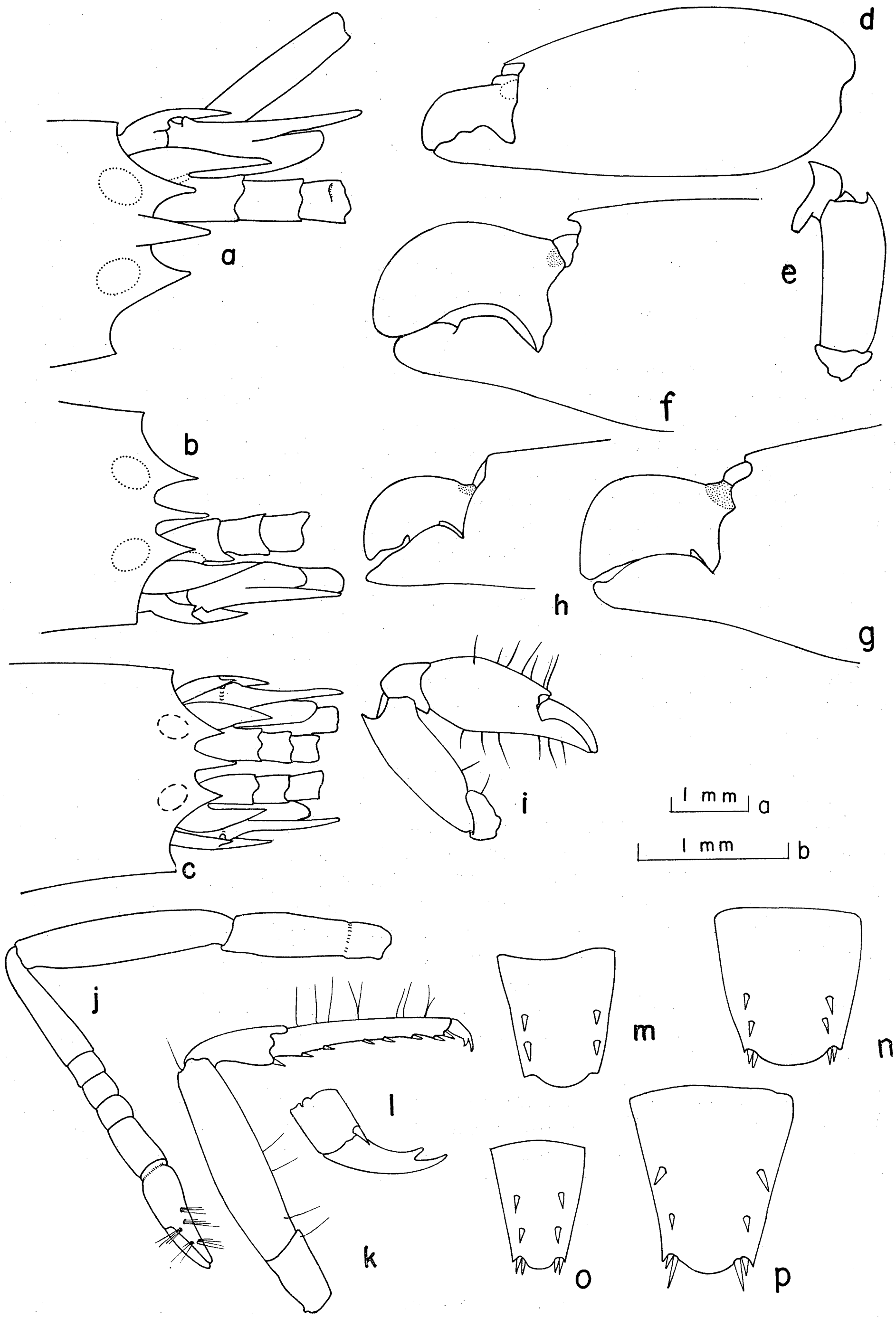
Two other nominal species should be considered. The first was described as *Synalpheus maccullochi* by Coutière from the coast of "S. W. Australia". This species was distinguished from *S. paulsoni* Nobili by having eggs of greater volume and from *S. tumidomanus* by the lack of strong tooth on the basicerite and the lack of teeth on the posterolateral angles of the telson. Through the courtesy of Mme. Laurent of the Muséum National d'Histoire Naturelle in Paris we were able to examine seventeen specimens from Australia that Coutière had identified as *S. maccullochi;* six came from the type locality, five came from Nelson's Bay, and six came from an unspecified area in South Australia. We have also examined six female specimens loaned to us by the South Australian Museum that Hale (1927b: 308) had reported as this species from Kangaroo Island, South Australia. All specimens fell within the range of variation we have discussed for *S. tumidomanus* and the species has been placed in synonymy to *S. tumidomanus*. We should also note that the use of egg size is not a good criterion for species separation, for as Brooks and Herrick (1891: 377) first noted, poecilogony exists in the Alpheidae, and as we point out (1968: 277) the eggs grow both larger and more elongate as the embyro matures. We observed this difference in both Coutière's specimens and in Hale's; in the latter of the five ovigerous females, two specimens had conspicuously larger eggs and in those eggs the eyespots were large and dark.

The other species is *S. anisocheir* Stebbing (1915: 86) from South Africa. Barnard (1950: 736) suggested that it was closely related to *S. hululensis*. We could find no characteristics in the descriptions or figures that would separate this species from the range of variation that we had found for *S. tumidomanus*. The two characteristics somewhat emphasized by Stebbing (he compared his species to no other) were the disproportionate sizes of the large and small chelae and the proportions of the articles of the second leg. These cannot be used to distinguish his form from *S. tumidomanus*. Barnard (1950: 736) described and drew the orbitorostral process "Rostrum with ventral prolongation (fig. 139e)" as a specific characteristic; we have compared his description to the process in our specimens and found them to be similar, if not identical (Banner & Banner, in preparation).

On the basis of the figures given by Fourmanoir of specimens he identified as *S. anisocheir,* we cannot determine the species he was studying, but the form of the orbital teeth and chela indicate it may be in the genus *Alpheus* which precludes the possibility that it is *S. tumidomanus*.

OPPOSITE

Fig. 28.—*Synalpheus tumidomanus* (Paulson). Variation in specimens from Australia. a, b, c, anterior region of carapace; d, e, f, g, h, large chelae (d and e same specimen); i, small cheliped; j, second leg; k, l, third leg and dactylus; n, m, o, p, telsons. a, b, c, d, e, f, g, h, i, j, k, m, n, o, scale a; l, p., scale b.



a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
1 mm a
1 mm b

Upon studying specimens of *S. tumidomanus* in Japan, Miya (1972: 65) reached the conclusion that *S. japonicus* was also a synonym; he further accepts the variation we had described in 1968 as applying to the Japanese specimens.

Biological notes: Our specimens have been collected from the intertidal zone to waters up to slightly over 81 fathoms deep, from the heads of dead coral and from sponges. Our specimens ranged in size from 10–25 mm.

Australian distribution: *S. tumidomanus* has been found off all shores of Australia and at Norfolk Island and Lord Howe Island, Tasman Sea.

General distribution: In the Indo-Pacific the species is known (under various names) from South Africa; Red Sea; Persian Gulf; Ceylon; Maldive Archipelago; Singapore; Thailand; Indonesia; Philippines*; Japan and across the central Pacific to the Phoenix Archipelago. It has also been found on the Mediterranean coast of Israel. Whether it or closely related species occur in the Atlantic and eastern Pacific remains to be determined.

Synalpheus paraneomeris Coutière

Fig. 29

Synalpheus paraneomeris Coutière, 1905a, Fauna and Geog. Mald. and Laccad. 2 (4): 872, pl. 71, fig. 7. Banner, 1953, Pacif. Sci. 7 (1): 40, fig. 13, 14; 1956, Pacif. Sci. 10 (3): 331, fig. 6.

Synalpheus paraneomeris halmaherensis De Man, 1909a, Tijdschr. ned. dierk. Vereen 11 (2): 122.

Synalpheus paraneomeris praedabundus De Man, 1909a, Tijdschr. ned. dierk. Vereen 11 (2): 123.

Synalpheus paraneomeris prolatus De Man, 1911, Siboga Exped. 39a[1] (2): 241 [*cf*. Banner 1953: 43].

Synalpheus paraneomeris prasalini Coutière, 1921, Trans. Linn. Soc. Lond. II, 17 (4): 415, pl. 61, fig. 6.

Synalpheus paraneomeris seychellensis Coutière, 1921, Trans. Linn. Soc. Lond. II, 17 (4): 415, pl. 61, fig. 7.

Synalpheus townsendi Coutière, 1909, Proc. U. S. natn. Mus. 36 (1659): 32 [*partim cf*. Banner, 1953: 44].

Specimens examined: 2 specimens from AM 214; 4, AM 326; 10, BAU 10; 3, BAU 11; 3, BAU 15; 3, BAU 16; 3, BAU 21; 1, BAU 29; 2, BAU 30; 2, BAU 31; 5, BAU 32; 3, BAU 33; 1, BAU 34; 3, BAU 47; 2, BAU 48; 10, BAU 55; 2, BAU 57; 2, BAU 58.

Diagnosis: Rostrum narrow and acute, reaching to near end of first antennular article. Orbital hoods triangular, acute to subacute, variable in length but not reaching beyond end of rostrum. Rostral base with orbitorostral process.

Second and third antennular article equal, slightly longer than broad; visible part of first article slightly longer. Stylocerite reaching from near base to near end of second antennular article. Lateral tooth of scaphocerite variable, longer than antennular peduncle; squamous portion variable in breadth and length, reaching to or beyond middle of third antennular article. Carpocerite usually 5.0 times as long as broad, reaching beyond end of third antennular article. Inferior spine of basicerite a little shorter than stylocerite, superior margin not produced.

Large chela subcylindrical, 2.6 times as long as broad, fingers occupying distal 0.3. Superodistal margin of palm at most slightly produced. Merus 3.0 times as long as broad, superior margin often produced into a small acute tooth. Small chela three times as long as broad, fingers shorter than palm, dactylus not broadened. Merus similar to that for large chela.

Carpal article of second legs with ratio: 10:1:1:1:3.

Merus of third legs four times as long as broad, unarmed. Carpus 0.4 as long as merus, distosuperior margin projected as tooth, inferodistal margin bearing spine. Propodus almost equal to merus, bearing 4–5 slender spines on inferior margin and two distally. Dactylus biunguiculate, with inferior tooth usually a little shorter and broader at base than superior unguis. Dactylus often slightly expanded with inferior margin convex proximal to inferior unguis, as if it were a vestige of a third unguis.

Telson 2.2 times as long as posterior margin is broad, posterolateral margin forms right angles or slight rounded projections, inner pair of posterolateral spines long and slender, over twice length of outer pair. Spinules on upper surface small and lying posterior to middle.

Discussion: Although Coutière in his original description remarked on the variation in some of the characteristics, he described two additional varieties and De Man described three varieties of the species. All were described on the basis of but few specimens. The junior author, first with 100 specimens from Hawaii (1953) and later with 90 specimens from the Marianas (1956) pointed out the wide range of variation found within the populations of this species and discarded the varietal names as they appeared to be merely designations of individuals within the normal span of variation. Collections studied later made no changes in this assessment. In his earliest paper, the junior author also reported that the single broken specimen that Coutière had reported from Hawaii as *S. townsendi*, an Atlantic species, appeared to be *S. paraneomeris*.

The Australian specimens also show similar variability in proportions and have several not previously remarked upon. Thus, some from Australia have a slight rounded projection above the dactylar articulation on the large chela, a characteristic not reported from Hawaii or the Marianas. Two characteristics, variable in other populations, appear to be more fixed in the Australian specimens: first, the superior margin of the meri of the large and small chelae always projected as a small acute tooth in the Australian specimens, but only occasionally did so in the Hawaiian specimens; second, the inner pair of spinules of the posterior margin of the telson was consistently much longer than the outer pair in the Australian specimens, while in other collections studied the inner pair at times was only slightly longer than the outer pair.

Miya (1972: 54) pointed out that in the Japanese specimens of *S. paraneomeris* the posterolateral corners of the telson were spiniform; a characteristic we have not observed in our collections. Further, his specimens do not appear to have the inferior margin of the dactylus of the third legs slightly convex proximal to the inferior unguis. Perhaps this may indicate a geographically isolated subspecies.

Biological notes: All the Australian specimens were taken from dead coral heads in water up to 15 ft, except for two specimens that were taken by trawl at 11 fathoms. The deepest record for the species was the one identified by Coutière as *S. townsendi,* taken by trawl in Hawaii at 69 fathoms; however, as it was without major thoracic appendages, its identification was not certain.

Banner reported (1953: 41) "Colour typically olive brown to grey, but those living in heads of *Pocillipora meandrina* reddish". Yaldwyn in field notes (AM 326) stated "Body and appendages greenish, transparent with scattering of small red chromatophores. Eyes black; tips of fingers green and eggs green". Our specimens ranged from 7–15 mm in length, most specimens being around 10 mm.

Australian distribution: All Australian specimens were collected from north eastern Australia and the Great Barrier Reef from near Cairns southward to off Cape Moreton, near Brisbane.

General distribution: Maldive Archipelago; Indonesia; Japan; Philippines*; Mariana; Caroline; Marshall; Gilbert; Fiji; Samoa; Line and Hawaiian Islands. The species was not found in our Malayo-Thai collections.

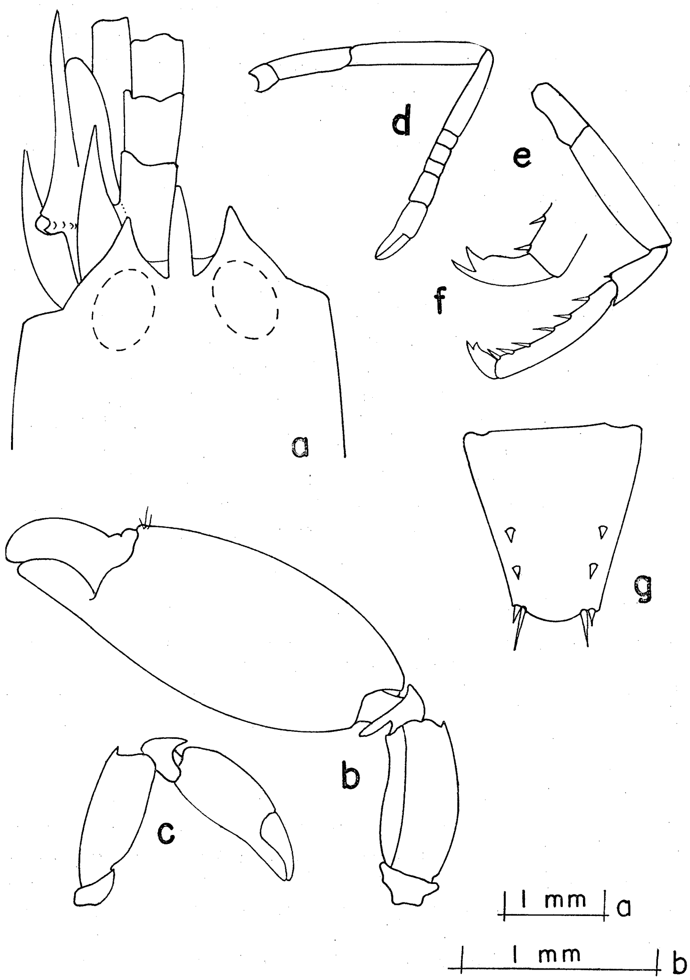


Fig. 29.—*Synalpheus paraneomeris* Coutiere. 10 mm female from BAU 55. a, anterior region, dorsal view; b, large cheliped; c, small cheliped; d, second leg; e, f, third leg and enlarged dactylus; g, telson. b, c, d, e, scale a; a, f, g, scale b.

APPENDIX

Alpheids Associated with Crinoids

A number of species of alpheids, mostly synalpheids of the Comatularum group, are known to live upon the comatulid crinoids or feather stars. Some appear to be obligate symbionts; others appear to prefer the symbiotic association but may live freely; some appear to be on the crinoids by a matter of chance. As we have remarked in the Introduction (p. 277) we suspect that collection data may not show the true association, for the shrimp may be dislodged from the crinoid in the collecting, particularly in the hauling of a dredge. In some cases the collector may have even separated the shrimp from the host without noting the association in his locality notes.

The following Australian species are known to be associated with crinoids (for synonymy, see main text):

Athanas indicus (Coutière)

Synalpheus comatularum (Haswell)

Synalpheus stimpsoni (De Man)

Synalpheus carinatus (De Man)

Synalpheus demani Borradaile

In addition the Australian *S. tropidodactylus* which is morphologically closely associated with the first three species of *Synalpheus* may also be associated with crinoids, for the only two specimens known were collected by dredging and may have been dislodged from a crinoid in the process. Of the non-Australian members of the specialized Comatularum group, *S. odontophorus* was reported originally by De Man (1911: 208) from Indonesia and later by Miya (1972: 51) from Japan in dredge hauls without any indication of symbiotic associations; however we have specimens yet unreported, from the South China Sea which came from crinoids. Thus in the Comatularum group of Coutière, five of the six presently recognized species are definitely, or may be, associated with crinoids. The sixth species of the group, *S. albatrossi* Coutière, probably is not in such an association for it is known only from the Hawaiian Archipelago where shallow-water crinoids do not occur.

Of the two species reported from crinoids not in the Comatularum group, *Athanas indicus* (Coutière) and *Synalpheus demani*, little can be said. *Athanas indicus* is normally associated with echinoids (see Part I, p. 329), but a specimen collected from Swains Reefs (AM 392) was reported to be taken from a crinoid. *Synalpheus demani* in Australian waters is known only from dredge hauls, but we (Banner & Banner 1968: 274) have reported it from crinoids in the Marshall Islands. Miya (1972: 62) has recorded that all of his Japanese specimens "were living in association with *Comanthina schlegeli* (Carpenter)".

It should be noted that Johnson (1962a: 49) lists *Athanas jedanensis* De Man, *Synalpheus acanthitelsonis* Coutière, *Synalpheus quadrispinosus* De Man, and *Alpheus paralcyone* Coutière as occurring in "crinoid grounds" and he suggests they may be symbionts upon the echinoderms; these species have not elsewhere been so reported. Finally a specimen of *Alpheus edwardsi* (Audouin) was reported by C. Smalley (CS 31) as being upon a crinoid in Western Australia; we have not considered it here because obviously this is not the normal habitat for this well-known and often-collected species.

A number of authors have remarked on the association of the shrimp with the crinoids, most especially Potts (1915a, b) working in Torres Straits, and A. H. Clark (1921) who not only reviewed all previous reports, but also added his own personal observations. Most of the observations were limited to *S. stimpsoni* (named by Potts *S. brucei*) and *S. comatularum*. According to Clark the shrimp are "semiparasitic commensals" which have "to a greater or less extent adopted the sucking up of food particles from the streams flowing down the ambulacral grooves of the crinoids to the mouth." Potts pointed out that the shrimp are afforded protection from predators by the crinoid which folds its arms over the disc—and the shrimp—when disturbed. Clark stated that the most heavily infested family of the crinoids are the large and shallow water comastreids of the Indo-Pacific, which, unlike many other families of crinoids, lack plates and spines to cover the ambulacral grooves and thus protect their food supply.

While Potts was primarily concerned with color patterns, he had other observations on the biology of the shrimp (1915a): They live as mated pairs, normally on the disc facing towards the mouth. When disturbed they take refuge on the underside of the arms. They resist displacement by digging into the flesh of the host with the hook-shaped dactylus of the small chela of *S. comatularum* and by the sharp, curved biunguiculate dactyli of the third to fifth thoracic legs of *S. stimpsoni*. When displaced, they will attempt to return immediately to their host, but if it is not available, they will shun light and approach any other objects, whether living subjects or not. If a group of them are kept in a glass dish, all will cling together. Potts also remarked on zonation in the Torres Straits, with *S. stimpsoni* occupying the upper zone in the reef and *S. comatularum* being dominant below 5 fathoms. (We have records of the latter species being collected intertidally.)

Potts pointed out that both species inhabit two species of crinoids, *Comanthus timorensis* and *Comatula purpurea;* the former crinoid species is extremely variable in color, ranging from pale green through banded to a dark green; the latter species is red. Potts observed that the shrimp had bright red and dark purple, almost black, chromatophores, and that (presumably by contraction of the chromatophores) the shrimp could become almost transparent. In almost all cases the color of the shrimp on any individual crinoid was adjusted to blend completely with the color of the host, usually in the form of pigmented longitudinal stripes against the transparent, or white, background. In a few cases he observed contrasting coloration which he interpreted to be that of a new arrival from a crinoid of a different color. He remarked that in his preservative mixture of formalin and glycerine, the purple pigment dissolved, but the red color remained fixed in the specimens. Clark gave other similar examples of protective coloration.

Key to the species of alpheids known to live on or or suspected of living on crinoids as symbionts

1. Eyes dorsally and laterally exposed .... *Athanas indicus* (pt. 1, p. 327)

— Eyes covered by orbital hoods...................... (*Synalpheus*)

2. (1) Dactylus of third leg biunguiculate; without orbitorostral process.... 3

— Dactylus of third leg triunguiculate; with orbitorostral process...... .... *S. demani* (p. 324)

3. (2) Distoinferior margin of third leg with tooth 4

— Distoinferior margin of third leg inermous 6

4. (3) Dactylus of small chela crescentric, strongly hooked .... *S. comatularum* (p. 289)

— Dactylus of small chela straight 5

5. (4) Fixed finger of large chela bearing strong, flat tooth on medial side.... .... *S. odontophorus*

— Fixed finger of large chela with medial edge rounded, not projecting.. .... *S. stimpsoni* (p. 292)

6. (3) Rostral carina strong and continued almost to posterior end of carapace .... *S. carinatus* (p. 283)

— Rostral carina slight and terminating anterior to eyes .... *S. tropidodactylus* (p. 286)

Note: We recently were loaned a specimen of *Synalpheus* from a crinoid collected near Lizard Island, Queensland that is apparently new. We plan to describe it in Part III of this study.