

The genus stands in the closest possible relationship to *Hymenopenaeus*, and parallels it in a curious manner in certain diversities of structure; thus, as in *Hymenopenaeus*, the orbital angle is in some species of *Solenocera* imperceptible, in others strong and dentiform; a notch in the cervical carina above the hepatic spine is in some species present or even dentiform, in others absent; either pterygostomial or branchiostegal spine may be present, or both may be absent.

A number of characters occurring in some species of *Hymenopenaeus* seem never to appear in *Solenocera*; thus branchiostegal and pterygostomial spine are never simultaneously present in the latter; there are no post-cervical mid-dorsal teeth on the carapace; and except in the doubtful form *S. maldivensis* described by Borradaile, 1910, there are no ventral rostral teeth; the branchiostegal carina is always marginal, the portion of the carapace ventral to it forming a membranous branchiostegite; the tooth of the externodistal margin of the uropodal exopod, when present, is terminal rather than lateral.

The channel-like nature of the antennular flagella of *Solenocera* is the only certainly diagnostic character upon which the generic separation is based. The additional differences between *Hymenopenaeus* and *Solenocera* noted by Smith, 1885, and Bouvier, 1908, that in the latter the terminal segment of the mandibular palp is broader than the basal one, is not universally applicable, the distal segment being reported to be narrower than the basal in *Solenocera comatus* Stebbing. In most species of *Solenocera*, contrary to the usual condition in *Hymenopenaeus*, the exopod of the uropod completely lacks a tooth on its external distal margin, but a terminal tooth is figured for *Solenocera melanitho* DeMan. A difference which will probably prove not to be of diagnostic value has been observed in available material, where the seventh somite bears a gill much more minute and weakly branched than that of *Hymenopenaeus*.

The genus has been briefly reviewed by Burkenroad, 1934a, who, in the lack of sufficient material, was unable to determine whether the presence or absence of branchiostegal and pterygostomial spines indicated the boundaries of natural subdivisions within the genus. As a contribution to the clarification of synonymies undertaken in the preceding paper, it may be mentioned that Bate's confusion of *Hymenopenaeus aequalis* with *Solenocera crassicornis* H. Milne Edwards, in 1881, seems good indication that the latter possessed a pterygostomial rather than a branchiostegal spine; but that the type of *S. crassicornis*, which, on enquiry, can not be located at the Paris Museum, was evidently destroyed subsequent to Bate's visit, in the course of morphological investigations by Mocquard, 1883.

In a freshly-caught specimen of *Solenocera vioscai*, the antennular flagella were observed to be prolonged beyond the abrupt constriction previously thought to terminate them, by a slender, segmented filament about one-eighth as long as the main part of the flagellum in the case of the superior ramus; shorter in the inferior. Search among the types of *Solenocera agassizii* Faxon revealed a

similar termination in an unmutilated specimen. These filaments are evidently equivalent to those described by Wood Mason and Alcock for *Solenocera* ("Parasolenocera") *annectens*. The figures of the tips of the antennulae of *S. jaxoni* by DeMan, 1911, seem to indicate that a similar filament has been broken off in the figured specimen. It seems possible that such terminal appendages may occur in all species of *Solenocera*; and the opinion expressed in a preceding paper (1934a), that the filamentous termination of the antennular flagella (upon which the separation of *Parasolenocera* Wood Mason and Alcock from *Solenocera* was chiefly based) represents a character of no generic significance, seems to stand confirmed by the present observation.

### ***Solenocera vioscai* Burkenroad**

*Solenocera vioscai*, Burkenroad, 1934a.

*Solenocera siphonocera*, Smith, 1886, part.

1 female, juvenile. Carapace length, 8.8 mm, rostrum 3 mm. *B.O.C.* 225. N. 29° 16', W. 87° 54' ("Atlantis" St. 2377), March 24, 1935. Trawl, 125 fathoms.

For comparison with the above, the smaller of the two cotypes (*B.O.C.* 130) has been obtained by exchange, through the great kindness of the American Museum of Natural History.

The previous records of the species are from considerably less than the present depth.

Like the Venezuelan juvenile mentioned in the description of *S. vioscai*, the present juvenile has only six instead of nine dorsal carapacic teeth, of which the anteriormost is far posterior to the tip of the rostrum. Also unlike the types, the posteriormost (epigastric) tooth is nearly half as far from the dorsal crossing of the cervical groove as from the orbital margin; and the second tooth is less than one-fifth the distance between cervical and orbit, instead of one-fourth. The orbital angle, although sharp, is not dentiform as in the adult. The carina posteriorly margining the anterior (ventral) part of the cervical groove extends farther ventrally, to the level of the pterygostomial spine, before turning forward. The pterygostomial is relatively longer than in the adult. The dorsal carina of the carapace is hardly perceptible behind the level of the cervical sulcus; likewise, the third pleonic tergum is uncarinated. The telson falls much shorter of the tip of the uropodal endopod; and its lateral teeth are relatively much longer than in the adult. The antennular flagella are slightly shorter and broader than in the types; the inferior flagellum is .6 mm in breadth, the superior .4 mm. The antennal scale is very much longer than in the adult, extending nearly one-sixth of its own length past the tip of the antennular peduncle. The breadth of the distal segment of the mandibular palp is nearly as great as the length of the basal segment, instead of considerably less as in the available cotype. The coxae of the fifth legs bear a strong spine

at their inner anterior margin (as in many species of *Hymenopenaeus*) which has disappeared in the adult.

The thelycum of the present juvenile very closely resembles that of the much larger types.

A comparison of *S. vioscai* with the types of the Pacific American *S. agassizi* reveals three diagnostic features not previously noted. These are:

(1) The epipodites of *S. vioscai* are at most mitten-shaped (like those of the Mediterranean *S. membranacea*), whereas the middle three epipods of *S. agassizi* are deeply furcate.

(2) The prolongation of the inner surface of the coxa of the fourth leg of *S. vioscai*, which abuts proximally against a sternal "stop," does not extend medially nearly to the midline, whereas that of *S. agassizi* is so produced as to overlap its fellow of the opposite side.

(3) The high longitudinal ridge of the thirteenth sternite of *S. vioscai*, which ends anteriorly in a strongly projecting tooth overlapping the posterior margin of the twelfth sternite (omitted from the previous description and figure) is unrepresented in *S. agassizi*, where this sternite completely lacks carination.

It may be noted that in adult females of both *S. membranacea* and *S. agassizi* the coxa of the fifth leg bears a tooth like that which is present in the juvenile of *S. vioscai*, but absent in the adult.

The coloration of the freshly captured, but dead, juvenile of *S. vioscai* was as follows: An unpatterned translucent pale orange-red over-all, chiefly produced by small chromatophores. Eyes deep reddish-brown with greenish reflections. Gastric gland brownish-grey with light yellow-green flecks; gut red (as seen through the overlying tissues).

#### **Solenocera** species

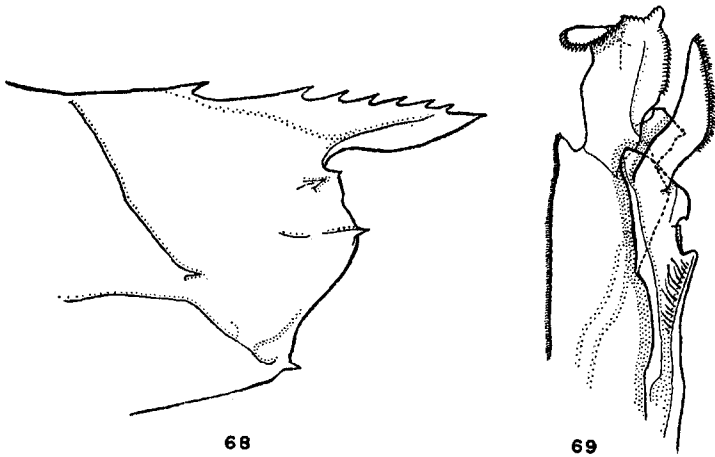
Figures 68 and 69, p. 124

? *Solenocera agassizi*, Faxon, 1893 and 1895.

1 male. Carapace 13 mm, rostrum 3.8 mm, total length 49 mm. *B.O.C. 132*, Pearl Islands, Gulf of Panama (8° 29' 40" N., 78° 52' 30" W.); March 31, 1926; trawl 19-24 fathoms.

The present specimen has been compared with the types of *S. agassizi*, from "Albatross" Station 3389 in the Gulf of Panama, which were made available through the great kindness of the Museum of Comparative Zoology. These specimens are of much larger size than is that of the Bingham Collection, the two males measuring 29 mm in carapace length, the females ranging from 23 to 40 mm. Since the present individual, despite its small size, is fully adult in sexual characters (joined petasomal endopods; well developed deferent apertures) and presents numerous differences from the types, it was at first

intended to describe it as a new species under the name *S. florea*, which is suggested for it in case further material indicates that two species of *Solenocera* actually do occur in Pacific America. However, the discovery that the juvenile female of *S. vioscai* considered in preceding paragraphs presents to a considerable degree the external characters of maturity (well developed oviduct apertures and sternal sculpture), and differs from the adults somewhat as does the present specimen from *S. agassizii*, has determined me to await further material before creating a new name.

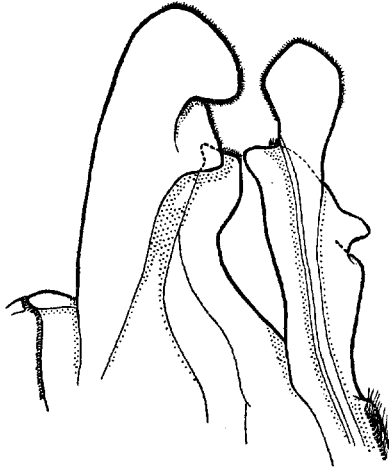


Carapace, anterior part, lateral view. 68. *Solenocera* species,  $\times 5.5$ . Petasma, left half, distal portion of posterior face. 69. *Solenocera* species,  $\times 7.5$ .

*B.O.C. 132* compares with Faxon's material as follows: The rostrum of the Bingham male is relatively short and deep, the distal part of its ventral margin strongly convex; whereas in the types of *S. agassizii* the rostrum is narrow, with a straight, or even concave, ventrodiscal margin. There are only six dorsal carapacic teeth, a smaller number than usually occurs in *S. agassizii*; the epigastric tooth is placed less than one and one-quarter times as far from the orbital margin as from the dorsal end of the cervical sulcus, rather than twice as far as in the types; and the interval between the first and second teeth of the rostral series is less than one-fifth the distance between the first tooth and the dorsal end of the cervical sulcus, as compared with more than one-third in the types. The postrostral carina, which, although low, reaches nearly to the posterior margin of the carapace in *S. agassizii*, disappears behind the level of the cervical sulcus in *B.O.C. 132*; and the sharp carina of the third pleonic somite of the type is represented only by a faint ridge in the Bingham specimen. The dorsal margin of the pterygostomian spine forms a right angle with the

anterior margin of the carapace, instead of curving gently into it as in *S. agassizii*. It seems possible, as indicated by the comparison between juvenile and adult of *S. vioscai*, that the above differences between *B.O.C. 132* and the types of *S. agassizii* are those between juvenile and adult.

In two characters, the Bingham male differs from the types in a manner the reverse of that in which the juvenile female of *S. vioscai* differs from the adult: Its antennular flagella are longer (nearly two and one-third times their peduncle) and more slender than those of *S. agassizii*; and the antennal scale barely reaches to the end of the antennular peduncle, instead far beyond it. The significance of these differences is doubtful.



Petasma, left half, distal portion of posterior face. 70. *Solenocera agassizii* Faxon, COPYR (Albatross St. 3389),  $\times 5$ .

Finally, *B.O.C. 132* differs strikingly from the male of *S. agassizii* in petasma (figure 70, p. 125). It seems possible that the copulatory organs of the two available specimens of the latter are worn or broken, but the fact that the two types are identical in petasma is against this possibility. It is difficult to believe that the petasmal characters of the Bingham male are those of juvenility, because in no other peneid has gross change in the copulatory appendage been observed to occur after the coupling of the two rami has taken place. I believe it to be a fact that individual variations at all approaching in strength those described below have not been found in any species of peneid. The lateral part of the petasma is heavily chitinized. The distal part of its external margin is corrugated by three projections, the proximal of which (marked by the row of setae) is placed at about the third quarter of the external margin in the Bingham male, close to the two more distal projections, the distalmost of which

is much larger than the middle one. In *S. agassizii* the proximal projection of the external margin is placed far from the distal ones, at about the middle of the margin; and the middle projection is larger than the distalmost. Surmounting the lateral part of the petasma in *B.O.C. 132* is a long, slender, acuminate distoventral projection only one margin of which is edged with strong denticles; in *S. agassizii* this lobe is a short, oval lamella minutely denticulate on both lateral and median edges. The distal end of the lateral part of the petasma (distoventral flap), behind the base of the distoventral projection, is unarmed in *B.O.C. 132*; in *S. agassizii* this area bears a row of large spinules. The distolateral lobe of the petasma of the Bingham male bears a pair of rigid lamellar projections on its dorsolateral face; its distal part is a large subrectangular structure with a heavily armed and crenellated distal margin conspicuously projecting at its median end. The distolateral lobe of *S. agassizii* is small; its lateral edge is deeply notched, and its distal margin rounded and not projecting medially.

In other features than the above, *B.O.C. 132* closely resembles the types of *S. agassizii*. Its precise identity must remain in doubt until further specimens have become available.

#### PENAEINAE Burkenroad

Series *PENAEAE* (*Penaeus series*, Burkenroad, 1934a)

#### **FUNCHALIA** Johnson

*Funchalia*, Johnson, 1867; Bouvier, 1908; Lenz and Strunck, 1914; Calman, 1925; Burkenroad, 1934a.

*Aristeus*, part, Bate, 1888.

*Penaeus*, part, Faxon, 1895; Lenz and Strunck, 1914, part; Schmitt, 1935, part.

*Hemipenaeopsis*, Bouvier, 1905a.

*Grimaldiella*, Bouvier, 1905a.

? *Penaeus*, part, Hanström, 1933.

The genus as here defined includes a species regarded by previous workers as pertaining to *Penaeus*, but separated from that genus and placed with *Funchalia*, in the subgenus *Pelagopenaeus*, by Burkenroad, 1934a.

The relations of *Funchalia* s. s. to other Penaeinae have been discussed in some detail by Bouvier, 1908, who regards the genus as the most primitive of the subfamily, and as forming, with *Penaeopsis* and *Parapenaeus*, a group not very directly related to *Penaeus*. This arrangement is accepted by Balss, 1925. In the preceding paper, it has been briefly indicated that *Funchalia* forms, with *Penaeus*, a very compact series well distinguished from the other three maniples of *Penaeinae*, the *Parapeneae*, *Trachypeneae* and *Macropetasmae*. Bouvier is correct in assigning to *Funchalia* a position very close to the *Solenocerinae*, but he is quite wrong to separate it from *Penaeus*.

The Peneae are distinguished from all other Penaeinae by the presence of a pleurobranch on the fourteenth somite, and of an epipodite on the third maxilliped; the occurrence of ventral rostral teeth and of an unenclosed sperm receptacle in some or all of the species of both the included genera; and the presence of a relatively simple open petasma (which also occurs in a single group of the Parapeneae). These are all characters indicative of a near approach to the Solenocerinae. The maxillary palp has a much elongated distal lobe, and all the epipodites are strongly forked. It may be noted that the branchial formula of *Funchalia* is identical with that of *Penaeus*; in addition to the erroneous attribution by Bouvier of three gills to the eighth somite, the branchial lamella of the seventh is filamentose and not, as implied by Bouvier, naked.

*Funchalia* differs from *Penaeus* in a number of characters. The carapace of the former lacks any trace of orbital angle, a structure which appears late in development in *Penaeus*. The carapace of *Funchalia* has a produced dentiform anteroinferior angle, but in agreement with *Penaeus*, where such a projection is lacking, this is not a true pterygostomial spine, since the pterygostomial which is reported present in larvae disappears in postmysis stages. The sulci of the carapace of *Funchalia* are obsolescent, while the various carinae chiefly represent ridges ill-marked or absent in *Penaeus*, as will be described in detail in a further paragraph. The lateral carina of the sixth pleonic segment of *Funchalia* is, like that of most other peneids, continuous, rather than interrupted as in *Penaeus*.<sup>1</sup> The telson of *Penaeus*, when armed, bears three pairs of mobile lateral spines. The telson of *Funchalia* is armed with three pairs of fixed spines, homologous with the mobiles found in Group II of *Penaeus*; but proximal to this true armature there occurs an extensive series of adventitious spinules not distinguished by appearance in the adult stages from the original, persistent, larval series. The carapace and pleon of *Funchalia*, like the telson, are covered

<sup>1</sup>In two available specimens of the Jurassic *Antrimpos speciosus* Münster, the carina of the twentieth somite seems to be continuous, although it does not, as in *Funchalia*, extend to the anterior and posterior margins of the somite. In other features, *Antrimpos* seems identical with the living species of *Penaeus*, to which genus (sensu stricto) it is referred by Balss, 1923. In the disappearance of the adrostral sulci at the level of the epigastric tooth, and the lack of telson armature, the Jurassic form agrees with Group I (Burkenroad, 1934a) of the living genus; in the presence of only a single ventral rostral tooth, with Group II. The posteroventral margin of the sixth pleonic somite, behind the tooth which terminates the inferior margin, is somewhat more convex than in any living species of *Penaeus*, and is rather more as in *Funchalia*. It seems very probable that *Antrimpos* is in the direct line of ancestry of the modern species of *Penaeus*, which have diverged from it slightly by modification of the more primitive continuous lateral carina of the twentieth somite.

The above observations are derived from a study of material from Solenhofen in the collection of the Department of Invertebrate Paleontology of Peabody Museum, for the opportunity to examine which I am deeply indebted to Dr. C. O. Dunbar.

with a peculiar dense pubescence. The superior antennular flagellum of *Funchalia* is longer than the carapace. The molar process of the mandible is obsolete; the incisor process much elongated. There are only three endites on the second maxilla, as in the postmysis of all Penaeinae, but as in the adults of Eusicyoninae alone; it may be noted that the proximal endite is in *Penaeus* reacquired very late in post-larval development. The basis and ischium of both first and second legs are armed. There is a well-developed tooth on the external margin of the uropodal exopods, far proximad the tip. The petasma (in the subgenus *Pelagopenaeus*, that of *Funchalia* s. s. adult being unknown) differs from that of *Penaeus* in bearing a distoventral projection like that of the Parapeneae, some Solenocerinae, and the Eusicyoninae.

*Funchalia* is a pelagic genus, *Penaeus* a benthonic, littoral or sublittoral one. A number of the differences between the two genera are very probably connected with this difference in habit, and have little significance as indicators of phylogeny. Thus *Penaeus*, a considerable portion of the food of which is composed of heavily-shelled molluscs and other tough or rigid objects, might be expected to have a vigorously-developed molar process. The peculiarities of the exoskeletal sculpture of *Funchalia* are similar to those of many of the oceanic forms, but the fact that the absence of hepatic spine in *F. villosa* is demonstrably secondary, whereas it is primary in Aristaeinae, suggests that the resemblances may be the results of convergence. In both subgenera of *Funchalia*, the mass of bottom-debris utilized as lithocyst concretion by *Penaeus* is replaced by a large pellet of clear gelatinous material (more elongate in *Funchalia* s. s. than in *Pelagopenaeus*), although the lithocyst chamber retains an opening to the exterior. This statolith is presumably composed of cuticular material secreted by tegumental glands, such as Lang and Yonge, 1935, have shown to be employed in cementing the sand-grains of the homarid statolith. A similar condition has been noted in *Sergestes* by Hanström, 1933, and in the Aristaeine "*Amalopenaeus*" by Hanström, 1934, who suggests that an autogenous statolith will be found to characterize other pelagic shrimp.

#### Subgenus FUNCHALIA s. s.

Species of the subgenus have been recorded from the Mediterranean (Stephensen, 1923), the temperate North Atlantic (Johnson, 1878; Bouvier, 1908 and 1922; Lenz and Strunck, 1914; Sund, 1920; Stephensen, 1923), and the temperate South Atlantic (Lenz and Strunck, 1914; Calman, 1925), as well as from the Indian Ocean (Balss, 1925). The present records extend the range of the subgenus to the Caribbean. Unfortunately, the specific determination of much of the previously recorded material is uncertain, as will be shown below. The bathymetric range of members of the subgenus is not certainly determined, but the majority of the catches are from slight depths.

Two species attributable to the subgenus have in the past been named,



*Funchalia woodwardi* Johnson and *F. vanhoeffeni* Lenz and Strunck. The latter, known from two specimens taken in the South Atlantic near Tristan de Cunha, actually represents the male of material reported as *F. woodwardi* by Lenz and Strunck. For reasons detailed below, it appears that material attributed to *F. woodwardi* by previous investigators comprises two species. Since the name *Hemipenaeopsis villosa* (later retracted in favor of *Funchalia woodwardi*) was applied by Bouvier to material which apparently consisted of both forms, the name *villosa* is available for the undescribed component.

### ***Funchalia villosa* (Bouvier)**

*Hemipenaeopsis villosus*, part, Bouvier, 1905a.

*Grimaldiella richardi*, part, Bouvier, 1905a.

*Funchalia woodwardi*, Bouvier, part, 1907 and 1908; Lenz and Strunck, 1914.

*Funchalia vanhoeffeni*, Lenz and Strunck, 1914.

(*Funchalia* ?), Gurney, 1924.

1 female, impregnated. *B.O.C. 143*. Atlantis St. 1939; February 3, 1934. N. 16° 10', W. 76° 28'. Depth between 50 and 200 m.

1 female, impregnated. *B.O.C. 141*. Pawnee St. 18; March 10, 1927. N. 23° 39' 25'', W. 76° 41'. 7000 feet wire.

1 female, unimpregnated. *B.O.C. 142*. Pawnee St. 48; April 6, 1927. N. 21° 44', W. 72° 43' 25''. 7000 feet wire.

*B.O.C. 143*, carapace 17 mm, rostrum 6 mm, total 71 mm. *B.O.C. 141*, carapace 16 mm, rostral tip broken, total about 70 mm. *B.O.C. 142*, carapace 14 mm, rostrum 5 mm, total about 65 mm. In addition to the above, a juvenile female of carapace 9.8, rostrum 4.0, total 46 mm (Atlantis St. 1034, Aug. 8, 1931, tub 1) has been loaned for examination by Dr. J. G. F. Wheeler of the Bermuda Biological Station for Research. Seven juvenile males and four juvenile females of carapace length 5.4 to 8.0 mm, 50 to 1000 fathoms, June, July, August and September; and an adult female, impregnated, carapace 16, rostrum 5, total 67 mm, 1000 fathoms, July, from pelagic collections of the Bermuda Oceanographic Expeditions of the New York Zoological Society have been placed at my disposal by Dr. William Beebe.

The rostrum of *Funchalia villosa* is broad at base, very slender distally; the tip is horizontal or depressed, and reaches little beyond the eyes, not to the end of the first segment of the antennular peduncle. The rostrum is armed, in the

three Bingham specimens, with  $\frac{6+1}{0}$ ,  $\frac{5+1}{0}$ ,  $\frac{5+r+1}{0}$  teeth, of which the

epigastric is separated from the posterior rostral by an interval equal to that between the first (posterior) and the third to fourth rostral teeth. The posterior tooth of the rostral series lies behind the orbital margin. The lateral ridge of the rostrum is very poorly marked. The postrostral carina is distinct to about the posterior one-ninth of the carapace. The hepatic spine is completely absent.

The antennal angle terminates in a small spine. The anteroventral angle of the carapace is strongly produced as a dentiform projection slightly dorsad the turning point of the margin. There is an extremely faint trace of dorsal cervical sulcus, the upper portion of which turns posteriorly. From the unarmed hepatic buttress, which is faintly outlined by very shallow sulci, a slight trace of ventral cervical sulcus runs obliquely downward to reach the anterior margin above the anteroinferior angle; dorsally this sulcus is continued backward beneath the obtuse ridge of the hepatic buttress. From the posterior end of the hepatic ridge, a low obliquely vertical carina runs to posteroventral, while from the same point a well-marked cardiaco-branchial ridge takes rise and, sloping sharply upward, then turning posteriorly, reaches the hinder margin of the carapace. From the anterior end of the dorsal limb of the cardiocbranchialis, a very faint ridge and sulcus run anterodorsally. From the anteroventral angle of the carapace a well-marked longitudinal carina runs posteriorly to less than halfway between the anterior margin and the vertical ridge. The antennal carina is well marked; the sulcus dorsal to it turns dorsally at the level of the hepatic buttress as a very shallow groove paralleling and anterior to the faint cervical sulcus. On the posterodorsal lateral surface of the carapace is a short obtuse carina sloping anterodorsally from its posterior end. There is a sharp, unisulcate middorsal carina on the fourth, fifth, and sixth pleonic somites, that of the sixth ending in a rather long tooth. On the dorsal midline of the second somite, just behind a deep transverse depression, is a very faint oval elevation, and a still fainter one exists in a similar position on the third somite. There is a midlateral longitudinal unisulcated carina on the sixth, fifth, and fourth pleonic somites, that of the fourth running obliquely to dorsal. There is a vertical ridge on the first to fourth pleonic pleura. The telson is more than three-quarters the length of the sixth pleonic somite. Its basolateral shoulder is conspicuously cut into three lobes. The lateral margins of the telson bear a considerable series of fixed spines, largest distally, the three distal pairs of which represent spines present in the mysis stage (at which time the anterior two are mobile, the distal fixed), while the remainder are modified setae such as clothe the telson dorsally, and are not homologous to the true lateral armature of other peneids. It is possible that the fourth larval pair also persists, at about the middle of the telson, but it cannot be distinguished in adults from the adventitious series.

There is a strong vestige of a tubercle on the median distal surface of the ocular peduncle. The superior antennular flagellum is as long as the carapace plus the rostrum; the inferior about three-fifths of the superior. The second segment of the antennal peduncle bears a well-developed ancecerite. There is no trace of a parapaneid spine in the adult. The antennal flagellum is about two and one-half times as long as the animal; on the distal three-fifths of it each segment bears a pair of plumose setae arched over toward one another

and producing by their repetition a sort of hollow cylinder of considerably greater diameter than the flagellum, somewhat as in certain Sergestidae. The mandibular palps are one-fifth longer than the distance from the outer base of the palp to the tip of the incisor process; the tip of the second joint of the palp is obliquely deeply concave, and the inner margin is considerably produced. The palp seems subject to asymmetrical development or frequent loss and regeneration, the right one in No. 142 having, by contrast with the left, the inner margin of the tip scarcely produced, while in No. 141 the left palp is quite small, with an oval distal segment. The dactyl of the third maxillipedes is subcylindrical, tapering from slightly swollen base to tip. The finger of the third chela is nearly three-quarters of the palm. The dactyls of the fourth and fifth legs are more than two-thirds as long as the propodi. The endopod of the uropod extends from one-third to one-fourth of its length beyond the telson, and falls considerably short of the tooth on the external margin of the exopods.

The median plate of the thelycum is a high narrow  $\Lambda$ -shaped ridge forming the anterior wall of a deep depression. Posteriorly, on the fourteenth somite, this depression is bounded by the rim of the transverse groove, which is rather low posteromedially, but is produced anteriorly into somewhat overhanging lateral hoods which meet the posterior ends of the median plate, and form the lateral margins of the depression. The depression of the thelycum thus has the shape of a U somewhat narrowed at its open end, capped, by a  $\Lambda = \hat{\Lambda}$ . The depression runs posteriorly more than half-way between the fourth and fifth leg bases, and the part enclosed between the lateral hoods is considerably longer than wide. The oblique anterolateral margin of either lateral hood is only slightly concave. From the inner anterior end of each lateral hood a ridge which in its anterior part forms the free median edge of the hood runs back to the posterior margin of the fifth legs. Slightly behind the level of the posterior margin of the depression, this ridge curves conspicuously to lateral. There is no longitudinal ridge on the floor of the depression. In the three available impregnated specimens, the depression of the thelycum is completely filled by a white spermatophoric mass.

The four adult females and the twelve juveniles of *Funchalia* available to me appear to be conspecific with the two immature females of 45 mm and less total length partially described by Bouvier, 1908 as "*F. woodwardi*" and evidently included in his "*Hemipenaeopsis villosus*"; as well as with the seven females and two males of from 72 to 85 mm total length described by Lenz and Strunck under the names "*Funchalia woodwardi*" and "*F. vanhöffeni*"; and with the 66 mm female of Station 3028, the 25 mm male of Station 3030, the 24 mm female of Station 3033, and the 25.5 mm male of Station 3036 briefly characterized by Bouvier, 1922, under the name "*F. woodwardi*."

Of the true *F. woodwardi*, here considered to be distinct from *F. villosa*, information is available as to the type, a female of 157 mm (Johnson, 1867,

Miers, 1878, and Calman, 1925); an immature male of 56 mm described by Bouvier, 1908; three females of from 130 to 149 mm described by Calman, 1925; and a male of 100 mm from Station 3028, briefly characterized by Bouvier, 1922. The differences between descriptions of this latter group of specimens and of those referred above to *F. villosa*, which have led me to regard them as representing distinct species, are as follows:

In all material 60 mm or more in length which is described in the present paper or by previous investigators as lacking the hepatic spine (comprising 12 females ranging in length from 65 to 85 mm and two males of between 72 and 85 mm), the rostrum and postrostral carina are armed with from 5 to 7, usually 5, teeth. In material described as with an hepatic spine (it may be noted that although Johnson describes the surface of the carapace as unarmed, Calman has observed a small hepatic spine in the type), comprising four females ranging in length from 130 to 157 mm and two males of 56 and 100 mm, there are 11 to 13, usually 11, teeth on the rostral carina. There is thus a range of variation in each group in number of rostral teeth of 2, an interval between the maximum of one group and the minimum of the other of 4, and an interval between the modes of 6 teeth.

Turning now to available descriptions and specimens of less than 60 mm, it is found that Bouvier has described an early postlarva of 17 mm, as with hepatic spine and only six rostral teeth; and has described two males of 25 and 25.5 mm and two females of 24 and 45 mm as without hepatic and with 5 or 6 rostrals. In the twelve small specimens available to me, ranging from 23.3 to 46 mm, the rostral teeth are 6 or 7 in number (of which, however, the distalmost is so minute as to escape observation at magnifications of less than 30 diameters) and there is no evidence of multiplication with increase in size of the individual. In all of the available specimens an hepatic spine is present. In the smallest it is .19 mm, in the largest .09 mm, in length, the rate of reduction with increase in size being fairly regular. In the small specimens, in which the carapacic tomentum is just beginning to appear, the spine is rather conspicuous; but in larger specimens the hepatic is scarcely larger than the surrounding setae, and may be found only by determined search. It is therefore suggested that an inconspicuous hepatic spine was probably present in juvenile specimens which Bouvier believed to lack it; but it may definitely be stated that in juveniles up to 46 mm with only 5 to 7 rostral teeth, the hepatic spine decreases in length with increase in size of the individual to the point of disappearance at 46 mm; while in specimens of more than 60 mm with similar rostral formula it is completely absent.

There are two records of specimens of *Funchalia* less than 60 mm in total length and with more than seven rostral teeth: Lenz and Strunck describe a juvenile of 24 mm as with 9 rostrals and a very distinct hepatic; and Bouvier describes a male of 56 mm as with 13 rostrals and a conspicuous hepatic.

To summarize the foregoing, it seems fairly evident that known material of *Funchalia*, far from displaying haphazard irregularities in development and number of hepatic and rostral teeth, may be divided into two groups: one with a reported maximum size of 85 mm, fewer than eight rostral teeth in postmysis stages, and an hepatic spine dwindling to disappearance with the progress of maturation; the other with a maximum of 157 mm, more than eight rostral teeth in postmysis stages, and an hepatic present at all sizes. It seems fairly clear, although the evidence presented is not conclusive, that a simple explanation of this bimodality on the grounds of appearance of hepatic and increase in rostral count with increase in size of the individual is impossible. A search for further distinctions between these groups may therefore be made. As a first item, it may be observed that the smallest impregnated female of *Funchalia* is 65 mm total length. The largest known female of the genus is 157 mm in total length. If this latter specimen is conspecific with the smallest impregnated one, females of *Funchalia* must attain a length more than double that of sexual maturity. An increase of this order of magnitude is known in Eusicyoninae (Burkenroad, 1934b) but not among other Penaeidae.

There are certain points of resemblance between Bouvier's description of an immature male of 56 mm and Calman's of very large females, both with hepatic spine; which are not shared by the females of the present collection, or those described by Bouvier and by Lenz and Strunck, all without hepatic spine. Thus, in the former specimens, the rostrum is shown as reaching beyond the first segment of the antennular peduncle; in the latter group, not to the end. In the former the mandibular palp is indicated to be not much longer than the blade (measured from the outer margin of the palp); in the latter it is considerably longer. In the former, the produced inner distal end of the terminal segment of the mandibular palp is shown as sloping broadly out from the concave anterior margin; in the latter, though variable, it is narrow and is rather sharply inflected to meet the anterior margin. In the former, the dactyl of the fourth and fifth legs is less than half as long as the propodus; in specimens of the latter over 65 mm in length it is two-thirds or more of the propodus. This last difference between the two groups requires critical examination, however, since it is discovered that juveniles of *F. villosa* have fifth dactyls relatively much shorter than in the individuals of *F. woodwardi* described by Calman and Bouvier. Briefly, in *F. villosa* of total length 23.3 mm, the propodus is 5.7 times as long as the dactyl; by 46 mm the dactyl has increased to more than two-fifths, while at 67 mm it is almost two-thirds the penultimate joint. We have here, therefore, a heterogonous growth series into which, however, Bouvier's, and especially Calman's specimens cannot be fitted.

The above agreements between the descriptions of two specimens with hepatic spine and numerous rostrals, one individual being smaller, one much larger than specimens lacking hepatic, are emphasized in order to demonstrate

that the differences described in the next paragraph between adult females of *F. woodwardi* and of *F. villosa*, the former twice the length of the latter, are indicative of specific distinctions and are not merely referable to individual variation or to difference in size.

Through the very great kindness of Dr. W. T. Calman and Dr. I. Gordon of the British Museum, I have been enabled to examine one of the South African females of *F. woodwardi*, compared with the Madeiran type and described by Calman, 1925. The specimen is an impregnated female of carapace 37, rostral length 11 mm. It differs from *F. villosa* as follows: The rostrum is relatively longer, reaching to the end of the first segment of the antennular peduncle; and is armed dorsally with a larger number of teeth (11), of which the third from the rear is behind rather than in front of the level of the orbital margin. The rostrum has a strong lateral ridge, (as in *Pelagopenaeus*), which is only vaguely indicated in *F. villosa*. The antennal angle is not unarmed as indicated by Calman's figure, but bears a small tooth like that of *F. villosa*. The longitudinal carina running posteriorly from the hepatic prominence is strong (as in *Pelagopenaeus*) rather than very weak as in *F. villosa*. An hepatic tooth (as in *Pelagopenaeus*) is present. The oblique ridge from the anterior end of the dorsal limb of the sigmoid cardiacobranchial carina is much stronger than in *F. villosa*. There is a strong longitudinal carina ventral to the midlateral one, on the posterior part of the lateral surface of the sixth pleonic somite (also present in *Pelagopenaeus*) which is not perceptible in *F. villosa*. The telson extends to the level of the distolateral tooth of the uropodal exopod, instead of falling far short of this point. The oblique distal margin of the mandibular palp is only very slightly concave, whereas in *F. villosa* it is strongly so. The mandibular palp is not so long as the blade, instead of being considerably longer. The dactyl of the third maxillipede is shorter, broader, and more flattened than the narrow, almost styliform segment found in females of *F. villosa*, but is not so lanceolate as that of the male of the latter species, according to figures by Lenz and Strunck. The chelae are much shorter and stouter than are those of *F. villosa*, the palm and finger of the third pair measuring, respectively, 2.7 and 2.8 mm in length as compared to 2.2 and 1.6 mm for the much smaller adults of *F. villosa*. The dactyls of the fourth and fifth legs are (as in *Pelagopenaeus*) conspicuously shorter than in *F. villosa*, the dactyl of the fourth in *F. woodwardi* being only slightly more than one-half the propodus, as compared to nearly two-thirds in the latter. The thelycum in the available female is obscured by a sperm-mass which is not, as in *F. villosa*, an ellipsoid neatly fitted within the receptacle, but an irregular body covering the median plate and extending back over the posterior lip of the depression. The following conspicuous differences from the thelycum of *F. villosa* may be made out: The ridge of the lateral hoods is straight, not inflected; the anterolateral margin of the hoods is deeply emarginate rather than only slightly concave, and the part

of the receptacle enclosed between the hoods is evidently wider than long, instead of longer than wide.

In presence of hepatic spine and in shortness of the dactyls of the posterior legs, *F. woodwardi* is evidently equivalent to juvenile instars of *F. villosa*. In other features, *F. woodwardi* is completely independent of the newly distinguished form.

Brief comment on described larvae of *Funchalia* may be given here. The early postmysis of *Funchalia*, described by Gurney, 1924, from New Zealand, seems referable to *F. villosa*, since a postmysis of 13.34 mm from the Bermuda collections of the Department of Tropical Research of the New York Zoological Society, clearly attributable to the juvenile series of *F. villosa* described in preceding paragraphs, appears to be a slightly older stage of the same species as Gurney's larva. The Mediterranean larvae described by Monticelli and Lobbiano, 1902, as referable to *Aristaeus antennatus*, and by Stephensen, 1923, as *Aristaeomorpha foliacea*, seem, especially because of the earlier appearance of rostral teeth, ascribable to *F. woodwardi*. The juvenile of 24 mm from St. Helena, described as *Funchalia* sp. by Lenz and Strunck, 1914, is probably ascribable to *F. woodwardi*; in addition to characters of rostral and hepatic teeth, the double carina of the sixth pleonic pleura is strongly suggestive of the condition of adult *F. woodwardi*.

I have referred to *F. villosa* the specimens taken in company with females of their "*F. woodwardi*," which are described by Lenz and Strunck as females of a new species (*F. vanhoeffeni*) distinguishable by the expanded dactyls of their third maxillipedes and their peculiar "thelycum." The suspicion of the identity of these specimens was based on the fact that the figure of the "thelycum" of *F. vanhoeffeni* is strongly reminiscent of the genital sternites of males of *Pelagopenaeus*, in which males, also, the dactyls of the third maxillipedes are lanceolate in comparison with the styliiform dactyls of the available females. In response to an inquiry, Dr. A. Schellenberg of the Zoologisches Museum der Universität, Berlin, has been so kind as to examine the types, and to offer the following information: "Beides [exemplare von *F. vanhoeffeni*] sind ♂ mit wohl ausgebildeten Petasma." The supposed differences between *F. "vanhoeffeni"* and *F. "woodwardi"* can therefore be stated to represent sexual dimorphism within *F. villosa*.

The distribution of the two species of *Funchalia* s. s. as far as the records permit differentiation, is as follows: Adults of *F. villosa* are known from the eastern and western North Atlantic, the south central South Atlantic, and the Caribbean; adults of *F. woodwardi* from the eastern North Atlantic and the southeastern South Atlantic. Larvae probably of *F. villosa* are known from the western North Atlantic and the South Pacific; larvae probably of *F. woodwardi* from the Mediterranean and the central South Atlantic.

## Subgenus PELAGOPENAEUS Burkenroad

*Pelagopenaeus* is distinguished from *Funchalis* s.s. by the presence of a ventral armature on its rostrum; the elongation of the branchiostegal carina of its carapace; and the occurrence of a prominent dorsal longitudinal carina of which no complete equivalent exists in *Funchalia* s. s. or in *Penaeus*; its unarmed antennal angle; the shorter incisor process of its mandibles; and the median extension, as free flaps, of the lateral hoods of the fourteenth sternite of the female. No other differences of importance between the two subgenera have been found.

The ventral rostral armature which occurs in some Penaeinae has been invested with considerable significance by certain systematists, but serial arrangements founded on this character in the past are clearly artificial. Within such homogeneous genera as *Eusicyonia* and *Hymenopenaeus*, a ventral armature may be either present or absent. Therefore, since *Funchalia* and *Pelagopenaeus* are clearly very closely related, and possess very numerous characters in common which are not shared by *Penaeus* and *Heteropenaeus*, the other group of the series, it seems better not to set up *Pelagopenaeus* as an independent genus.

Nine specimens have heretofore been taken. One female, described as *Penaeus balboae* by Faxon, 1893 and 1895, was captured off Cocos Island in the American Pacific, at a depth between surface and 770 fathoms; another female, described without recognizance of Faxon's work as *Penaeus meridionalis* Lenz and Strunck, 1914, was taken in the middle of the temperate South Atlantic, at a depth of ten meters, during the night; while four females and three males are recorded as *Penaeus balboae*, without detailed description, by Schmitt, 1935, from the American Pacific, at the surface. Whether "*Penaeus* sp." noted from east of Madeira at 3800 meters by Hanström, 1933, is referable to *Pelagopenaeus* is not known. Of the three individuals of *Pelagopenaeus* in the Bingham Collection, all males, two were taken in the North and Southwestern Caribbean at the surface, by night, and one off Bermuda, at a depth of less than 2000 meters.

The above specimens seem to represent a single uncommon but widely distributed species which, like *Funchalia*, chiefly inhabits the upper water-layers of the open sea.

***Funchalia* (*Pelagopenaeus*) *balboae* (Faxon)**

Figure 71, p. 139

*Penaeus balboae*, Faxon, 1893 and 1895; Alcock, 1906; Schmitt, 1935.

*Penaeus meridionalis*, Lenz and Strunck, 1914.

*Funchalia* (*Pelagopenaeus*) *balboae*, Burkenroad, 1934a.

*Funchalia* (*Pelagopenaeus*) *meridionalis*, Burkenroad, 1934a.

1 male, adult. B.O.C. 130. Pawnee Station 59; N. 32° 19' 18", W. 64° 32' 30"; April 21, 1927. 8000 feet wire.



1 male, adult. *B.O.C. 131*. Sargassum Haul 111; N. 21° 04', W. 84° 11'; February 28, 1934, night. Surface.

1 male, badly damaged. *B.O.C. 132*. Sargassum Haul 77; N. 10° 20', W. 79° 15'; February 6, 1934, night. Surface.

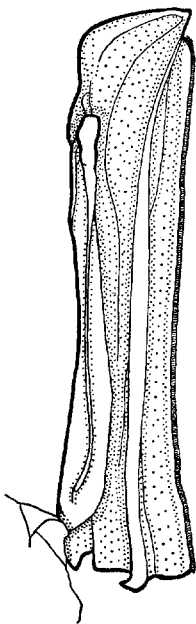
*B.O.C. 130*, carapace 31 mm, rostrum 14.2 mm, total 135 mm. *B.O.C. 131* and *B.O.C. 132*, respective carapace lengths 30 and 28 mm.

The rostrum of the largest specimen reaches about to middle of second segment of the antennular peduncle and is armed with  $\frac{13+1}{4}$  teeth. Two teeth in addition to the epigastric lie behind the orbital margin. The epigastric is nearly as far distant from the posterior tooth of the rostral series as is this from the third tooth of the rostral series. The ultimate tooth is as far from the rostral tip as from the antepenultimate tooth. The ultimate tooth of the ventral margin lies beneath the ultimate of the dorsal margin; it is succeeded by three well-spaced teeth, the posterior of which lies just anterior to the sixth dorsal tooth from the tip, well posterior to the distal end of the first antennular segment. The rostrum is horizontal, with a slightly upturned tip. Its lateral carina is well marked and extends from somewhat in advance of the epigastric tooth nearly to the rostral tip. The rostra of both of the smaller specimens are broken short; the remaining portions are in agreement with the above. The postrostral carina runs to within about one-seventh of the posterior margin of the carapace, at which point it terminates abruptly. There is a short, faint, transverse ridge just behind the end of the postrostral carina. There is no trace of an orbital angle. The antennal angle is broadly rounded and unarmed; its inferior margin has a sigmoid curve. The anteroventral angle of the carapace is produced and dentiform. There is a small hepatic spine placed just in advance of the level of the epigastric tooth, somewhat closer to the vertical carina than to the end of the antennal angle. The faint sulci which occur in *Funchalia* (ventral and dorsal parts of the anterior cervical and the groove parallel and anterior to the ascending limb of the dorsal cervical) are perceptible, but the horizontal limb of the dorsal cervical of *Funchalia* is absent. The sigmoid cardiacobranchial carina is like that of *Funchalia*, and reaches the posterior margin of the carapace. At a point slightly in advance of the middle of the carapace an obliquely vertical ridge slopes downward and backward from the base of the ascending part of the sigmoid curve of the cardiao-branchial ridge, to meet the elongated branchiostegal carina. This latter reaches to within one-sixth of its length of the posterior margin of the carapace. A well-marked, longitudinal carina, dorsal to the cardiao-branchial ridge, with a shallow sigmoid curvature in its midsection, extends from somewhat anterior to the level of the epigastric tooth as far posterior as the end of the postrostral carina. At its ill-marked posterior end, it recurves upon itself, reappearing as a short ridge extending anterodorsally. This oblique ridge occurs in *Funchalia*, where the

main, longitudinal carina is absent. From the apex of the ascending part of the sigmoid curve of the cardiaco-branchial carina a very broad, faint, transverse crest anteriorly margined by a shallow sulcus runs dorsally to meet the dorsolateral longitudinal carina. This crest is present in *Funchalia* though the dorsolateral carina is not. The pleon is nearly identical with the same part in *Funchalia* save that the dorsal (but not the lateral) carinae of the fourth, fifth, and sixth somites are sulcate; and that the carina of the fifth somite ends in a slight projection, the sixth being toothed in both subgenera. The tip of the telson is missing in all the specimens, but it appears to have reached beyond the externodistal tooth of the uropodal exopods.

The superior antennular flagella are somewhat stouter than the inferior and extend well beyond them. In the largest specimen the complete inferior ramus measures 28.5 mm, less than the carapace without the rostrum. In No. 131, the incomplete superior ramus measures 72 mm; the complete inferior ramus measures 26 mm. The antennular peduncle is like that of *Funchalia*; a very short external scale occurs on the basal segment. The upturned outer rim of the distal part of the basal segment, as in *Funchalia*, lacks any longitudinal carina. The inner distal margin of this joint supports a large projection. The external border of the antennal scale terminates in a large tooth which extends well beyond the end of the antennular peduncle. The distal segment of the mandibular palp is little more than twice the length of the basal segment, and tapers to a narrow tip. The mandible resembles that of *Funchalia*, but the incisor process has a relatively more slender tip and is much less produced, the length of the anterior margin measured from the external base of the palp being less than three-fifths of the palp. The cutting edge of the mandible is concave, the blade being shaped like the end of a scimitar. The exopodites of the second and third maxillipedes reach beyond the middle of the antennal peduncle. The endopod of the third maxillipede reaches a dactyl beyond the peduncle. The dactyl is laterally flattened, lanceolate, more than one and one-half times as long as the propodus. Dactyl and propodus together exceed the carpus in length. As in *Funchalia*, the exopods of the pereopods have a conspicuous joint in the middle; those of the first legs reach nearly to the end of the ischium, being rather larger than those of the succeeding legs. In No. 131, the exopodites of the fifth legs are completely absent, whereas in the largest specimen these rami are as large as those of the preceding legs. It may be noted in this connection that the fifth exopod is delayed in reappearance longer than are the others, in postmysis stages of *Funchalia*. The third legs extend to the middle of the antennal peduncle. As in the chelae of the preceding legs, both fingers bear teeth, and the inner margins of both as well as the median margin of the fixed finger and part of the palm are finely denticulated. The fourth legs are subequal in length to the third; the fifth are even shorter. The dactyls of these two pereopods are less than half the length of the propodus, and form slender,

sharp, curved grappling hooks. The diaeresis of the uropodal exopods is well marked, and there is a strong, projecting tooth about one-fourth the external margin proximad the tip. The uropodal endopodite extends well beyond this tooth.



Petasma, right half, posterior face. 71. *Funchalia (Pelagopenaeus) balboae* Faxon, North Atlantic ♂,  $\times 6.2$ .

There is a conspicuous lameliform tooth-like projection in the midline of both thirteenth and fourteenth pereonic sternites. The male genital orifices are subcoxal, and, as in certain species of *Penaeus*, the anterior margin of the swollen area bearing the gaping, transverse orifice is produced as a fleshy finger armed with long setae. The petasma is simple and open, bearing a close superficial resemblance to that of *Penaeopsis megalops* (Smith), Burkenroad, 1934b. It is, however, unique among Penaeinae with open petasma in that the ventrolateral margin gives rise to a free *distoventral projection*, as in many Solenocerinae. The free edge of distolateral lobe is weakly denticulate, as in the Solenocerine *Hymenopenaeus robustus* Smith or *Solenocera agassizii* Faxon.

The color in fresh (though dead) specimens was whitish (translucent in life?) stippled with red chromatophores.

The present material differs from the description of *Funchalia meridionalis*

(Lenz and Strunck) 1914, in a number of points, but these differences seem referable in the main to errors on the part of the German investigators. Doctor A. Schellenberg of the Zoologisches Museum der Universität, Berlin, has had the great and deeply appreciated kindness to compare the type of *F. meridionalis* with drawings of the Bingham specimens. According to the information supplied by Doctor Schellenberg, the exopod of the uropod of *F. meridionalis*, described and figured as lacking a tooth on the external margin, and figured as lacking the normal sculpture, actually possesses the latter as well as the damaged remnants of the former. The anterolateral corner of the basal segment of the antennular peduncle, figured as unarmed, bears a spine. The shape of the mandible, of which the cutting edge is figured as strongly convex instead of strongly concave, and as separated from the lateral portion by a deep notch, instead of by a projecting corner, is actually similar to that of present material. The antennal angle is rounded, rather than acute as figured, and its ventral margin is sigmoid, not convex. The anteroinferior angle is tooth-like rather than merely sharp-cornered. Other differences between the description and figures by Lenz and Strunck and the present material, which probably lack real basis, are as follows: The cardio-branchial carina is shown as not reaching the posterior margin of the carapace. The recurved portion of the dorsolateral carina of the carapace is not indicated in the figures, nor is the lateral carina of the rostrum. The blunt projection figured as on one side only at the distal end of the telson, is probably the result of injury-repair. The upturned lateral margin of the basal segment of the antennular peduncle is figured as less deep and as less rounded anteriorly than it is in our material. The midlateral carina of this margin, figured and described by Lenz and Strunck, perhaps represents the ventral margin of the peduncle, the supposed ventral margin of the investigators probably being formed by the distal ends of a thickly set row of setae. The antepenultimate segment of the second maxillipede is figured as triangular, without a distomedian corner overlapping the penultimate segment. The immovable fingers of the chelae are described and figured as lacking teeth (although these structures are correctly noted by the same authors as present on both fingers in *F. "woodwardi"*). The rostrum is described as with a tooth less both above and below; and the ventral teeth are figured as more crowded, than in the undamaged specimen of the Bingham Collection.

The present material has been directly compared with the female holotype of *Penaeus balboae*, in the collection of the Museum of Comparative Zoology at Harvard. Faxon, by a slip of the pen, has stated that the specimen is a male. The rostrum of the type is broken, but according to Schmitt, 1935, in the seven Pacific specimens which he has examined the formula is  $16/4$  or  $5$ , and the tip of the rostrum does not reach the end of the second segment of the antennular peduncle. A number of differences between Faxon's description and the present material are without actual foundation, the type and the Bingham

specimens being identical in these features, which are briefly listed herewith: The ventral margin of the antennal angle of the type is figured as with a distinct subsidiary angle instead of a merely sinuous outline; and the antennal and cardiaco-branchial carinae as reaching neither the anterior nor the posterior margins, respectively; while the recurved portion of the dorsolateral carina of the carapace has not been indicated. The hepatic tooth is figured as placed much closer to the tip of the antennal angle than to the transverse carina, well in front of the epigastric tooth. The stylocerite is described and figured as absent. The antennal scale is figured as with the tooth of the external margin very short and not extending beyond the antennular peduncle. It may be noted that Faxon's figures 1 and 1c are at variance as to the length of the pereopodal exopods which are stated in the text to be very short.

Such differences as are perceptible on direct comparison between the North Atlantic males and the Pacific American female appear to be of the nature of sexual dimorphism. The third maxillipedes are a little longer in the Atlantic males, and have a slightly longer dactyl which is flattened, expanded, and lanceolate, rather than subcylindrical and styliform as in the type of *F. balboae*. The third maxillipedes of the Atlantic female examined by Lenz and Strunck were unfortunately missing. One or another form of sexual dimorphism is known to involve the dactyl of the third maxillipedes in many Penaeidae, including some species of *Penaeus*, and there is evidence for an identical sexual difference in *Funchalia villosa*.

The thelycum of the type, which is partially obscured by an enclosed sperm mass, seems to resemble that figured by Lenz and Strunck for their South Atlantic female. It differs from that found in *Funchalia* s. s. somewhat as the thelycum of most species of *Penaeus* differs from that of certain species of the first division of the genus (Burkenroad, 1934a); in that the lateral hoods of sternite XIV are produced as free flaps, which, however, do not as in *Penaeus* completely cover the spermatophores.

Subsequent to completion of the foregoing paragraphs I have been enabled, through the very great kindness of Doctor W. L. Schmitt, to examine a Pacific male and female of *F. balboae* from the collections of the U. S. National Museum, of the lot recorded by Dr. Schmitt (1935) in his recent study of *Penaeus*. The carapace of the male measures 23.5, the rostrum 12, of the female 26 and 13 mm; the male especially being thus considerably smaller than the Atlantic specimens compared with it. The male rostral formula is  $\frac{15 + 1}{5}$ , the female  $\frac{13 + r + 1}{4}$ . The relations of ventral to dorsal teeth are, counting from the distal

end, identical with the Atlantic specimen; the proximal ventral tooth is, however, anterior to the distal end of the first antennular segment. The antennal angle is sharper than in Atlantic specimens; there is a sharp denticle rather

than a rounded protuberance at the posterior end of the postrostral carina, and a faint trace of the larval anterior dorsal organ remains. The prosartema is slightly shorter than in Atlantic specimens. The superior flagellum of the antennule is in the male only 33.5 mm long (the inferior being 19 mm), and is thus relatively much shorter than in the Atlantic males; in the female the superior flagellum is still shorter and slenderer, being only a fourth longer than the inferior. The exopods of the walking legs are shorter, and those of the fifth pair, which are present in the largest Atlantic specimen, are here absent (as in the smaller Atlantic male). The third maxillipede of the male is slightly shorter than in Atlantic specimens, and its dactyl, although narrowly lanceolate as compared with the styliform finger of the female, is much less expanded than in Atlantic males. The petasma differs by its somewhat shorter distoventral projection. The thelycum of the young Pacific female is unimpregnated and certain details not visible in the type are therefore visible. The floor of the receptacle is not depressed below the level of its slightly raised posterior rim; and is setose. The flaps which partly enclose the receptacle are expansions of the ridges found on the lateral hoods of *Funchalia* s. s. Otherwise the thelycum closely resembles that of *F. villosa*. The differences of these from other specimens of *F. balboae*, where not referable to individual variation (as in rostral formula), seem attributable to the more juvenile condition of the Pacific specimens; and it is probable that the stocks of *F. balboae* in the two oceans are to be regarded as specifically identical.

### SUMMARY

#### TAXONOMY

##### ARISTAEINAE.

BENTHESICYMAE. Material examined, *Benthescycymus bartletti*, *tanneri*, *altus*, *investigatoris*, *carinatus*, *laciniatus*,\* *brasiliensis*,\* *urinator*\* n. sp., *cereus*\* n. sp., *strabus*, n. sp. *iridescens*.\* *Bentheogennema intermedia*.\* *Gennadas capensis*,\* *kempii*,\* *elegans*,\* *brevirostris*, *tinayrei*,\* *parvus*, *valens*,\* *gilchristi*,\* *bouvieri*, *talismani*,\* *scutatus*.\*

1. The distinctions between the maniple Benthescycymae and the maniple Aristaeae are reviewed. It is found that there is only a single completely diagnostic difference.
2. The species of Benthescycymae are divisible into four genera, *Benthonectes* Smith, *Benthescycymus* Bate, *Bentheogennema* n. nom., and *Gennadas* Bate, the diagnostic characters of which are discussed in detail. *Amalopenaeus* Smith is a synonym of *Gennadas* Bate.
3. *Benthescycymus* is composed of two superspecific groups, centering about *B. crenatus* Bate and *B. bartletti* Smith, for the species of which diagnostic keys are presented.

\* Figured. Illustrations from camera lucida drawings by the author.

4. *Benthescycymus hjorti* Sund and *Gennadas pectinatus* Schmitt appear to be synonymous with *Benthescycymus laciniatus* Rathbun, which may be identical with *B. crenatus* Bate. *B. pleocanthus* Bate is synonymous with *B. bartletti* Smith. *Benthescycymus moratus* Smith is synonymous with *B. brasiliensis* Bate. *B. mollis* Bate, *B. armatus* MacGilchrist, and *B. longipes* Bouvier are synonymous with *B. iridescens* Bate. Bate's material of *B. brasiliensis* includes the three new species *B. urinator*, *B. strabus* and *B. cereus*, with the former of which *B. moratus* Rathbun (*not* Smith) is identical.
5. *Bentheogennema calmani* (Kemp) is distinct from *B. intermedia* (Bate) but synonymous with *B. borealis* (Rathbun). *Gennadas* sp. Rathbun represents *Bentheogennema intermedia* (Bate).
6. The species of *Gennadas* are divisible into two groups on the basis of differences in genital structure.
7. From consideration of the demonstrable correlations in form between male and female copulatory organs, it is suggested that *Gennadas gardineri* (Balss) may be the female of *G. incertus* (Balss). The female of *G. capensis* Calman, previously unknown, is described; the species is distinct from *G. kemp* Stebbing. *G. alcocki* Kemp, part, is the male of *G. bowieri* Kemp. *G. scutatus indicus* Kemp, *G. alcocki* Kemp and *G. clavicarpus* DeMan are synonyms of *G. propinquus* Rathbun. *G. similis* Stephensen seems to be a synonym of *G. brevirostris* Bouvier (*G. elegans* A. Milne-Edwards and Bouvier). A diagnostic key to the species of the genus is presented.

ARISTEAE. Material examined, *Hepomadus tener*. *Plesiopenaeus armatus*, *coruscans*.\* *Hemipenaeus carpenteri*, *spinidorsalis*. *Aristaeus occidentalis*.

8. The distinctness of *Hepomadus tener* Smith from *H. glacialis* Bate is observed to be not entirely certain.
9. *Plesiopenaeus* and *Aristaeopsis*, as used by recent authors, refer each to the other's original genotype. Since the two groups are structurally not clearly distinguished, the latter is synonymized with the former thus avoiding confusion.
10. The distinctness of *Plesiopenaeus armatus tridens* (Smith) from *P. armatus* (Bate) is observed to be doubtful.
11. An Atlantic form apparently identical with *Plesiopenaeus coruscans* (Wood-Mason), heretofore known only from the Indo-Pacific, is described.
12. The diagnoses of the genera *Hemipenaeus*, *Aristaeus*, and *Plesiopenaeus* are modified in recognition of the occurrence of a podobranch on XII and an epipodite on XIII in species of *Hemipenaeus*.
13. It is indicated that the Atlantic form indistinguishable from the Pacific-American *Hemipenaeus triton* Faxon is probably identical with *H. carpenteri* Wood Mason.

SOLENO CERINAE. Material examined: *Haliporus thetis*. *Hymenopenaeus*

*laevis, nereus, doris, debilis,\* aphoticus\* n. sp., diomedea, robustus, modestus, mülleri. Solenocera agassizii,\* sp. indet.\* vioscai, membranacea.*

14. The presence of two appendices on the second pleopod of males of this subfamily and of the Aristaeinae is pointed out, and a previous suggestion that the Solenocerinae are more closely related to Aristaeinae than to Penaeinae, based on larval structure, is thereby strengthened.
15. It is pointed out that the Jurassic *Aeger* displays more features in common with the modern Solenocerinae than with the Aristaeinae to which it has been referred.
16. *Haliporus* Bate is restricted to two peculiar species very closely approaching the aristaeine mode, *H. curvirostris* Bate and *H. thetis* Faxon, the latter of which is redescribed.
17. *Hymenopenaeus* Smith is re-established for most of the species of *Haliporus* auct., which are divisible into four superspecific groups. The genus is reviewed.
18. *Hymenopenaeus androgynus* (Bouvier), *H. sp.* (Lenz and Strunck) and *H. microps* Smith, are synonymous with *Hymenopenaeus laevis* (Bate).
19. *H. robustus* Smith is shown to stand in near relationship not to *H. diomedea* (Faxon) but rather to *H. modestus* Smith and *H. lucasii* (Bate).
20. *Hymenopenaeus aphoticus*, a new Atlantic species rather closely related to *H. debilis*, is described.
21. Further distinctions between *Solenocera vioscai* Burkenroad and *S. agassizii* Faxon are made known. Juvenile or variant forms of both are described.

*PENAEINAE.* Material examined: *Funchalia villosa, woodwardi, balboae.\**

22. The members of the series Peneae are compared. It is shown that in at least one character the Jurassic *Penaeus (Antrimpos) speciosus* resembles *Funchalia* rather than the living species of *Penaeus*.
23. It is shown that two species have heretofore been confused under the name *F. woodwardi* Johnson. The name *F. villosa* (Bouvier) is available for the component distinct from the type. It is pointed out that the supposedly female types of *F. vanhoeffeni* Lenz and Strunck represent males of *F. villosa*.
24. *F. (Pelagopenaeus) balboae* (Faxon) is a bioceanic species with which *Penaeus meridionalis* Lenz and Strunck is identical.

#### MORPHOLOGY

1. It is shown that in *Gennadas, Bentheogennema*, and certain of the species of *Benthesicymus* the thelycum differs from that of other Penaeidae in that the enclosed or invaginated sperm receptacles are placed between the twelfth and thirteenth sternites rather than the thirteenth and fourteenth sternites as in Penaeinae with enclosed receptacles [p. 50]. In certain species of *Benthesicymus*, the Aristeae, the Solenocerinae, and certain



- species of Penaeinae, there are no enclosed receptacles; this open thelycum seems to represent the basic form from which the enclosed receptacles of Benthescyminae and Penaeinae-Eusicyoninae have been independently derived [p. 62].
2. The major portion of the spermatophore as found in males of *Bentheogennema* and *Gennadas*, composed of the sperm-free accessory portions homologous with those which function for anchorage and protection of the exposed spermatophore of peneids without enclosed receptacles, seems to be discarded during sperm transfer, and the sperm mass which it surrounds alone to be inserted into the female receptacle [p. 62]. This mode of adaptation of spermatophore to the mechanical limitations of enclosed storage is contrasted with that found in the Penaeinae, where the accessory material is diminished in bulk and is transferred to the female, instead of being elaborated and cast off. A possible correlation between type of spermatophore reduction and of male copulatory organ is pointed out [p. 63].
  3. It is pointed out that there is no evidence available in support of the view that gross reversible changes in secondary sexual characters (such as, it is shown, may probably occur in certain Astacidae) actually take place in Penaeidae [p. 53, 61].
  4. Additions are made to the descriptions of the ocular pigment-fleck of Benthescyminae [p. 20]. The peculiar reverse-reniform eye of *Benthescymus investigatoris*, in which the proximal part of the layer of crystalline cones appears to have degenerated, is described [p. 49].
  5. The occurrence of intraspecific variation in presence or degree of development of the gills among Aristeae is confirmed [p. 86, 93].
  6. The parapeneid spine of the antennular peduncle is shown to occur, as in Penaeinae, in juveniles of Aristeae which lack the structure as adults. The spine, otherwise known in adults only within the series Parapeneae of Penaeinae, is present in mature individuals of *Benthescymus crenatus* Bate and *Haliporus thetis* Faxon [p. 29, 102].
  7. The occurrence of compound photophores in a species of the family, *Hymenopenaeus debilis*, is made known. The distribution of "open" and of "closed" systems of luminescence among crustacea is considered with reference to *Plesiopenaeus coruscans* [p. 112, 99].

#### DISTRIBUTION

1. The Aristaeinae and Solenocerinae are chiefly oceanic, the Penaeinae and Eusicyoninae chiefly littoral in habit. It is pointed out that so far as present knowledge goes, the oceanic forms, which are usually, though by no means always, cosmopolitan, seem often to be irregularly distributed within their great range [p. 1].
2. The presence of an Indo-Pacific and extreme southeastern Atlantic com-

- ponent in the oceanic fauna of the Bahaman region, not represented in the eastern basin of the North Atlantic, is made known [p. 3].
3. It is shown that, whereas the littoral peneid faunas of the Atlantic and Pacific American coasts are more nearly related to one another than to the faunas of other regions of the world, the reverse seems to be true of the deep-water peneids. This contrast is indicated to have a possible cause in the shallow depth of post-Cretaceous Middle American intercommunications between the Atlantic and Pacific, which while placing the littoral populations in contiguity, left the deep-water forms effectively at opposite ends of the world. It is therefore suggested that deep-water species common to Atlantic and Pacific America will be found to have maintained their identity by circumferential continuity [p. 6].
  4. Revision of the *Benthesicymus brasiliensis* complex permits a new statement of the distributions of the component species. *B. brasiliensis* Bate seems to be limited to the Atlantic; and *B. urinator* n. sp., to the Indo-Pacific; while *B. iridescens* Bate and *B. cereus* n. sp. are found in both oceans [p. 29].
  5. Although Balss' Indo-Pacific records must be considered as ambiguous, it is shown that *Bentheogennema intermedia* (Bate) does occur in the region [p. 57].
  6. The known Atlantic range of *Gennadas capensis* Calman and *G. bowieri* Kemp is considerably extended. *G. parvus* Bate is recorded from the Atlantic for the first time. The peculiar distribution of *G. elegans* (Smith) is discussed, and its absence from the southwestern North Atlantic is pointed out. Its replacement in this region by *G. capensis* Calman is compared with the similar phenomenon off the Cape of Good Hope [p. 71, 72, 74, 81].
  7. The known range of *Plesiopenaeus coruscans* (Wood Mason and Alcock) and of *Hemipenaeus carpenteri* Wood Mason is extended to the Atlantic [p. 96, 91].
  8. Pelagic captures of *Hymenopenaeus laevis* (Bate) and of *H. aphoticus* n. sp. are recorded. An analysis of the gut and statocyst contents indicates these specimens to have frequented the bottom, and leads to the suggestion that, as possibly also in certain species of *Benthesicymus* with statolith of benthonic derivation, these Solenocerinae may be quasipelagic [p. 105].
  9. The known range of *Hymenopenaeus mülleri* (Bate) is extended north to Rio de Janeiro [p. 120].
  10. The known range of *Funchalia (Pelagopenaeus) balboae* Faxon is extended to the Atlantic [p. 136].

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