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STUDIES ON INDIAN COPEPODS 2. AN ACCOUNT OF THE MORPHOLOGY AND LIFE HISTORY OF A HARPACTICOID COPEPOD, *TISBINTRA JONESI*, SP. NOV. FROM THE GULF OF MANNAR*

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PART I. DESCRIPTION OF THE SPECIES

SEWELL (1940) erected the genus *Tisbintra* to receive a single female copepod which he obtained during the John Murray Expedition in a surface tow-netting in the Mankauri Harbour, Nicobar Islands. To my knowledge no other species has so far been added to this genus and the genotype itself, *T. nankaurica* Sewell, has never again been recorded (Dr. Sewell has confirmed this in a personal communication). The discovery of a new representative of this genus with many morphological deviations is, therefore, of interest; specially so, because of the light it throws on the systematic position of the genus. Below is given an account of the morphology and life history of a new copepod obtained from the Gulf of Mannar and identified as a species of *Tisbintra* Sewell.

The occurrence of this species was first observed by Dr. S. Jones and it was at his instance that a detailed examination was undertaken. I have, therefore, much pleasure in naming the species *T. jonesi.*

Gooding (1957) has called attention to the fact that several terms have from time to time been used to differentiate the regions of the copepod body. Sars (1901) was the first to introduce some order by suggesting the terms cephalosomej metasome and urosome, the first two together to denote the usually broader anterior region and the last to denote the narrower posterior region respectively, irrespective of the morphological origin. Wilson (1932) adopted the nomenclature of Sars but interpreted that part of the body in front of the movable articulation as the metasome

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(which actually is the combined cephalosome and metasome of Sars) and the part behind the articulation as the urosome ; but in the text he has used other terms very frequently. I have adopted the terminology suggested by Gooding *{loc. cit.)* which appears to have definite advantages over the earlier ones. But the term abdomen may be added to denote the post-genital segments. In an earlier paper (Ummerkutty, 1960) I used the terms basipod, exopod and endopod to indicate the basal segment-complex and the external and internal rami respectively. The first term is probably not appropriate for the basal segment-complex actually comprises what are usually termed as coxopodite and basipodite; the term ' protopod' would be a correct one. In this paper the ' endopod', the ' exopod' and the protopod have been employed not only to describe the parts of the swimming legs but also for those of the cephalosomal appendages of the adult animals. The terms' protopodite, * ' endopodite' and ' exopodite' have been used only in the case of copepodites. In describing the ornamentation of the swimming legs I have followed Sewell (1949) in differentiating spines by Roman and setae by Arabic numerals.

The holotype, allotype and paratypes have been deposited in the Reference Collection Museum of the Central Marine Fisheries Research Station. All the diagrams are drawn with the aid of a *camera lucida.*

Tisbintra Jonesi sp. nov.

Occurrence. The species was first observed in the marine aquarium tanks of the Central Marine Fisheries Research Station. The animal was foun'd to creep on the glass walls and on the decaying vegetable matter on the bottom, probably feeding on them. It is of interest to note that this was one of the few copepods found to establish in good numbers in the aquaria to which it gains access through the pumping system.

In nature they were captured in the coastal plankton when the sea was in a disturbed condition. It appears that it is a bottom dweller and is brought upto the surface by water movements.

FEMALE

The colour. Body is transparent, tinged with faint yellow; dark shades are present in the mid-dorsal region of the metasomal segments. In mature specimens the ovary and its branches are seen as dark bands. So also is the gut when it is filled with food. *The body* is depressed, the anterior and posterior regions being clearly demarcated. The prosome is rather elongate-ovate, a little less than twice as long as wide and is vaulted dorsally. Cephalosome is fused with the first pedigerous segment and is almost as long as all the metasomal segments combined. The epimeral plates of the second and third prosomal segments are well-developed, being produced laterally and posteriorly and are rounded at the edge ; that of the last segment is very small without lateral expansion. Urosome is moderately slender; the genital segment is as long as the next three segments combined and is divided dorsally along the middle (Fig. I, 1). On the ventral side the division is incomplete and there is a transverse genital aperture which is guarded by a long slender spine on each side (Fig. I, 2). The longest specimen measures 1.1 mm. and the proportional lengths of the prosome and the urosome are 59 : 41. The second innermost furcal seta is the longest and is distinctly longer than the urosome.

Antennule (Fig. I, 3) is short, hardly exceeding the length of cephalosome and consists of 8 segments having the following proportions :

1	2	3	4	5	6	7	8
9.5	25.0	21.0	22.5	4.0	5.0	4.5	8.5=>10O

The antennule carries a large number of rather short setae and the presence of a crescent-shaped knob, just beyond the mid-length of the third segment bearing 4 radiating setae, is a characteristic feature. The aesthetask on the 4th segment is well-developed and extends far beyond the tip of the antennule. The latter is divided into proximal wider and distal narrower parts, each being composed of 4 segments ; the distal four segments are much smaller and their combined length is just a little more than 1 /4th of the proximal wider part. *Antenna* (Fig. I,4) : The enddpod consists of 3 segments, the terminal segment being the longest. The first segment carries a very small bristle on the outerside, at one-third of the length of the segment and a long seta at its distal inner margin. The second segment is devoid of any seta. The third segment has two stout setae on the anterior margin a little beyond the mid-length. At the apex it has one spine and five setae, 3 of which have a characteristic curve. The exopod is composed of two segments and is attached to the side of the basal endopod segment; the proximal segment is shorter bearing one seta ; the distal one bears two setae basally and three terminally one of which is very small. *Labrum* (Fig. I, 5) : This is rather prominent tapering distally ; terminal edge is denticulate, coarse in the middle and finer at the sides. In addition, two fine hairs are present on either side of the denticulated area. *Mandible* (Fig. I, 6): This consists of a biramous palp and a slender biting ramus. The latter is provided with several teeth at the apex and has a truncate projection on its postero-lateral margin. The rami of the palp are uniarticulate and slender and are borne on a uniarticulate protopod. The two rami represent the exopod and the endopod. *Maxillule* (Fig. 1,7) : A palp is present but an epipodal lobe is entirely lacking. The body of the maxillule is provided with a tuft of setae at its apex, a strong solitary seta sub-terminally on the distal outer margin and 2 short setae on the ventral side ; the latter actually terminate two elevated lines which converge towards the apex. The palp carries a number of setae which are arranged linearly along its inner margin from the mid-length to the apex. *Maxilla* (Fig. I, 8) : This is two-segmented but the segmentation is not easily discernible ; there is no lateral lobe on the basal segment; the distal segment bears at its apex a long stout claw which is serrate at the distal inner edge ; a process, spatulate and fringed, is present on the inner margin of the claw just beyond its mid-length ; a group of 4 radiating bristles and an accessory spine are present near the base of the claw. *Maxilliped* (Fig. I, 9) : In the maxilliped, the third segment is not separated from the second ; the terminal claw is very slender and distinctly longer than the second and third segments combined ; the accessory spine, as in the maxilla, is close to the base of the claw ; the basal segment is sparsely provided with hairs; in addition, it bears a small projection at its proximal outer margin which is provided with a tuft of hairs.

First leg (Fig. I, 10): The exopod consists of three stout segments and the endopod of two much elongated segments, both closely resembling those of *T. nankawica* Sewell; but the arrangements of spine on the exopod is different from that of the latter species. The marginal spine on the first exopod segment is long with a wavy appearance whereas that on the second exopod segment is short and stout, a condition generally found in species of *Tisbe* and in contrast to that of *T. nankaurica.* Exopod II is of about the same length as exopod I and bears an inner seta and an outer spine; exopod III is quadrate in form and bears two slender spines

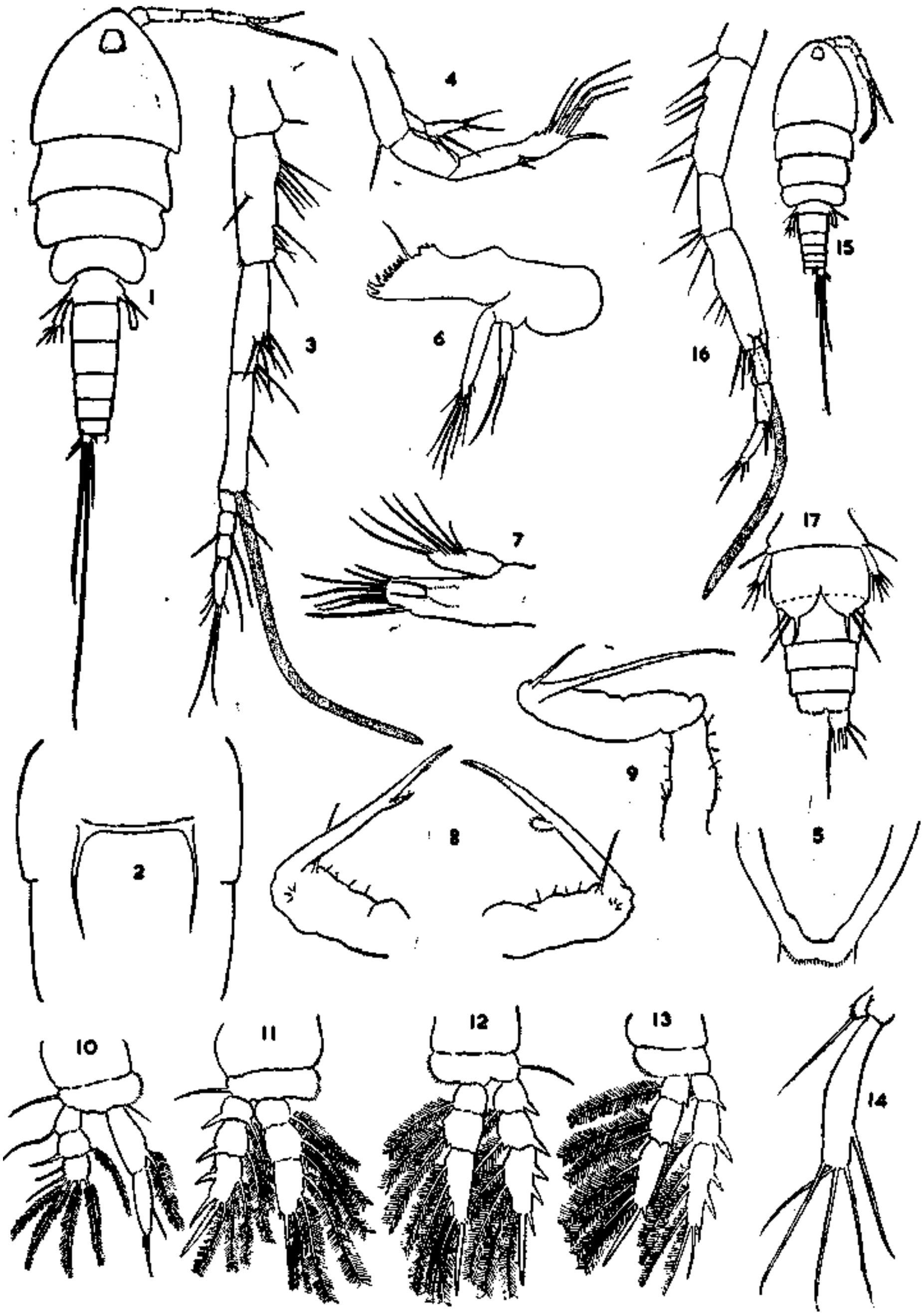

FIG. I

1. Female, adult, dorsal view.
2. „ genital segment ventral view.
3. „ antennule.
4. „ antenna.
5. „ labrum.
6. „ mandible.
7. „ maxillule.
8. Female, maxillae.
9. „ maxilliped.
10-14. First to fifth legs.
15. Male, adult, dorsal view.
16. „ urosome ventral view.
17. „ antennule.

on its outer margin and four plumose setae at the apex. The endopod is considerably longer than the exopod and consists of only two segments of approximately equal length; the proximal segment is moderately stout, is equal in length to the three exopod segments combined and bears a single inner seta at about the junction of the middle and distal thirds ; the distal segment is slender and bears a spine at about its mid-length and two spines at its apex one of which is stronger and longer than the other. Both segments of endopod bear small hairs on their inner margins. Second, third and fourth legs (Fig. I, 11, 12 & 13) are all with 3-segmented rami and are more or less similar in appearance. However, in the second leg the proximal spine on the third segment of the exopod is markedly reduced in size. The number of setae and spines borne by different segments, of the endopods and exopods are given below (Si, St and Se represent the inner, the terminal and the outer margins of the segments ; and P_s-P_4 represent the second to third swimming legs).

	Protopod				Endopod							Exopod						
	1		2		1		2		3			1		2		3		
	Si	Se	Si	Se	Si	Se	Si	Se	Si	St	Se	Si	Se	Si	Se	Si	St	Se
P2	0	0	0	1	1	0	2	0	4	I	0	1	I	1	I	3	I	III
P3	0	0	0	1	1	0	2	0	5	I	0	1	I	1	I	4	i	m
P4	0	0	0	0	1	0	2	0	4	I	0	1	I	1	I	4	i	in

Fifth leg (Fig. I, 14): In the fifth leg the basal segment is produced externally in a small conical process that bears a loiig and a short seta and a few hairs at its tip; there is no inner expansion ; the distal segment is cylindrical, narrower at the base than at the apex and is 6 times as long as broad ; it bears one seta subterminally on its distal inner margin and 4 setae at the apex, one of which is smaller than the other three setae which are rather subequal.

MALE

The male (Fig. I, 15) resembles the female in general form but measures only 0.64 mm. The proportionate lengths of the prosome and urosome are 66.6 : 33.4. The differences between the two sexes consist of the geniculate antennule, the presence of vestigeal sixth pair of legs and the six-segmented nature of the urosome of the male, besides the smaller size of the latter. *Antennule* (Fig. 1,17): This forms a grasping organ and is strongly built and consists of only 7 segments having the following proportions.

1	2	3	4	5	6	7	
9.5	25.0	11.5	25.5	9.0	9.5 ,	10.0	= 100

The aesthetask is borne by the fourth segment as in the female. The antennules are not provided with as many setae as are present in the case of female.

The genital armature or sixth pair of legs (Fig. I, 16) is a broad bi-lobed flap covering the entire ventral side of the genital segment and part of the succeeding segment. It bears 3 spines on either side ; the innermost is stout and backwardly directed; the outer ones are rather slender and posterolateral.

The urosome is 6-segmented consisting of the fifth leg-bearing segment, the genital segment and 4 abdominal segments. The first segment is of about the same proportionate dimensions as in the female. The genital segment and the first abdominal segment are subequal and are the largest segments of the urosome. The last three abdominal segments diminish in size to the posterior side.

T. jonesi differs from *T. nankaurica* in a number of features and they are listed below:—

T. nankaurica Sewell	*T. jonesi* sp. nov.
Size of the female 1.23 mm. and the proportional lengths of prosome and urosome=62 : 38	Size of the female 1.1 mm. and the proportional lengths of prosome and urosome -59:41.
Rostrum distinct.	Rostrum indistinct.
Second inner furcal seta is as long as the urosome.	Much longer than the urosome.
Genital segment in female divided laterally.	Divided laterally and dorsally.
The genital aperture situated very near to the pjoximal end of the segment and the spines guarding the aperture hardly reaching its mid-length.	The genital aperture situated at about i the length of the genital segment away from its proximal end and the spines guarding the aperture reaching well into its J length.
. The>seta:tion on the antennule very sparse.	Rather profuse. A characteristic crescent-shaped knob bearing 4 radiating setae present on the third segment.
. The~apical setae" of the endopod of second antenna -aH straight.	Three of the setae have a characteristic . outward bend at their 2/3 lengths.
Mjixilhile and its palp each tipped with a tuft of stout spine-like setae..	- In addition to the terminal tuft of setae, the maxillule also bears 3 spines, one on the distal outer margin and 2 on the ventral side. The maxillular palp bears a number of setae on its inner margin arranged linearly from about the mid-length to the apex.
. Maxilla is comparatively simple in structure with only awngleistout ferminalclaw, having ho serration.	An accessory spine present r«|ar the base of the terminal claw which bears on its inner margin near the" centre, a spatulate and fringed prqcess. The distal end of the claw is serrate.
Maxilliped not described or sketched by Sewell.	Maxilliped apparently with no division between the second and third segments. An .accessory spine and a terminal claw present.
The marginal spine on the first exopcd segment of the first leg is of moderate length whereas that on the second segment is considerably longer.	The marginal spine on the first exopod segment of the first leg is considerably longei than that on the second segment.
Exopod EH of .first leg bears 3 delicate setae-like spines on the outer margin and 4 plumose setae on the distal margin.	Exopod ID? offirst leg bears 2 delicate seta-like spines on the outer margia 4 plumose setae on the distal margin.
Second segment of first endopod bears a single straight spine distally.	Second segment of first endopod bears 2 spines one of which is shorter than the other.
Fifth leg Jong ,and slender with one inner and three terminal setae.	Fifth leg long and slender with one inner and four apical setae. : \

Notes on the Genus—The absence of male specimens of *T. nankaurka* and the tact that the genus has been based on a single species have naturally placed limitations on the scope of its definition as provided by Sewell. When new allied forms, not sharing all the features of the genus are discovered, the original definition would

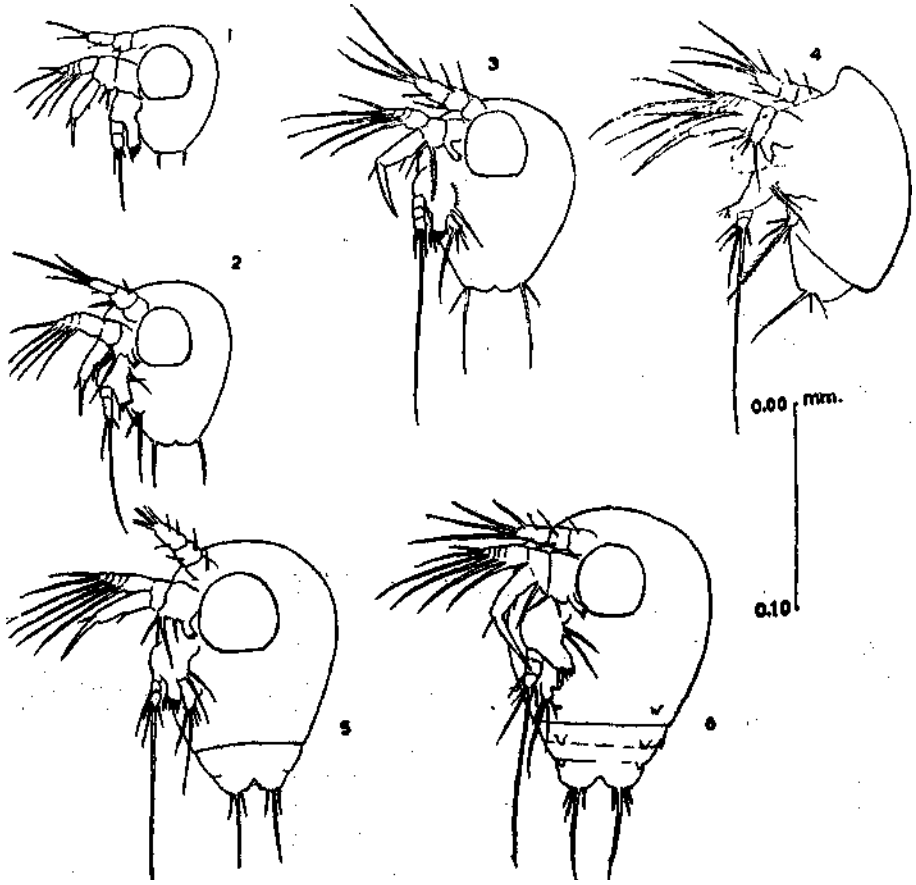

FIG. II

1-6. Naupliar stages first to sixth. Fourth stage lateral view; all the others ventral view.

require either modification or expansion. Alternately the new forms could be kept as a subgroup in the older genus. In the present case it appears that it is not in the fitness of things to treat *T. nankaurka* and *T.jonesi* as anything more than two species of the same genus for they both possess many common features. However, this would necessitate some alteration in the definition of the genus *Tisbintra.* The presence of a rounded rostral projection on the cephalosome, for instance, is considered as a generic character by Sewell. In the present species the rostrum is absent although it is undoubtedly a representative of the genus.l Again, in *T. nankaurka* the genital segment shows transverse division only laterally and this is described as a generic character by Sewell; in *T. jonesi* the division extends to the dorsal side as well, Conversely,*'Jhe* highly reduced proximal spine on the terminal segment of the exopod of the second leg is described as a specific feature by Sewell. It appears that, this character may well be of generic importance for it is present in *T, jonest* also. In view of these facts the genus *Tisbintra* Sewell is redefined here as follows :

Body depressed ; cephalosome fused with the first segment, forming the cephalothorax; the epimeral plates of first and second metasomal segments are produced laterally and posteriorly and are rounded at the edge ; that of the third metasomal segment distinctly less wide. Urosome half as wide as the metasome ; the segment bearing the fifth leg greatly narrowed and is almost as wide as the following genital segment; the latter in female long and divided and is provided with 2 long spines, one on either side of the genital aperture ; in male it is provided with a well developed genital armature ; Abdomen 3-segmented in female and 4-segmented in male. Caudal rami short with second inner seta much elongate ; antennule slender, 8-segmented in female, 7-segmented and geniculate in male; endopod of antenna 3-segmented, exopod 2-segmented and much smaller; the mandible possesses a biramous palp and a slender biting ramus provided with several teeth distally and with a truncate projection on its posterior margin; maxillule without an epipodal lobe; maxilla and maxxiliped both uncinate. Endopod of first legs 2-segmented and prehensile, exopod 3-segmented and natatory; rami of second, third and fourth legs 3-segmented ; proximal spine on the third exopod segment of second leg markedly reduced in size ; fifth leg 2-segmented, basal segment without an inner expansion, distal segment narrow, and elongate. A single ovisac present.

PART II. LIFE HISTORY

Procedure. Live egg-carrying females were picked from aquarium tanks and fresh plankton and kept in filtered sea water contained in beakers of 100 cc. and 200 cc. capacities. In most cases it hardly took more than 24 hours for the larvae to hatch out, depending on the condition of maturity of the eggs. The hatching was cent percent successful and the larvae thus hatched developed through all the naupliar and copepodite stages to the adults, the whole process taking 7 to 9 days, in normal room teperature (28° C-31° C), varying according to the intensity of feeding. The animals were fed on a variety of marine food items such as powdered *GraciUaria crassa,** ground dried clams and a variety of fresh chopped sea weeds. All these appeared to be quite acceptable to the copepod.

Stages were picked at regular frequent intervals and preserved for subsequent study. Live specimens of the various stages also were examined. Experiments were repeated and the nauplii and copepodites were studied from different series of culture to confirm the results. Samples containing all the different developmental stages were also taken from'aquarium tanks for examination and comparison. However, no nauplius or copepodite (except a few fifth stages) were obtained from the plankton.

All drawings have been made from specimens reared in the laboratory. The instars are separated only by one moult as in other copepods that have been studied. There are six naupliar and six copepodite stages, the last of which is the adult. They are described below in detail. All the diagrams were made with the aid of a camera lucida.

* Kindly supplied by Dr. (Mrs.) F. Thivy.

Naupliar Stages. There are six naupliar stages the last of which moults into the first copepodite. Like most of the harpacticoids the naupliar stages are bottom-living and come up to the surface waters only when they are disturbed. They are highly depressed, sub-circular in shape and transparent. They swim about gracefully and are capable of performing quick creeping movements along the glass walls of the culture jars and the pieces of algae that are introduced as food items.

NAUPLIUS I. (Fig. II, 1)

The first nauplius varies in length from 0.58-0.62 mm. and lasts for about 12 hours at 28° C-31° C. It has 3 pairs of appendages, the antennule, the antenna and the mandible. The antennule is 3-segmented with the terminal segment bearing 3 setae, two at the apex and one at the mid-length, and the middle segment carrying 1 seta. In the atenna the endopodite is stoutly built and 1-segmented, terminating in a stout claw more than half as long as the ramus itself. Itralso carries 2 spines, one near the claw and the other at the mid-length. The exopodite is 4-jointed, first .three of them carrying 1 seta each and the apical one 2 setae. The endopodite and the exopodite are borne on a bimeroiis protopodite. The protopodite I of antenna is provided with a rudimentary masticatory blade; Protopodite II bears 2 spines. Mandible consists of an exopodite of only two joints of equal length and an endopodite of one segment which is as long as the combined length of the exopodite segments. Exopodite II bears 3 setae, one of which is very long. Endopodite bears 2 fine setae and 3 spines. The caudal armature consists of 2 rather flaccid setae.

NAUPLIUS II. (Fig. II, 2)

The second nauplius varies in length from 0.80-0.90 mm. and lives for about 16-20 hrs. at normal room temperature. The structural advances over the first stage are as follows : Antenaule is 3-segmented; 2 setae are present on the second segment and an additional apical seta on the third segment; first segment is still without any seta. The masticatory blade of the antenna is well defined and is denticulate. Of the two setae present on the second protopodite, the inner one becomes longer and setiferous while the outer one is more spine-like. Mandible: The protopodite (which is still unsegmented) bears 2 setae, one of these being twice as long as the other. Maxillule appears as two strong setae, borne on a bud, one on either side just behind the mandible. Caudal armature, again, consists of 2 setae which are comparatively longer and stouter than those of the first stage. The posterior margin of the body of the nauplius gives a cleaved appearance.

NAUPLIUS HI. (Fig. II, 3)

The length varies from 0.10-0.105 mm. and the duration of life is the same as in the second stage at 28°C-31°C. The third stage shows the following morphological advances over the second stage. Antennule : First segment now carries 1 seta and the terminal segment is with one more seta at mid-length. Mandible : Fine bristles appear in the basal inner margin, of the protopodite, just before the two setae and the long seta of the terminal exopodite segment is-longer than the entire body. Maxillule : A small additional seta appears on the inner side of the large seta and a protopodite is present Caudal armature now consists of two setae on either side, the inner one being much longer than the outer.

NAUPLIUS IV. (Fig. II, 4)

The length varies from 0.12-0.125 mm. and lasts for about 14 to 16 hours at normal room temperature. The number of setae present on the segments of antennule remains the same except that one seta is added in the terminal segment, bringing the total number to six. Antenna : The masticatory blade is quite long and a seta is present near its base. A third, seta is added to the two setae on the second protopodite segment. The exopodite becomes 5-segmented, the first 4 segments bearing one seta each and the terminal segment 2 setae. Mandible : Terminal exopodite segment bears 4 apical and one subapical seta. The masticatory palp is stouter than in the previous stage. Maxillule is quite well-developed with 4 setae, one of which is very stout and long bearing hairs all along its length. Each caudal ramus carries 2 small setae in addition to the long seta.

NAUPLIUS V. (Fig. II, 5)

The fifth stage varies in length from 0.135-0.140 mm. and live for 14 to 18 hours at normal room temperature before moulting into the next stage. This stage is very similar to the fourth stage, but the segmentation of the posterior region becomes much more distinct. The oral appendages show little change except the maxillule which now shows signs of segmentation. Each caudal ramus carries 3 setae.

NAUPLIUS VI. (Fig. II, 6)

This stage varies in length from 0.14-0.15 mm. and lives for about 20 to 24 hours. The sixth nauplius moults into the first copepodite and is far advanced iri structure than the fifth stage. The rudiment of maxillae and first and second pairs of legs are present as buds. But none of these bears any seta. The other appendages are very similar to those of the fifth stage. There are four setae on each caudal ramus and they are all longer and stouter than those of the previous stages. The distinguishing features of the sixth nauplius are the clearly segmented hind part of the body and the presence of the rudiments of the first and second swimming legs.

Copepodite Stages. There are five copepodites, the last of which moults into the adults. Like the nauplii the instars are separated by only one moult. The copepodites are active creatures most of them creeping about on the algal pieces in the culture dishes and making quick movements at slight disturbances. The segmentation of the prosome and the urosome as well as that of the swimming feet follow the general pattern of the harpacticoid development.

COPEPODITE I. (Fig. Ill, 1)

The first copepodite is a miniature adult, but with only 5 segments, 3 prosbmal and 2.urosomal and the distinction in width between the two regions is considerably small. The caudal rami is wider than long and stuffy. The furcal setae are all well-developed and resemble those of the adult.

All the mouth parts have made their appearances and resemble the adult structures in their basic pattern. The details of the differences from the latter are

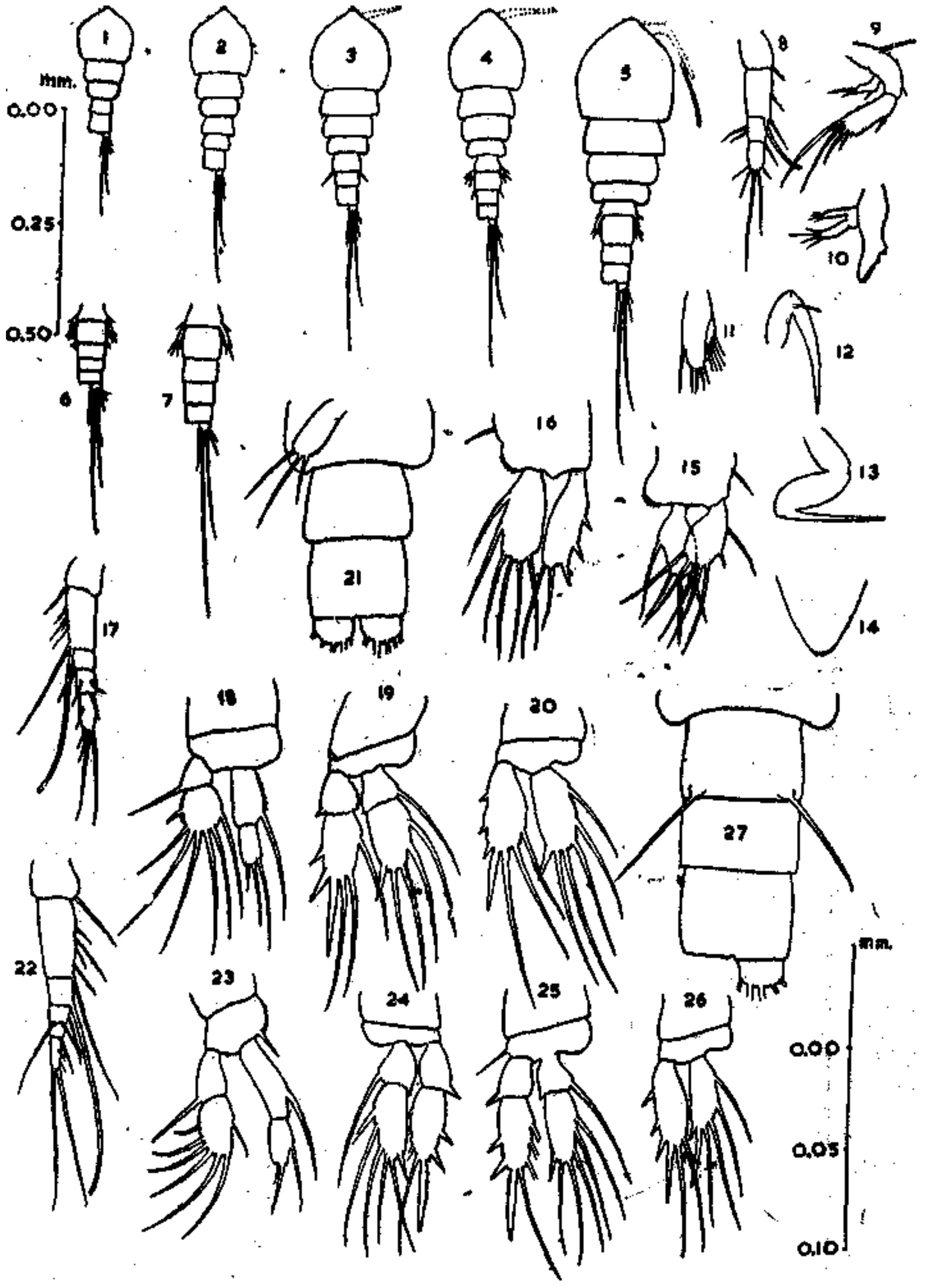

FIG. Ill

1-3. Copepodite first to third.
4. Copepodite IV male.
5.'Copepodite IV female.
6. Urosome of Copepodite V male.
7. „ „ V female.
8. First Cop. antenmile.
9. „ antenna.
10. „ mandible.
11. „ maxillule.
12. „ maxilla.
13. „ maxilliped.
14. „ labrum.

15-16. first and second swimming legs.
17. Second Cap. antenriule.
18-20. „ first to third /swimming legs.
21. „ urosome wife last prosomal segment carrying the fifth eg.
22. Third Cop. antennule.
23-26. „ first to fourth legs.
27. „ Urosome with vestigeal fifth leg, ventral view.

(Diagrams 1 to 7 of Fig. m are rf'awn according to Scale 1 and 8 to 27 according to Scale 2).

noted below : Antennule (Fig. III, 8) : This is only four segmented ; the third segment bears a fine aesthetask. Antenna (Fig. III, 9) : The division of exopodite into 2 segments is not discernible. In the endopodite there are only 4 apical setae and a small bristle. Maxilla (Fig. III, 12) : The spatulate process of the apical claw has not yet appeared ; the terminal edge of the claw not serrated. Maxilliped (Fig. III, 13) : No accessory spine is present ; the tuft of hairs on the proximal segment is absent.

There are only two pairs of swimming legs and vestige of the third (Fig. III, 15 & 16). The rami of both the first and second legs are 1-segmented. The vestigeal third leg is peg-like, bearing 3 setae. The exopodite of first leg anticipates the adult structure: the proximal spine is already much longer than the second spine, a character which the present species possesses, in contrast to the only other known species of the genus, *T. nankaurica*. The division of the protopodite is not clear. The average length of this stage is 0.208 mm. It lives for about 18 hours under normal room temperature (28°C-31°C).

COPEPODITE II. (Fig. III, 2)

The number of segments is increased to six, 4 prosomal and 2 urosomal. The general appearance is similar to that of the first stage. Antennule (Fig. III, 17) is 5-segmented, the second one bearing the aesthetask. All other mouth parts show adult structures except the maxilla which still has not developed the spatulate process on the terminal claw. There are three pairs of swimming legs and a vestige of the fourth (Fig. III, 18, 19, 20 & 21). The rami of the first two legs are 2-segmented and those of the third leg 1-segmented ; the protopodites of all the three pairs of legs are clearly 2-segmented. The vestigeal fourth leg is only a small process with three terminal setae. The average length of this stage is 0.375 and the duration of life about 20 hours.

COPEPODITE III. (Fig. III, 3)

There are 4 segments in the prosome while a third segment is added to the urosome. The distinction in width between the two divisions is more pronounced than in the preceding stages. Antennule (Fig. III, 22) is 6-segmented the third segment bearing the aeshetask. The other cephalosomal appendages are very similar to those of the adult. There are 4 pairs of biramous legs and a vestige of the fifth (Fig. III, 23, 24, 25, 26 & 27). The rami of the first three pairs are 2-segmented and those of the fourth only 1-segmented. The protopodite of all the four pairs of legs are clearly segmented. The protopodite II of first legs has not yet developed the seta on its outer margin. The fifth vestigeal segment is borne by the first urosomal segment and is each represented by only a single seta with a well defined base. The average length is 0.460 mm. This stage lasts for about 20 hours.

COPEPODITE IV. (Fig. III, 4 & 5)

Prosomal and urosomal segments are now equal in number, each region being composed of four segments. The body has all the adult features, including the lateral expansion of the first and second metasomal segments and the dimorphism of the sexes. The male is much smaller than the female being only slightly longer than the third stage :

The size of the male=0.490 mm.

The size of the female=0.577 mm.

The sexes are easily distinguished by the presence on the second urosomal (genital) segment of the male of a spine representing the vestige of the sixth pair of legs (the so-called genital armature, Fig. IV, 1).

The antennule is 7-segmented in both sexes (Fig. IV, 2). The first four pairs of swimming legs are biramous, each ramus being composed of 2 segments (Fig. IV, 3, 4, 5 & 6). The fifth pair of legs (Fig. IV, 1) consists of a short peg-like structure with three apical and one basal setae. In the male the sixth pair of legs is each represented by a single seta projecting postero-laterally from the second urosomal (genital) segment. The fourth stage lives for about the same period as the third stage.

Copepodite V. (Fig. III, 6 & 7)

This stage has nine segments, 4 prosomal and 5 urosomal in both sexes. In the female the genital segment is not yet divided but is distinctly longer than the other segments of urosome. The two spines on either side of the genital aperture are present but are shorter than those of the adult. Length of the female is 0.832 mm. and that of male 0.535. Antennule : This is stumpy and 7-segmented in male (Fig. IV, 8) and normal and 8-segmented in female (Fig. IV, 7). In the latter all the adult features, including the crescent-shaped knob on the third segment have been formed. But in the male although the proximal segments of the antennule are foreshortened it has not become completely geniculate. All the swimming legs are present (Fig. IV, 10, 11, 12 & 13). The first four pairs of legs are biramous, the rami being 3-segmented except the first endopod which is only 2-segmented. The setation of the various segments are similar to those of the adult except in the fifth leg (Fig. IV, 14) where there are only 3 apical and 1 sub-apical setae whereas in the adult the corresponding numbers are 4 and 1. The proximal spines of the third exopodite segment of the second leg is considerably reduced in size.

The Adults

The detailed description of the adult male and female are given in the earlier part of this paper.

Remarks. Johnson and Olson (1948) have given an account of the life history of *Tisbe furcata* which they reared through all the stages in the Laboratory. Few more marine harpacticoids have been subjected to large amount of investigations and much detail is known about their life histories and reproduction. (Nicholls, 1935 ; Fraser, 1936 ; Gurney, 1930 & 1932). However, the knowledge of the life histories of harpacticoid copepods from Indian waters is extremely meagre. Krishnaswamy (1950 and 1955) has given an account of the life histories of *Macrosetella gracilis* and *Leptostacus euryhalinus*. Rao (1958) described the developmental stages of *Euterpina acutifons*. Of these *Leptostacus euryhalinus* is a psammophilious copepod, the other two being planktonic in their habits.

Many previous investigators (Gurney, *loc. cit* ; Johnson, 1934 a & b ; 1935) have called attention to the striking similarity that exists between the nauplius larvae of marine copepods belonging to the same genus. Johnson (1935) cites the developmental stages of *Labidocera*, *Epilabidocera* and *Pontella* to show that this identity can be found even in the larvae of different but closely related genera and concludes

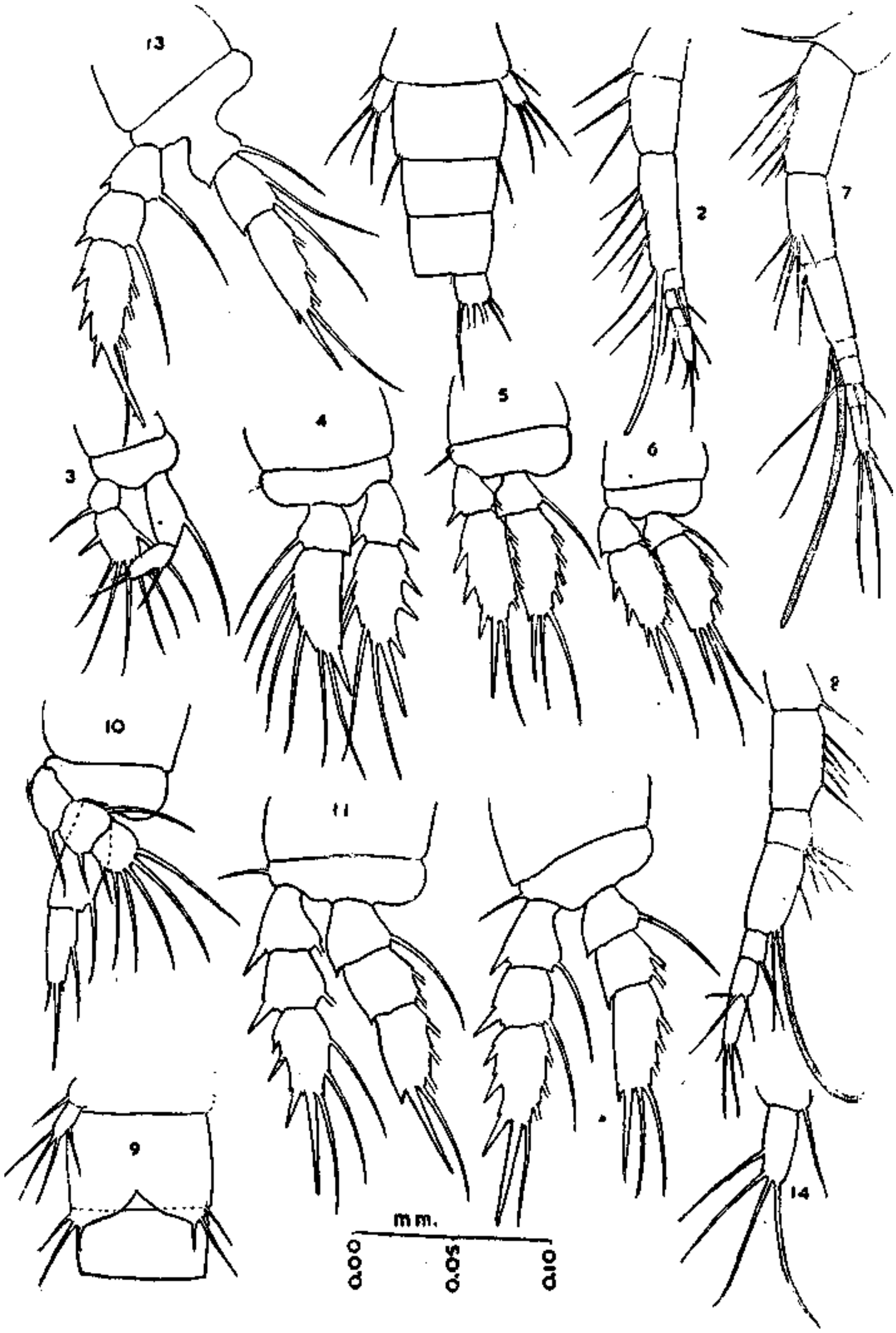

Fig. IV

1. Fourth Cop. male urosome with fifth leg, and vestigeal genital armature.
2. ,, antennule.
3. ,, first **leg.**
4-6. ,, female second to **fourth legs.**
7. Fifth Cop. female antennule.
8. Fifth Cop. male antennule.
9. »> >> first and second urosomal segments with fifth **leg** and genital armature.

10-14. Female first to fifth **legs.**

that the larvae of allied genera conform each other in essential structural details. It is, therefore, not surprising to observe a very close similarity between the larvae of *Tisbintra* and *Tisbe.* In fact, that is what one should expect for these forms have not only close systematic kinship but they both occupy the same ecological niche, namely, the bottom inshore waters. A very close similarity exists between the naupliar stages of *Tisbintra jonesi* and *Tisbe furcata.* The real differences between these species, however, make their appearances from first copepodite onwards. Judging from the figures of Johnson and Olson *(loc. cit.)* it is clear even in the general appearance they are widely separated ; while the cephalothorax of *T. furcata* is almost as long as the combined length of all other four segments that of *T. jonesi* is just a little more than one-third the entire body length. The differences in the various copepodite stages of the two species, such as the reduced development of the proximal spine of the third segment of the second exopodite and 2-segmented' nature of the endopodite of the first leg are traceable to the conditions of the adult.

SUMMARY

(1) A new species of harpacticoid copepod *Tisbintra jonesi* is described in detail and a redefinition of the genus *Tisbintra* Sewell is rendered in the light of the information available regarding the male.

(2) The complete account of the life-cycle of this species is given. As in all other copepods that are studied there are six naupliar and six copepodite stages, the last of which is the adult.

(3) The striking similarities of the naupliar stages of *Tisbintra jonesi* with those of *Tisbe furcata* are briefly discussed.

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