A REVIEW OF THE SUBGENUS *THERMOCYCLOPS* KIEFER OF THE GENUS *MESOCYCLOPS* SARS, WITH A DESCRIPTION OF A NEW FORM OF *MESOCYCLOPS* (*THERMOCYCLOPS*) *SCHMEILI* POPPE AND MRÁZEK (CRUSTACEA : COPEPODA)

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(With 5 Text-figures)

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I—INTRODUCTION

A preliminary examination of a small collection of examples of a species of the genus *Mesocyclops* Claus indicated that I had before me a form that did not appear to correspond exactly to any hitherto known species, differing in small details of structure from those previously recorded, though it clearly belonged to the subgenus *Thermocyclops* Kiefer. In 1930 the late Dr. Calman in his Presidential Address to the Zoology Section of the British Association for the Advancement of Science remarked, " It may be a counsel of perfection to suggest that no one should introduce a specific name without undertaking at least a partial revision of the genus including it, but there are very many instances, where the multiplication of species might with advantage be postponed until we learn something about those that are supposed to be ' known' " Gurney (1931, p. 27) pointed out that in our study of the genus *Cyclops* (s. lat.) we had at that time reached a stage where extensive and detailed study had resulted in the creation of a number of subspecies and varieties, often based on minute differences, being described in any given species : and that it is impossible correctly to judge of the value of such small differences until we know the range of variation that may be found in such a species, firstly in a stable environment and secondly in environments of rather different characters and he (*loc. cit.*, p. 29) points out that " The probability seems to be that further investigation would show that the subspecific characters are merely manifestations of individual variability throughout the range of the species " This point of view becomes even more important when we have to consider those groups in which the so-called species and subspecies are separated from one another by such differences in details of structure as may well be due to a slight variation in the rate of development and these, in turn, possibly be due to slight seasonal differences in the environment in which the examples were living. Gurney (1933, p. 301) sums up the position as it then existed in the following words : " No less than 27 species of *Thermocyclops* have now been described, several of which differ less from typical *C. hyalinus* than some of these Indian and African specimens do and it seems there need be no end to the number that may be described in future, if reliance is placed on minute differences in lengths of segments, spines and setae " Lowndes (1934, p. 83) remarked, " That taxonomy is getting to an impossible state must be recognised by almost everyone " and a little later (*loc. cit.*, p. 88) he sums up the situation by remarking, " as Taxonomy progresses, more and more detail is incorporated with the result that specific distinctions, unless they are carefully tested by breeding experiments, become more and more unreliable " Lindberg (1942, p. 149) quotes Chappuis (I have been unable to check this reference) as saying regarding Lowndes' views that this author appears to have arrived at the paradoxical conclusion that the more detailed the description of an animal, the more the animal becomes unrecognisable or in other words the better defined species is that which is known only from a single specimen. Kiefer (1952, p. 18) points out that the fundamental concept of taxonomy is the species concept and that, in the Linnaean tradition, the description of a species applies only to a single individual, the " Type " As descriptions become more and more detailed it equally becomes more and more obvious that no two individuals are identical and the most minute details of structure become individualistic and not specific, as, for instance, the finger-prints of a human being.

In a study of the subfamily Cyclopinae of the family Cyclopidae the taxonomist is faced with a difficult problem. In 1929 Kiefer divided the genus *Mesocyclops* Sars into two subgenera, *Mesocyclops* (s. str.) and *Thermocyclops* Kiefer, with at that time five species in the former and fifteen in the latter. But already the subdivision of the species into subspecies had begun and *Mesocyclops leuckarti* Claus had been divided into the following subspecies :—

Mesocyclops (*Mesocyclops*) *leuckarti leuckarti* (Claus)
" " " *bodanicola* Kiefer
" " " *aequatorialis* Kiefer
" " " *edax* (Forbes)

and since then the following subspecies and forms have been added :—

Mesocyclops leuckarti decannensis Lindberg
" " *pehpeiensis* Hu
" " forma *fortii* Mann
" " forma *pilosa* Kiefer

In 1933 Gurney called attention to the difficulty experienced in distinguishing between the various species that were then known and he pointed out that in the genus *Mesocyclops* (s. lat.) there were as many as 35 recorded species.

II—THE SUBGENUS *THERMOCYCLOPS*

At the present day there are as many as 47 species and subspecies in the subgenus *Thermocyclops*, namely :—

1. *Mesocyclops* (*Thermocyclops*) *analogus* Kiefer
2. „ „ *asiaticus* Kiefer
3. „ „ *brehmi* Kiefer
4. „ „ *brevifurcatus* Harada
5. „ „ *conspicuus* Lindberg
6. „ „ *crenulatus* Brehm
7. „ „ *dybowskii* (Lande)
8. „ „ *emini* (Mrázek)
9. „ „ *hyalinus* (Rehb.) *hyalinus* (s. str.)
10. „ „ „ *consimilis* Kiefer
11. „ „ „ *macrolasius* Kiefer
12. „ „ „ *ndalaganus* Kiefer
13. „ „ „ *kivuensis* Kiefer
14. „ „ „ *persicus* Lindberg
15. „ „ *ianthinus* Harada
16. „ „ *incisus* Kiefer
17. „ „ *infrequens* Kiefer *infrequens* (s. str.)
18. „ „ *infrequens* Kiefer *nigerianus* Kiefer
19. „ „ *infrequens* Kiefer *eduardanus* Kiefer
20. „ „ *inopinus* Kiefer
21. „ „ *inversus* Kiefer
22. „ „ *iwoyiensis* Onabamiro
23. „ „ *macracanthus* Kiefer
24. „ „ *mahéensis* Lindberg
25. „ „ *microspinulosus* Lindberg
26. „ „ *minutus* Kiefer
27. „ „ *mongolicus* Kiefer
28. „ „ *neglectus* (Sars) *neglectus* (s. str.)
29. „ „ „ *decipiens* Kiefer
30. „ „ „ *prolatus* Kiefer
31. „ „ „ *nigerianus* Kiefer
32. „ „ *oblongatus* Sars

33. *Mesocyclops (Thermocyclops) oithonoides* (Sars)
34. " " *operculatus aberrans* Lindberg*
35. " " *operculifer* Kiefer *operculifer* (s. str.)
36. " " *pachysetosus* Lindberg
37. " " *retroversus* Kiefer
38. " " *rylovi* Smirnov
39. " " *schmeili* (Poppe and Mrázek) *schmeili* (s. str.)
40. " " *schmeili* (Poppe and Mrázek) *hastatus* Kiefer
41. " " *schuurmanae* Kiefer
42. " " *stephanides* Kiefer
43. " " *tenuis* Kiefer
44 " " *taihokuensis* Harada
45. " " *tinctus* Lindberg
46. " " *trichophorus* Kiefer
47. " " *vermifer* Lindberg

In many of these species the male is unknown and in others it is represented by only relatively few examples. Since no males were present in the collection under investigation I have confined my study to the females only of the subgenus.

In those species in which a sufficient number of individuals has been subjected to careful examination it is clear that each character may exhibit a considerable degree of variation ; and it is impossible to judge of the value of such small differences as criteria for the differentiation of species until we know the range of variation that may be found in such a species, first, in a given environment of a stable character and, secondly, in environments of different characters. Lowndes (1934, p. 85) has stated that " one will find that the amount of variation is in no way proportional to the area of distribution " : but Lindberg (1938, p. 213), after a wide experience of individuals of what he believes to be one species, taken in the same or in different localities, has stated that examples taken simultaneously in a single locality exhibit relatively little variation but that one finds considerably greater variation between animals taken in different localities and even in those taken in the same locality but at different times of the year, as in the dry or wet seasons.

Van Oye (1926) pointed out that in his study of the plankton of the rivers of the Belgian Congo he found that with the seasonal changes in the character of the water and especially of the amount of rain-fall, which brought increased amounts of nutritive material, there resulted a corresponding change in both the qualitative and quantitative character of the plankton, which exhibited a double rise and fall, the rise and fall of the zooplankton following about 8 to 15 days after that of the phytoplankton. Pruthi (1932) and I (Sewell, 1934) carried out a series of observations on

* Lindberg under the name *operculatus aberrans* and in his account states that this form showed a close resemblance to the species described by Kiefer under the name *operculifer*. The correct name for this form should be *operculijer aberrans*.

the character of the water and the plankton of the Tank in the Indian Museum compound during 1929-1931 and found similar changes, and that in both the Diaptomidae and the Cyclopidae there was a double annual change in the size of the individuals of the same species, both in males and females, and that in the numbers of ova that were being produced there was a maximum in the winter months, October-December, and some indication of a second rise in the reproduction rate in the hot weather months of March-May. Mann (1940) has pointed out that the final differentiation of the various species of Cyclopids can only be determined after the careful examination of a large number of examples and he shows that the proportions of the furcal rami, the distal segment of the endopod of the 4th leg, and the proportions of the inner to the outer spine on this segment or of the inner spine to the length of the segment may vary from one year to another in the same habitat or from one habitat to another, even when close to and not dissimilar in character.

The differentiation of the species and subspecies in this subgenus is largely based on a number of relatively small differences, many of them being measurements of different parts of the body. Both Lindberg (1942, p. 145) and Kiefer (1952) have given lists of the structural features on which they have relied for the determination of the species of the subgenus *Thermocyclops*, and I give these below :—

1. The total length of the animal and the relative proportions of the various segments of both the anterior and posterior regions of the body.

2. The position of the furcal rami, parallel or divergent, and the proportional measurements of their length and breadth.

3. The relative lengths of the furcal setae.

4. The length of the antennule and of its various segments.

5. The number of setae on the penultimate segment of the antenna.

6. The proportions of length to breadth of the distal segment of the endopod of the 4th leg.

7. The proportion of length of the distal segment of the endopod of the 4th leg and the length of the innermost of the two distal spines on the segment, or of these spines to each other.

8. The character of the connecting lamella between the 4th pair of legs and the number of spines or the presence of hairs, or absence of both hairs and spines, on the rounded prominences of the distal margin.

9. The relative lengths of the inner spine and outer seta on the distal margin of the free segment of the 5th leg.

10. The form of the receptaculum seminis.

11. The number of ova in the egg-sac of the female.

I will, before I describe the new form, try and indicate to what extent we find in some of the characters given above a range of variation both in individual species and also between one species and another.

1. *The total length of the animal.*—Throughout the whole subgenus *Thermocyclops*, the individuals of which are of small size, there appears to be a steady and progressive change of body length :—

Species	Total length of body from forehead to tip of furcal ramus
	mm.
M. (Th.) consimilis	0·570—0·722
,, ,, *retroversus*	0·60 —0·855
,, ,, *operculatus aberrans*	0·605—0·650
,, ,, *dybowskii*	0·65 —1·04
,, ,, *iwoyiensis*	0·74 —0·86
,, ,, *oithonoides*	0·75 —0·90
,, ,, *neglectus*	0·750—0·940
,, ,, *rylovi*	0·756—1·140
,, ,, *emini*	0·79 —1·04
,, ,, *vermifer*	0·779—1·074
,, ,, *hyalinus*	0·80 —1·0
,, ,, *asiaticus*	0·84 —0·92
,, ,, *pachysetosus*	0·845—0·940
,, ,, *schuurmanae*	0·893—0·959
,, ,, *oblongatus*	0·90
,, ,, *schmeili*	0·90 —1·083
,, ,, *macracanthus*	0·92
,, ,, *tinctus*	0·920—1·254
,, ,, *mahéensis*	0·922—1·017
,, ,, *asiaticus*	0·429—1·024
,, ,, *decipiens*	not quite 10
,, ,, *brehmi*	1·0
,, ,, *tenuis*	1·0
,, ,, *trichophorus*	about 1·0
,, ,, *nigerianus*	1·0
,, ,, *operculatus*	1·0
,, ,, *infrequens*	1·06 —1·10
,, ,, *inopinus*	1·160
,, ,, *conspicuus*	1·121—1·235
,, ,, *microspinulosus*	1·178—1·306

In such species as have been recorded from a number of different localities we find, as might be expected, a considerable range in body length, as for instance in *vermifer* and *rylovi* ; and it seems clear that there is no clean break in the total length of the animal as we pass from species to species throughout the whole series.

I have already indicated (*vide supra*, p. 72) that the size of these small crustacea may depend to some extent on the change of conditions present in their habitat during different seasons of the year, and the same doubtless is true of the various habitats in which they have been found. It also seems probable that a mere change of bodily size may be accompanied by definite changes in the relative proportions of various parts of the body.

2. *The proportional length of the furcal ramus and the proportions of its length to breadth.*—Lowndes (1932*a*, p. 282) has remarked that " the length of the caudal rami has always been considered an important specific character ", but he showed that in a female of *Cyclops strenuus*, in which the ratio of length of body to length of furcal ramus was 1·0 : 0·124 and the proportional length to breadth of the furcal ramus was 7·3 1·0, the corresponding ratios in her offspring were 1·0 : 0·108-0·130, with an average of 0·121 in the proportions of length of body to length of furcal ramus and a proportion of length : breadth of the ramus that ranged from 4·35-6·40, with an average of 5·524. It would thus seem that these measurements can hardly be considered very reliable specific characters.

In the Calanoida I found (Sewell, 1932) that at each moult, while the whole body increased in length, the various segments exhibited differences among themselves, but the abdomen in almost every case increased in length in proportion to the anterior region, while the furcal ramus tended to decrease. One would expect to find that the same phenomenon was present in the Cyclopoida and in the present examples this does seem to be the case :—

Stage	Total length of animal	Proportional lengths of		
		Whole animal	Abdomen	Furcal ramus
IV ..	0·717 mm.	1000	305	95
V	0·90 mm.	1000	331	95
VI ..	0·95—1·05 mm.	1000	350	85·7

Thus, while the abdomen as a whole increases in proportion to the rest of the body at each moult, the furcal ramus becomes progressively shorter. One might expect to find traces of the same phenomenon in the adults of the same species.

Lowndes (1932*b*, p. 70), when commenting on the great variability of the length of the furcal ramus in closely allied species and even in individuals of the same species, remarks " if the rami are acting as a heterogenic organ there should be some definite relationship between the length of the rami themselves and the total length of the animal. The data at our disposal is (*sic*) scanty, but such as there are shows that no such relationship exists. " But he (*loc. cit.*, p. 77) later states that, " now it would not be difficult to show that among *Cyclops* generally there is a very strong tendency among the females for an elongation of the caudal rami " .and " within a number of single species it would not be difficult to show that this tendency for the rami to elongate is very prevalent. Now, this elongation is unquestionably an aberrant feature. Nearly all the common species have forms with elongate rami and yet this elongation does not occur among the males". As there are no males in the present collection I have therefore been unable to check the correctness of this last assertion. In the females, howover, there does seem to be a definite connection between the total length of the animal and the proportional length and breadth of the furcal rami. Lowndes (*loc. cit.*) gives a number of measurements of examples of the genus *Cyclops*, and an analysis of these shows that with increasing size of the animal there is a quite clear tendency for the furcal ramus to be narrower in proportion to its length :—

Species with number of examples	Total length	Average proportions of furcal ramus	
		L.	B.
Cyclops strenuus			
7	<1·79 mm.	5·585	1·0
10	1·80—1·89	6·207	1·0
10	>1·90	6·786	1·0
Leptocyclops speratus			
5	0·75—0·82 mm.	4·18	1·0
6	1·00—1·36	5·335	1·0
Leptocyclops agilis			
5	<1·0 mm.	3·94	1·0
7	>1·0 ,,	4·55	1·0
Leptocyclops macruroides			
3	1·03 mm.	6·3	1·0
3	1·04—1·25 mm.	7·0	1·0

Lindberg (1942) and Gurney (1933), fortunately, have given us detailed measurements of a number of individuals in various species and these show clearly that a change in body length is accompanied by changes in the proportions of the length to the breadth of the furcal rami :—

a. In *Eucyclops serrulatus* (Fischer) : (Lindberg, 1942, p. 88)

Body-length in mm.	0·80—0·99	1·0—1·99	1·1—1·19	1·2—1·30
Average L : B of the furcal ramus	4·70 : 1·0	4·98 : 1·0	5·30 : 1·0	5·78 : 1·0
No. of examples measured	17	20	7	6

Extreme range from 3·68 : 1·0 to 6·58 : 1·0

b. In examples of *Mesocyclops leuckarti* (Claus) : (Lindberg, 1942, p. 176)

Body-length in mm.	<1·199	1·200-1·299	1·300-1·399	1·400-1·499	>1·50
Average L : B of the furcal ramus	3·093 : 1·0	3·331 : 1·0	3·439 : 1·0	3·461 : 1·0	3·552: 1·0
No. of examples measured	6	9	7	7	14

Extreme range from 2·68 : 1.0 to 4.24 : 1·0

c. In examples of *M.* (*Thermocyclops*) *rylovi* Smirnov : (Lindberg. 1942, p. 183)

Body-length in mm.	< 0·9	>0·9
Average L : B of the furcal ramus	3·314 : 1·0	3·407 : 1·0
No. of examples measured	5	12

Extreme range from 3·04 : 1·0 to 3·60 : 1·0

d. In examples of *M.* (*Thermocyclops*) *vermifer* Lindberg (1942, p. 185)

Body-length in mm.	0·70-0·79	0·80-0·89	0·90-0·99	1·0-1·1
Average L : B of the furcal ramus	3·10 : 1·0	2·95 : 1·0	2·91 : 1·0	2·88 : 1·0
No. of examples measured	1	6	12	9

Extreme range from 2·48 : 1·0 to 3·32 : 1·0

In the first three species noted above the furcal ramus tends to become longer in proportion to its breadth with an increasing total length of the animal ; but in the last instance, in *Thermocyclops vermifer*, the exact opposite appears to be the case. Incidentally this seems to provide another argument in favour of Lindberg's contention that *rylovi* and *vermifer* are different species. The proportions of length to breadth of the furcal ramus also appear to vary in the same species in different localities. Gurney (1933, p. 293) gives measurements of examples of *M.* (*Th.*) *leuckarti* (Claus) from various parts of the old world, and in different regions the average proportions of the ramus in length to breadth are as follows :—

	Europe	Palestine, Seistan and India	Ceylon, Rangoon and Sarawak
	3·427 : 1·0	3·396 : 1·0	2·708 : 1·0
	(13 examples)	(6 examples)	(4 examples)
Average body length ..	0·97 mm.	1·08 mm.	0·95 mm.

and Lindberg (1935, p. 410) for his subspecies, *deccanensis*, from India gives the proportions as averaging 3·379 : 1·0, in 4 examples with a range of 2·88-4·03 : 1·0. Lindberg (1942, p. 143) has himself called attention to the difference in the proportions of the ramus in specimens taken in the south area of Iran and in those from the north region. He remarks, "La forme septentrionale, tout en étant plus petite, a aussi montré une furca plus coutre que celle des animaux du Sud, et sa soie dorsal a été légérement inférieure en longueur ; cette soie a parfois été fortement ciliée chez les échantillons du Sud "

3. *The relative lengths of the furcal setae.*—Previous observers have attributed considerable importance as an aid to the identification of a species to the proportional lengths of the furcal setae. Smirnov (1929) in his account of *Mesocyclops rylovi* laid great stress on the proportional lengths of seta 1 to 3 ; he remarks, "For the species described here the proportion of the innermost seta to the median seta is very characteristic, 1 : 1·43 or 1·0 to 1·75 " Between the lower and higher figure there is a range of 22·36 per cent. Gurney (1933, p. 64) has pointed out that great care must be exercised in attributing undue importance to such measurements, and points out that " absolute accuracy in measuring a seta is almost impossible. Setae are commonly so fine towards the end that it is not always possible to be sure that the end has been correctly seen, and it may have been broken or worn away " Below I give the average proportional lengths of the furcal setae in a number of species and subspecies, taking the length of the 2nd seta, the longest, as 100. In numbering the furcal setae I have followed the method used by Giesbrecht and followed by Kiefer, taking the innermost seta as seta 1 and the outermost on the external lateral border as seta 5, the dorsal accessory seta being seta 6 : it is unfortunate that Gurney in his Monograph of the British Fresh-water Copepoda (1933) reversed this method and numbered the setae from without inwards.

Species	Data from	Seta 1	2	3	4	5	6
M. (*Th.*) *operculatus aberrans*	Lindberg, 1951	17·04	100	68·97	15·935	..	16·72
,, ,, Present specimens		25·14	100	76·6	15·38	6·52	16·14
,, ,, *tinctus*	Lindberg, 1941, 1947	26·2	100	71·1	20·2	..	19·2
,, ,, *schmeili hastatus*	Kiefer, 1952	34·4	100	88·2	32·6	..	20·8
,, ,, *dybowskii*	Gurney, 1933	36·8	100	75·3	20·9	..	23·2
,, ,, *inopinus*	Kiefer, 1926	37·9	100	84·2	22·6	..	..
,, ,, *schmeili schmeili*	Kiefer, 1952	39·8	100	81·3	22·6	..	16·9
,, ,, *schuurmanae*	Lindberg, 1951	42·9	100	69·1	19·1	..	25·1
,, ,, *pachysetosus*	Lindberg, 1951	43·8	100	93·95	29·5	..	25·1
,, ,, *hyalinus consimilis*	Kiefer, 1952	45·75	100	80·54	23·585	..	26·89
,, ,, *neglectus neglectus*	Lindberg, 1951	45·9	100	78·65	25·35	..	26·25
,, ,, *trichophorus*	Kiefer, 1930	46·4	100	71·4	17·1	..	..
,, ,, *iwoyiensis*	Onabamiro, 1952	48·13	100	68·19	20·27	..	20·53
,, ,, *mahéensis*	Lindberg, 1941	49·8	100	63·2	18·0	..	37·2
,, ,, *rylovi*	Lindberg, 1935	52·8	100	72·7	18·5	8·95	25·00
,, ,, *infrequens infrequens*	Kiefer, 1952	53·04	100	76·8	22·52	..	21·58

Species	Data from	Seta 1	2	3	4	5	6
M. (Th.) neglectus prolatus	Kiefer, 1952	57·11	100	89·22	24·51	..	26·94
,, ,, *vermifer*	Lindberg, 1935	58·8	100	78·5	20·8	9·7	25·2
,, ,, *hyalinus persicus*	Lindberg	59·43	100	77·1	22·35	..	..
,, ,, *infrequens decipiens*	Kiefer, 1952	62·78	100	80·72	22·18	..	24·44
,, ,, *tenuis*	Lowndes, 1934	60·0	100	73	13	..	40
,, ,, *oithonoides*	Gurney, 1933	64·2	100	71·9	21·5	..	..
,, ,, *microspinulosus*	Lindberg, 1942	64·7	100	83·55	27·07	..	25·47
,, ,, *hyalinus*	Mann, 1944	65·05	100	74·6	21·1	..	..
,, ,, *infrequens nigerianus*	Kiefer, 1952	67·37	100	82·63	26·315	..	42·11
,, ,, *retroversus*	Kiefer, 1952	67·89	100	84·05	26·41	..	45·44

Thus we have a steady and gradual increase in the proportional length of the 1st seta, as compared with the 2nd, from 17 to 68 a range of 58, whereas in setae 3 and 4 the range is only from 63 to 94 (31) in the former and from 15 to 33 (18) in the latter. The dorsal seta (seta 6) shows a gradual increase in length from 16·7 to 26·9 and then comes a clear break to 37·2 and then to 40 and 42 to 45·5.

A considerable range of variation is, however, present in a number of species and I give below the range of the proportional lengths of setae 1 and 2 in several :—

M. (*Th.*)	*tinctus*	from	23·8 to 33·0 : 100
,, ,,	*dybowskii*	,,	31·7 to 42·0 : 100
,, ,,	*schmeili hastatus*	,,	33·0 to 35·77 : 100
,, ,,	*schmeili schmeili*	,,	37·8 to 42·6 : 100
,, ,,	*mahéensis*	,,	42·8 to 54·7 : 100
,, ,,	*vermifer*	,,	55·5 to 61·6 : 100
,, ,,	*hyalinus*	,,	55·9 to 74·5 : 100
,, ,,	*microspinulosus*	,,	59·0 to 72·3 : 100

and, if I am right in attributing the present examples to *M.* (*Th.*) *schmeili* (s. lat.) then this species would appear to have a range from 33·07 to 45·5 : 100 and with *tinctus* forms an almost uninterrupted gradation from 23·8 to 42·6 and with *mahéensis* to 54·7 : 100.

In some species, of which examples have been recorded from several localities, and assuming that the identification of the individuals has been correct, there is or may be a great range of variation in different areas : Gurney (1933) provides a very good example of this among the specimens of *M.* (*Th.*) *hyalinus* (Rehberg) that he examined and measured from England, Egypt, India and Ceylon :—

Seta 1 : seta 2,	1·0 : 1·144 or 1·640	Calcutta, India.
	1·0 : 1·50 ..	Sutton, Norfolk.
	1·0 : 1·727	Ceylon.
	1·0 : 1·795	Lahore, Pakistan.
	1·0 : 2·021	River Nile.
Seta 1 : seta 3,	1·0 : 1·215 or 1·249	Sutton, Norfolk.
	1·0 : 1·304	Ceylon.
	1·0 : 1·321 or 1·575	River Nile, Egypt.
	1·0 : 1·366 or 1·371	Calcutta, India.
	1·0 : 1·51 ..	Lahore, Pakistan.

Lindberg (1938) in his examples of *hyalinus* from a number of different habitats in India found the range of variation in the relative proportions of seta 4 to seta 6 to be as great as from 1·0 : 0·757-1·266 and in *vermifer* to range from 1·0 : 0·526-1·0.

4. *The length of the antennule.*—Turning now to a consideration of the various appendages, the antennule in all species of the subgenus *Thermocyclops* is in the adult composed of seventeen segments but there is a considerable range of variation in the total length of this appendage, not only in different species but in some cases even in specimens of the same species. I give below the differences in certain species of the length of the antennule in comparison with the anterior region of the body :—

1. The antennule reaches only to the hinder margin of the cephalothorax (=Ceph.+Th. I) :—

   M. (*Th.*) *neglectus* Kiefer
   ,, ,, *rylovi* Smirnov
   ,, ,, *schmeili* Poppe and Mrázek (s. lat.)
   ,, ,, *trichophorus* Kiefer
   and the Present specimens

2. The antennule reaches to the middle of the 2nd thoracic segment :—

   M. (*Th.*) *conspicuus* Lindberg
   ,, ,, *infrequens* Kiefer
   ,, ,, *microspinulosus* Lindberg
   ,, ,, *minutus* (Lowndes)
   ,, ,, *operculifer* Kiefer
   ,, ,, *operculatus aberrans* Lindberg
   ,, ,, *stephanides* Kiefer
   ,, ,, *tenuis* (Marsh)
   ,, ,, *tinctus* Lindberg

3. The antennule reaches to the hinder margin of the 2nd thoracic segment :—

   M. (*Th.*) *analogus* Kiefer
   ,, ,, *decipiens* Kiefer
   ,, ,, *dybowskii* (Lande)
   ,, ,, *hyalinus* Rehberg
   ,, ,, *infrequens* Kiefer
   ,, ,, *microspinulosus* Lindberg
   ,, ,, *oblongatus* Sars
   ,, ,, *pachysetosus* Lindberg
   ,, ,, *schuurmanae* Kiefer
   ,, ,, *tinctus* Lindberg

4. The antennule reaches to the middle of the 3rd thoracic segment :—

   M. (*Th.*) *hyalinus* var. *persicus* Lindberg
   ,, ,, *mahéensis* Lindberg
   ,, ,, *vermifer* Lindberg

5. The antennule reaches to the hinder margin of the 3rd thoracic segment :—

   M. (*Th.*) *asiaticus* Kiefer
   ,, ,, *brehmi* Kiefer
   ,, ,, *macracanthus* Kiefer
   ,, ,, *retroversus* Kiefer
   ,, ,, *rylovi* Smirnov

6. The antennule reaches to the middle of the 4th thoracic segment :—

   M. (*Th.*) *mahéensis* Lindberg
   ,, ,, *oithonoides* (Sars)
   ,, ,, *vermifer* Lindberg

7. The antennule reaches to the posterior border of the 4th thoracic segment :—

   M. (*Th.*) *emini* Mrázek

8. The antennule reaches to the anterior border of the genital segment of the abdomen :—

   M. (*Th.*) *iwoyiensis* Onabamiro

It will be noted that the same species occur in more than one category :—thus *rylovi* is present in 1 and again in 5 and *mahéensis* is present in 4 and 6. Lindberg (1938, p. 215) has called attention to the degree of variation that he found in examples of *M. (Th.) vermifer* and *hyalinus* and he has given a table showing the percentages present in these two species, which I reproduce below :—

Length of Antennule	*M. (Th.) vermifer*	*M. (Th.) hyalinus*
The posterior border of Th. 2	11·2%	70·0%
The anterior margin of Th. 3	22·4	10·0
The middle of Th. 3	50·7	6·7
The posterior border of Th. 3	15·7	3·3

The above examples had all been killed in formalin, and Lindberg remarks that in the live specimens of *vermifer* in many cases the antennule reached as far as the middle or even the posterior border of the 4th thoracic segment.

Minor differences may well be caused by different degrees either of growth during development or of contraction during death. Similar differences in the length of the antennule have been noticed in species of the other subgenus, *Mesocyclops* : Harding (1955, p. 224), has pointed out that in examples of *Mesocyclops meridianus* (Kiefer) different observers have recorded the length of the antennule as reaching :

(1) beyond the cephalothorax (Th. 1) by the length of the last segment (Pesta),

(2) to the distal edge of the 2nd trunk segment (Lowndes), and

(3) to the middle of the 3rd thoracic segment :

and in the examples examined by him he found that the antennule varied from barely reaching the end of the cephalothorax to the end of the 2nd thoracic segment.

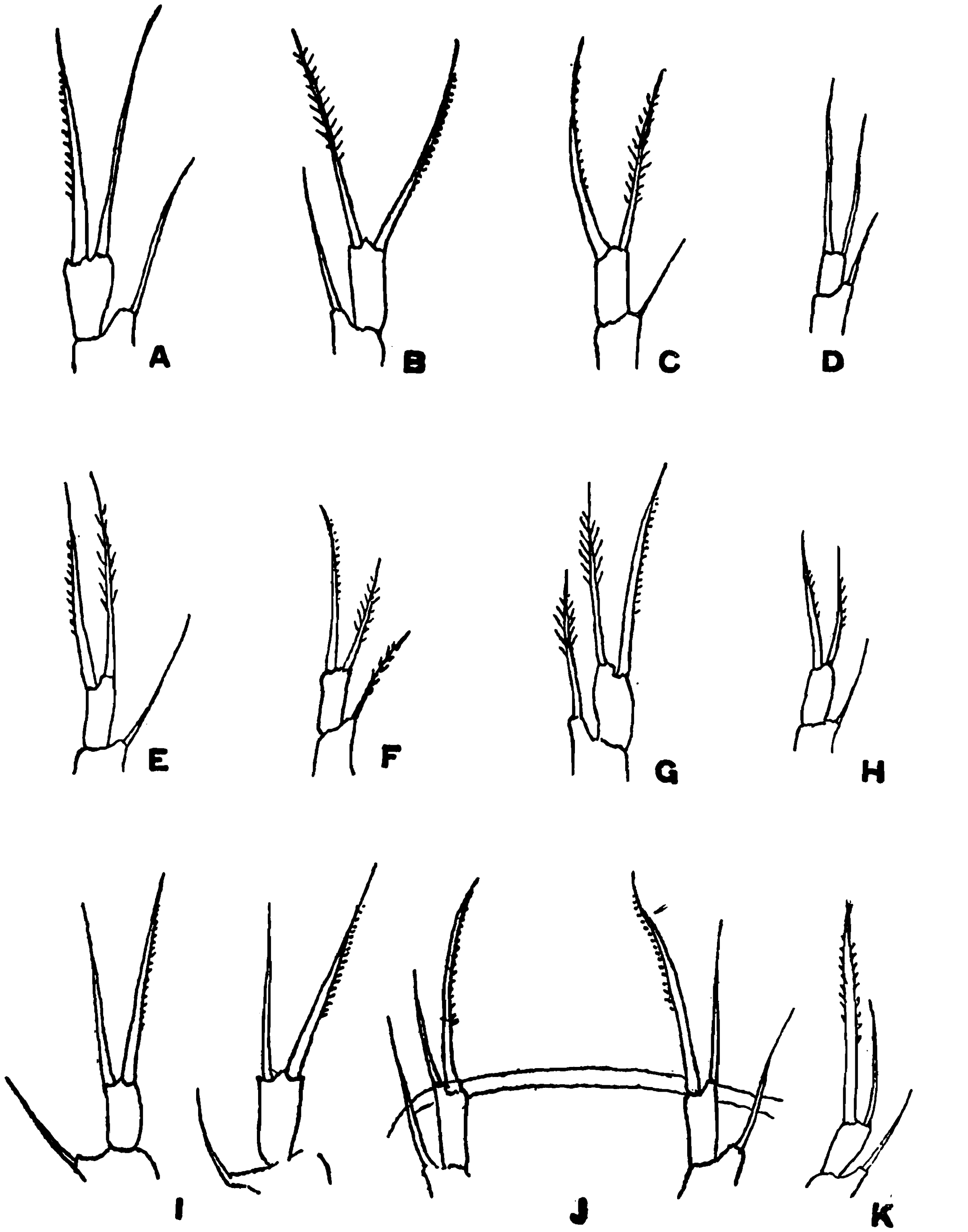
6 and 7. *The proportions of length to breadth of distal segment of endopod of the 4th leg, etc.*—In instances such as those in which the differentiation of two species is based in part on the proportion of length to breadth of a particular segment of an appendage, such as the proportions of the terminal segment of the endopod of the 4th swimming leg or the proportional lengths of the two terminal spines, it is of the greatest importance that we should have an adequate knowledge of the extent to which individuals of the same species may vary among themselves in adults taken from the same habitat at the same or a different season of the year and also in those from different habitats, as well as of the changes that may take place during the course of development. I shall deal more fully with this point in the systematic part of this report : suffice it to say here that in the case of most of the species in the subgenus *Thermocyclops* the differences are small and the whole series exhibit a gradual transition from one end of the scale to the other, and the inter-specific differences between several so-called species may lie within the extreme limits of the intra-specific variation of a single species : where this occurs it is obvious that such data are useless as definite specific characters. In the proportional lengths of the inner and outer spines on the distal end of the terminal segment of the endopod of the 4th swimming leg it seems probable that a slight though progressive change may occur, as in the furcal rami

with an increase in size of the individual. Lindberg (1941, p. 264) has given the proportions of these spines in specimens of *M.* (*Th.*) *tinctus* and these range from 1·67 to 1·89 : 1·0 ; but if we take the proportions in specimens of three size groups and average the results we get are the following :

	Total length of specimen		
	920-980μ	1107-1187μ	1206-1254μ
Proportion of inner spine to outer spine of endopod 3 of p_4.	1·744 : 1·0	1·777 : 1·0	1·794 : 1·0

8. *The character of the connecting lamella between the 4th pair of legs, etc.*—Another of the characters on which Kiefer places reliance in the diagnosis of species is the detailed structure of the connecting plate between the 4th pair of swimming legs. Lindberg (1942, pp. 145-151), however, in his comparison of the species *M.* (*Th.*) *rylovi* and *vermifer* is less convinced of the value of this structure and is of the opinion that with adequate collections of closely related forms from a sufficient number of habitats it will be necessary to suppress at least some of the so-called species and subspecies, since these will probably be found to come within the extreme limits of variation in one single species : he remarks that "C'est quand on dispose d'animaux nombreux, provenant d' un grand nombre du localités différentes que la distinction d'espèces cesse d'être simple et qu'on se rend compte de la valeur douteuse de certains traits de structure par suite de l'amplitude de leurs variations. Il en est ainsi notamment en ce qui concerne la lamelle basale de la quatrième paire de pattes, et aussi, mais à un moindre degré. pour le réceptacle séminal". Both Lindberg (*loc. cit.*, figs. 10 and 11) and Kiefer (1952, figs. 21-28) have given series of illustrations of this basal lamella in different species or subspecies, *rylovi, vermifer* and *hyalinus* and these show clearly that there may be a wide range of variation in individuals even from the same locality.

It has been stated that no taxonomist would create a new species on a single character, but Kiefer (1929, p. 78) has separated two subgenera of the genus *Mesocyclops*, namely, *Mesocyclops* Sars (s. str.) and *Thermocyclops* Kiefer, solely on the difference in the point of origin of the inner spine of the free segment of the 5th leg, this being situated on the inner border in *Mesocyclops* and on the distal margin in *Thermocyclops*. Gurney (1933, p. 287), commenting on Kiefer's proposal, remarks that "it may be admitted that there may be two subgroups, but they do not, in my opinion, require separation, and the sole distinguishing character is so trivial as to be almost inapplicable" As one's knowledge of the species of the subgenus *Thermocyclops* becomes more extensive it becomes clear that this inner spine in a number of species does not, strictly speaking, arise from the distal margin but from the inner border close to the distal inner angle of the segment (*vide* Text-fig. 1). Such a point of origin has clearly been shown by Sars (1913-18, pl. XXXVI, p. 5) in *Mesocyclops oithonoides*, which Kiefer has made the type of his new subgenus *Thermocyclops*, and this difference has been indicated by Gurney (1933, figs. 1889 and 1895) in two examples of what he considers to be *Cyclops hyalinus* from Norfolk, England and Lahore, Pakistan, respectively and in the first of these (fig. 1889) the point of origin of the inner spine agrees closely with that of *Mesocyclops crassus* (*vide* Sars, 1913-18, Pl. XXXVII) which Kiefer regards as a synonym of *hyalinus*. Lowndes (1934) has figured the 5th leg in both *Mesocyclops meridianus* Kiefer (*loc. cit.*, fig. 8 a) and in *Mesocyclops tenuis* (*loc. cit.*, fig. 9 e) and he shows



TEXT-FIG. 1.—The 5th leg of various species of the subgenus *Thermocyclops*.

A. *hyalinus* (after Kiefer). B. *hyalinus* (after Gurney). C. *vermifer* (after Lindberg). D. *inopinus* (after Kiefer). E. *oithonoides* (after Sars). F. *mongolicus* (after Kiefer). G. *dybowskii* (after Gūrney). H. *dybowskii* (after Sars). I. *schmeili*, f. *marmagoensis*, nov., from a larger specimen. J. *schmeili*, f. *marmagoensis*, nov., from a smaller one. K. *schmeili schmeili* (after Kiefer).

that in both of these species the inner spine of the 2nd segment of the 5th leg may arise at the end of the inner border of the segment close to distal inner angle exactly where it arises in some of the present specimens ; and yet Kiefer (1929) includes both these species in the subgenus

Mesocyclops. It would seem very doubtful that the distinction between these two subgenera can be maintained.

9. *The relative lengths of inner spine and outer seta of the free segment of 5th leg.*—Another point of difference in the species of *Thermocyclops* that has been utilised as a character for diagnosis are the proportional lengths of the inner spine and outer seta of the free segment : but here again we find that there is a gradual transition from one extreme, with the seta considerably shorter than the inner spine, to the other, in which the seta is longer than the spine (*vide infra,* p. 104).

10. *The form of receptaculum seiminis.*—Kiefer, (1929, 1930) in his keys for the identification of the various species of the genus *Mesocyclops,* with its two subgenera *Mesocyclops* (s. str.) and *Thermocyclops,* has utilised differences in the form of the receptaculum seminis as the chief and almost the sole distinguishing character, and in later publications he (1936, p. 230) states that according to his experience, which he modestly claims to be not inconsiderable, the shape of the receptaculum seminis is one of the most trustworthy characters for the differentiation of species. Lindberg (1938, p. 213), after making a careful study of a large number of examples of the two species *vermifer* and *hyalinus,* is less dogmatic ; he concludes that the observed differences in the structure of this organ, taken in conjunction with other slight differences justified him in concluding that they were two distinct species : but he showed that both species exhibited very considerable degrees of variation, and he remarks, "Les auteurs, tel que Kiefer, qui attachent une importance fondamental à les aspects même legèrement differents du receptacle seminal en vue de la distinction d'espèces, seront peut-être enclins à considérer que les divers types de receptacle seminal qui j' ai donnes, correspondent à autant d'espèces distinctes" He goes on to point out that as long as only one of the two species was present in any given habitat, the form of the receptaculum seminis was of importance in determining to which species the individuals should be referred, but in some cases where the two forms existed together certain specimens exhibited forms that were intermediate between the true *hyalinus* and *vermifer* forms, and these specimens he explained as being probably hybrids. In an earlier paper (Lindberg, 1935, p. 413) when engaged in making a study of the form that he believed to be *M.* (*Th.*) *rylovi* Smirnov, but which he later described as a new species under the name *vermifer,* noted that the receptaculum seminis is "assez variable selon de degre de remplissage". It seems possible that small differences in the form and dimensions of the seminal vesicle may be due, as suggested by Lindberg, to the degree of distension of the organ : if impregnation had occurred recently and before oviposition had taken place, the distension would be greater than at some later stage when some of the contents had been discharged to fertilise the ova.

11. *The number of ova.*—As regards the number of ova produced by each species, we have relatively little information :

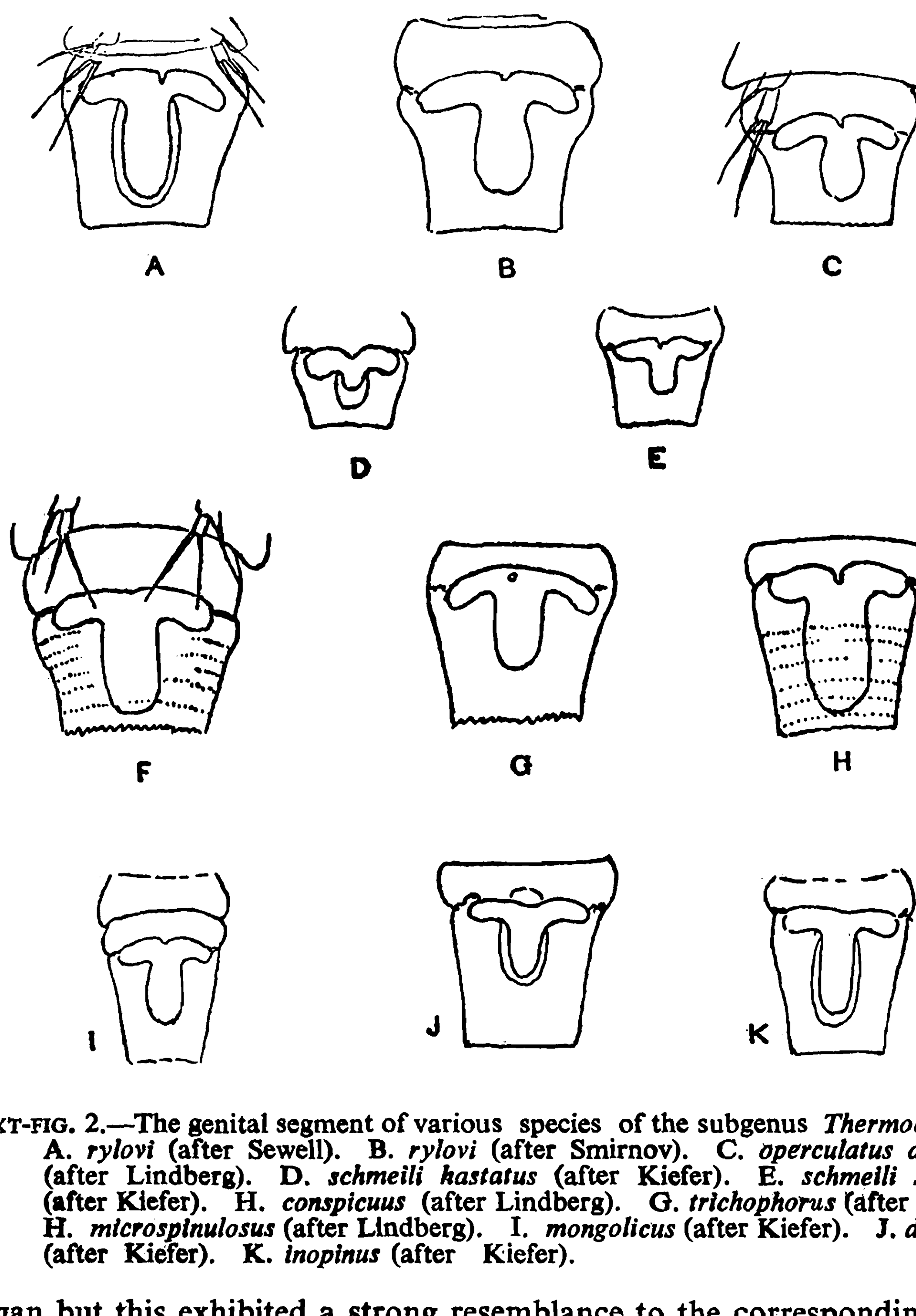
Species	No. of ova in the ovisacs
M. (*Th.*) *vermifer* . .	not more than 6 to 9 in each sac.
,, ,, *maheensis* .	6 to 9 large eggs.
,, ,, *microspinulosus* . .	the ovisacs appeared to contain few ova.
,, ,, *asiaticus* .	more than 10 ova.
,, ,, *rylovi*	more than 15 to 20 in each sac.
,, ,, *tinctus*	26 to 28 ova.

Such data are of little importance as a diagnostic character, for, as I have already pointed out, the number of ova carried may vary with the season of the year, and Lindberg (1941, p. 473) has recorded that examples of the female of the species *Cyclops strenuus divergens* may carry from 38 to as many as 104 ova and Gurney (1933, p. 298) states that the number of eggs in *hyalinus* is few and in *dybowskii* he figures (*loc. cit.*, fig. 1901) about 14 in each egg sac.

One character in the abdominal region that may perhaps be of some importance in helping to differentiate between species or at least between certain groups of species is the shape and dimensions of the genital segment : in certain species of the subgenus *Thermocyclops* the genital segment is noticeably short and broad, whereas in others it is markedly elongate. In the table below I give the proportions of length to breadth in a series of species :—

Species			Proportions of the genital segment : Length to breadth	
M. (*Th.*)	*tinctus* Lindberg		0·73-1·10	: 1·0
„	„	Present examples	0·816-1·03	: 1·0
„	„	*schmeili hastatus* Kiefer	0·909	: 1·0
„	„	*operculifer* Kiefer	0·914	: 1·0
„	„	*operculatus aberrans* Lindberg	0·87	: 1·0
„	„	*trichophorus* Kiefer	0·94	: 1·0
„	„	*schmeili schmeili* P. and M.	0·975	: 1·0
„	„	*conspicuus* Lindberg	1·057	: 1·0
„	„	*inopinus* Kiefer	1·08	: 1·0
„	„	*vermifer* Lindberg	0·92-1·58	: 1·0
„	„	*hyalinus* Kehberg	0·98-1·51	: 1·0
„	„	*rylovi* Smirnov	1·02-1·22	: 1·0
„	„	*microspinulosus* Lindberg	1·082-1·206	: 1·0
„	„	*dybowskii* (Lande)	1·17	: 1·0
„	„	*iwoyiensis* Onabamiro	1·4	: 1·0
„	„	*mahéensis* Lindberg	1·488-1·65	: 1·0

In several species a considerable range of variation has been recorded ; in *vermifer* Lindberg (1942) found a range of 0·92—1·58 : 1·0 and in *rylovi* between 1·02 and 1·22 : 1·0 and in the examples that I certified in 1934 as *rylovi* from 0·97—1·58 : 1·0. In the first group above *tinctus* has a range of 0·73—1·10 : 1·0 and the dimensions of the genital segment of all the other species in this group fall within these limits and the proportions of the first three species in the second group namely, *vermifer* and *hyalinus* and *rylovi* all overlap the highest proportions found in *tinctus* In preserved material it is often a matter of considerable difficulty to determine the form of the receptaculum seminis, as has been pointed out by Poppe and Mrázek (1895) in the case of *M. (Th.) schmeili* and by Smirnov (1929) in *M. (Th.) rylovi* ; in the present examples I was only able to distinguish the transverse bow-like anterior part of the



TEXT-FIG. 2.—The genital segment of various species of the subgenus *Thermocyclops*. A. *rylovi* (after Sewell). B. *rylovi* (after Smirnov). C. *operculatus aberrans* (after Lindberg). D. *schmeili hastatus* (after Kiefer). E. *schmeili schmeili* (after Kiefer). H. *conspicuus* (after Lindberg). G. *trichophorus* (after Kiefer). H. *microspinulosus* (after Lindberg). I. *mongolicus* (after Kiefer). J. *decipiens* (after Kiefer). K. *inopinus* (after Kiefer).

organ but this exhibited a strong resemblance to the corresponding part of the organ in several of the so-called species, especially those of the group that is characterised by a short and broad genital segment. In Text-fig. 2 I have reproduced from several authors their diagrams of the genital segment and the shape of the receptaculum seminis in

M. (Th.) rylovi Smirnov

" " *operculatus aberrans* Lindberg

" " *schmeili hastatus* Kiefer

M. (*Th.*) *schmeili schmeili* (s. str.) P. and M.

,, ,, *conspicuus* Lindberg

,, ,, *microspinulosus* Lindberg

,, ,, *trichophorus* Kiefer

,, ,, *mongolicus* Kiefer

,, ,, *decipiens* Kiefer

and ,, ,, *inopinus* Kiefer.

It seems to me that the degree of similarity between this organ in all these species is so marked and the differences so slight that it provides no adequate basis for specific discrimination.

Lindberg (1938, p. 215, Pl. IV figs. a-f and Pl. V, figs. a-p) in his comparison of *M.* (*Th.*) *vermifer* and *hyalinus* remarks, "Les differences entre les deux espèces ne sont pas très considérables" and in the figures that he gives shows that in both species there is a quite considerable range of variation and so can hardly be considered a reliable specific character.

III—SYSTEMATICS

Genus Mesocyclops Sars

Subgenus Thermocyclops Kiefer

Mesocyclops (Thermocyclops) schmeili Poppe and Mrazek forma **marmagoensis** nov.

Cyclops schmeili, Poppe and Mrázek, 1895 : Lindberg, 1951
Mesocyclops (*Thermocyclops*) *schmeili schmeili* (s. str.) P. and M.
,, ,, ,, *hastatus* Kiefer, 1952
,, ,, *tinctus* Lindberg, 1936, 1941
,, ,, *inopinus* Kiefer, 1952
,, ,, *trichophorus* Kiefer, 1930
,, ,, *operculifer* Kiefer, 1929
,, ,, *conspicuus* Lindberg, 1947

A small collection of a species of a cyclopid, belonging to the family Cyclopidae, subfamily Cyclopinae, was entrusted to me for examination and report by the Bombay Natural History Society, through the Zoological Survey of India, and I give here a description of these specimens, and have taken advantage of this opportunity of reviewing the subgenus *Thermocyclops* Kiefer.

The collection was made by Mr. Humayun Abdulali, of the Bombay Natural History Society "in a pool of fresh water, measuring 18"× 18"×12" (or approximately so), on a small island about a mile off the coast of Marmagoa. The pool was a few yards from the high-tide watermark and was fed by a spring. The water appeared to be perennial" It was well known as the only fresh water available on the island and was situated on the land-ward side. The collection was made in the first week of June, 1953 : usually the south-west monsoon commences early in June in this area, but Mr. Humayun Abdulali informs me in a letter that he did not experience any rain.

The collection includes the last three stages of development, Copepodid Stages IV and V and the adult, all the specimens being females.

♀ *Stage VI, Adult* (Text-fig. 3).

The total length, from the forehead to the tip of the furcal ramus measures from 0·95 to 1·05 mm.

The proportional lengths of the anterior and posterior regions of the body are as 1·47 : 1·0 in larger examples and 1·52 : 1·0 in smaller ones. The length and breadth of the cephalothorax are about equal and the proportional lengths of the anterior, *i.e.*, the cephalothorax[1] and thoracic segments II to IV, and the posterior region of the body, *i.e.*, the VI thoracic segment and the abdominal segments and furca, are as 1·474 : 1·0. The proportional lengths of the various segments of the body are as follows :—

	Ceph.-Th.	Th. II	Th. III	Th. IV	Th. V	Abd. 1-2	3	4	5	Furca	Total
	359	83	81	81	55	124	58	50	27	82	=1,000
	352	87	85	76	48	118	59	59	28	87	=1,000
	343	88	84	80	47	131	58	55	26	88	=1,000
Average	351	86	83	79	50	124	58	55	27	86	= 999

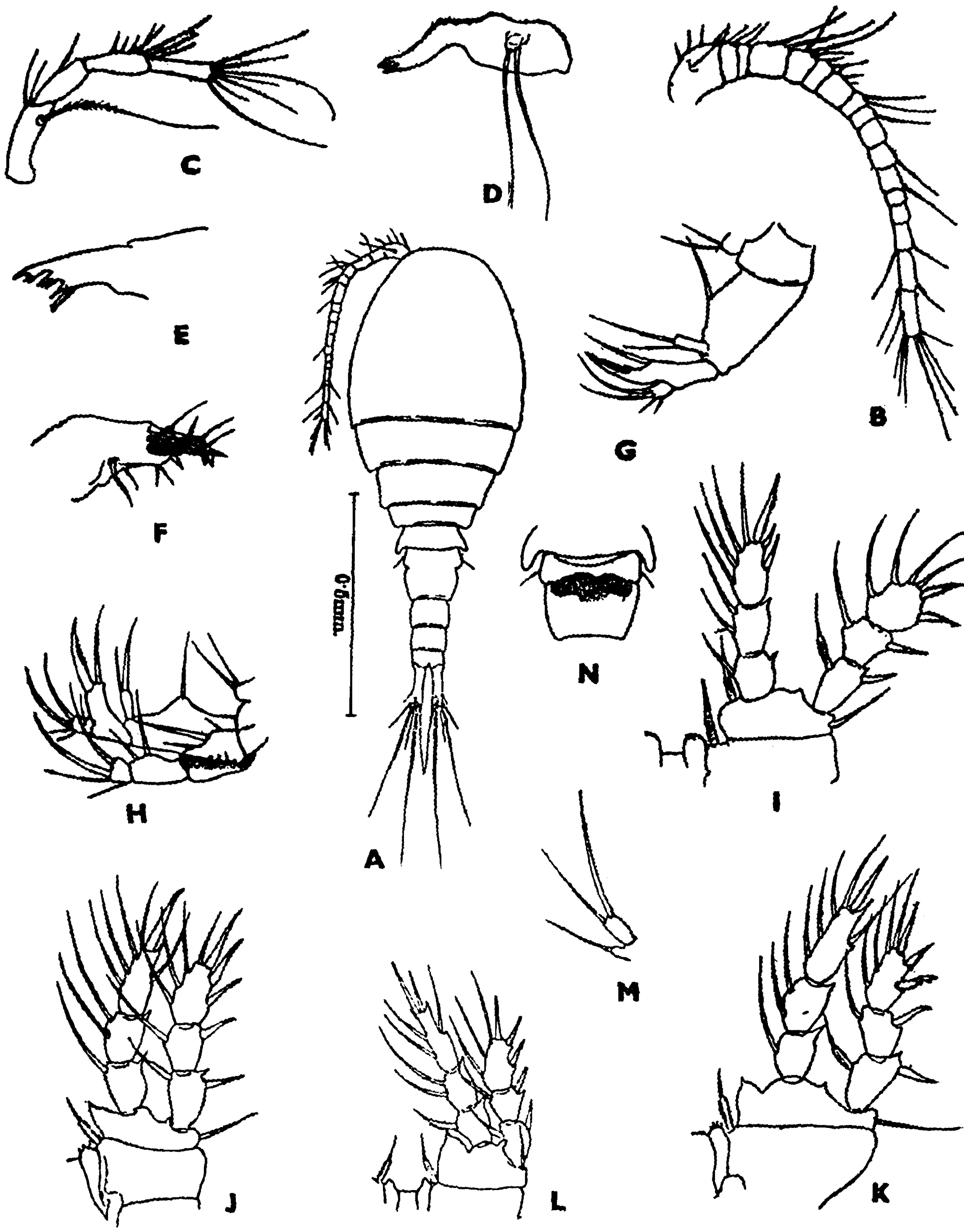
The postero-lateral borders of the 5th thoracic segment are devoid of any hairs and are produced backwards so as to overlap the anterior region of the genital segment of the abdomen. The genital segment (Text-fig. 3, N.) is slightly broader than long in the proportion of 100 : 94·2 and the posterior border is smooth and without any serrations, such as have been recorded by Lindberg (1951) in his examples of *schmeili* from Lake Tanganyika, while the whole surface of the segment is smooth and without either minute spinules or small pits, such as have been recorded in *Thermocyclops operculifer* Kiefer, *microspinulosus* Lindberg and in certain examples of *rylovi* Smirnov. Lindberg has recorded the same type of ornamentation in examples of *Mesocyclops leuckarti* (Claus) ; and Lowndes (1934, p. 108) has also recorded that in some examples of *Mesocyclops meridianus* Kiefer the genital segment was "quite short and the integument may bear a series of ring-like markings" Thus the presence of such markings in *M.* (*Th.*) *conspicuus* and *microspinulosus* can hardly be regarded as a possible specific character.

The furcal rami are only slightly divergent and their inner borders are smooth, thus differing from the examples of *M.* (*Th.*) *schmeili* reported from Lake Tanganyika by Lindberg (1951), in which the inner border is hairy. The proportions of the length and breadth of the furcal rami in the present specimens are as follows :—

Length	Breadth		
23 (15·5 7·5) :	6·0	or 3·83 :	1·0
24 (16·0 6·5) :	6·5	or 3·69 :	1·0
22·0 :	6·5	or 3·38 :	1·0
	Average	3·633 :	1·0

[1]In the following account I have used the term cephalothorax to indicate the anterior division of the body, which is formed by the fused head and 1st thoracic segment.

The 5th seta arises from the outer border of the ramus at approximately two-thirds of its length. I have given the lengths of the proximal and distal portions of the ramus in the table above.



TEXT-FIG. 3.—*Mesocyclops (Thermocyclops) schmeili* Poppe and Mrazek forma *marmagoensis*, nov.

A. Adult female, dorsal aspect. B. Antennule. C. Antenna. D. Mandible. E. Biting ramus of Mandible. F. Maxillula. G. Maxilla. H. Maxilla and Maxilliped. I. 1st swimming foot. J. 2nd swimming foot. K. 3rd swimming foot. L. 4th swimming foot. M. 5th leg. N. Genital segment of the abdomen.

Poppe and Mrazek (1895) in their original account of the species stated that the ramus was twice as long as the last abdominal segment; but Kiefer (1952, figs. 75 and 78) indicates that in his examples of the subspecies *schmeili* and *hastatus* the furcal ramus is much more nearly three times its length. In the present specimens the rami are equal to or slightly longer than the combined lengths of the last two abdominal segments, the proportions being 1·0-1·074 : 1·0 : in the two related subspecies, *schmeili* and *hastatus* from Africa, Kiefer (1952, figs. 75 and 78) figures the rami as having, so far as I can judge, the following proportional engths :—

	Furcal ramus	Abd. segs. 4 and 5	Proportions
M. (*Th.*) *schmeili hastatus* . .	14·5	12	1·22 : 1·0
M. (*Th.*) *schmeili schmeili* . .	16	13	1·23 : 1·0

In the various species and subspecies of the subgenus *Thermocyclops* the average proportions of length to breadth of the ramus exhibit a gradually progressive change, as shown below :—

Species or subspecies	Proportions of Length to Breadth	Data from
M. (*Th.*) *pachysetosus*	1·74-2·0 : 1·0	Lindberg, 1951
,, ,, *hyalinus* . .	1·90-3·0 : 1·0	Lindberg, 1938
	2·50 : 1·0	Kiefer, 1936
	2·125-2·48 : 1·0	Mann, 1940
	or 2·17-2·28 : 1·0	Kiefer, 1937
,, ,, *vermifer* . .	2·15-3·25 : 1·0	Lindberg, 1938
	2·476-3·00 : 1·0	Lindberg, 1935
,, ,, *hyalinus consimilis*	1·83-2·39 : 1·0	Kiefer, 1952
,, ,, *neglectus* .	2·0 : 1·0	Sars, 1909
	2·17-2·50 : 1·0	Lindberg, 1951
,, ,, *dybowskii*	2·32-3·5 : 1·0	Gurney, 1933
,, ,, *decipiens* }	2·5 : 1·0	Kiefer, 1929
,, ,, *infrequens* }		
,, ,, *mongolicus*	2·65-2·73 : 1·0	Kiefer, 1937
,, ,, *macracanthus* .	2·75-2·75 : 1·0	Kiefer, 1929
,, ,, *oithonoides*	2·85 : 1·0	Gurney, 1933
,, ,, *retroversus*	2·86-3·15 : 1·0	Lindberg, 1951
,, ,, *schuurmanae* . . .	2·86-3·19 : 1·0	Kiefer
,, ,, *schmeili hastatus*	2·97-3·19 : 1·0	Kiefer, 1952
,, ,, *trichophorus* .	barely 3·0 : 1·0	Kiefer, 1930
,, ,, *operculifer* . . .	3·0 : 1·0	Kiefer, 1929
,, ,, *oblongatus* . . .	3·1 : 1·0	Sars, 1927
,, ,, *rylovi*	3·04-3·60 : 1·0	Lindberg, 1942

Species or subspecies			Proportions of Length to Breadth	Data from
M.	(*Th.*)	Present examples	3·38-3·83 : 1·0	——
,,	,,	*mahéensis*	3·39-3·90 : 1·0	Lindberg, 1941
,,	,,	*tinctus*	3·42-4·75 : 1·0	Lindberg, 1941
,,	,,	*analogus*	3·5 -3·75 : 1·0	Kiefer, 1936
,,	,,	*inopinus*	3·5 -3·83 : 1·0	Kiefer, 1952
,,	,,	*conspicuus*	3·67-3·86 : 1·0	Lindberg, 1947
,,	,,	*operculatus aberrans*	3·75 : 1·0	Lindberg, 1951
,,	,,	*schmeili schmeili*	3·95-4·20 : 1·0	Kiefer, 1952
,,	,,	*brehmi*	3·50-4·33 : 1·0	Lindberg, 1951
,,	,,	*brehmi*	4·0 : 1·0	Kiefer, 1929

Thus the present specimens fall between *schmeili hastatus* and *schmeili schmeili*, the three forms forming an almost continuous series of 2·97-3·19, 3·38-3·83 and 3·50-4·33. If, as I believe, all three forms belong to the same species, this gives a possible range of variation in the proportion of the furcal ramus from 2·97 : 1·0 to 4·33 : 1·0, with a mean of 3·65 : 1·0 and a range of variation of 45 per cent : this may seem to be a very high degree of variation but in *Mesocyclops* (*Mesocyclops*) *serrulatus* (Fischer) which is a wide ranging species, the recorded extreme range is as great as from 3·68 : 1·0 to 6·58 : 1·0, with a mean of 5·13 : 1·0 and a range of variation of 76 per cent.

The furcal setae appear to be smooth and without marginal hairs ; they are of normal length, the longest (seta 2) being only very slightly shorter than the whole abdomen and only very slightly curved. Lindberg (1939) has given this curvature of the 2nd seta as an important diagnostic character between *hyalinus* and *vermifer*, this seta being almost always recurved in a semicircle in the former and only slightly curved or straight in the latter species : but Kiefer (1952) in a series of figures has shown (figs. 1-20) that this seta may in some cases in the various subspecies of *hyalinus*, namely *macrolacius*, *consimilis* and *kivuensis* be either straight or nearly straight, and further (*loc. cit.* figs. 61 and 62) that similar strongly curved setae may occur in *infrequens infrequens* and in *schmeili schmeili*. It thus seems clear that no reliance can be placed on this character as a diagnostic feature.

The proportional lengths of the furcal setae are as follows :—

Seta	1	2	3	4	5	6
	23·6	100	78·4	15·9	6·6	15·9
	24·4	100	78·9	15·6	6·7	13·3
	25·5	100	72·4	14·3	7·1	18·3
	26·1	100	78·3	16·3	6·5	18·4
	26·1	100	75·0	14·8	5·7	14·8
Average	25·14	100	76·6	15·38	6·52	16·4

The 4th seta, arising from the outer distal corner of the ramus is spine-like and the 5th seta arising from the outer border is situated almost exactly at the junction of the middle and distal thirds of the length of the ramus. Reference to the Table given above (*vide supra*, p. 79) of the proportional lengths of the setae in other species of *Thermocyclops* shows that the present specimens fall into line between *M.* (*Th.*) *tinctus* and *operculatus aberrans*.

Previous observers have attributed considerable importance to the relative proportions of the various setae to each other as an aid to the identification of a species. Smirnov (1929) in his account of *Thermocyclops rylovi* remarks, "For the species described here the proportions of the innermost seta to the median seta is very characteristic 1 : 1·43 or 1 : 1·75, average 1 : 1·55" Between the lower and the higher figure there is a range of 22 per cent.

I give below the average proportional lengths of seta 1 to the other apical setae and of seta 4 to the dorsal seta (seta 6):—

Species	Data from	Average proportional lengths of setae.			
		1—2	1—3	1—4	4—6
M. (*Th.*) *operculatus aberrans*	Lindberg	1·0 : 5·927	4·05	0·935	1·049
,, ,, *tinctus*	Lindberg	1·0 : 3·817	2·696	0·777	0·954
,, ,, Present examples		1·0 : 3·788	3·029	0·592	1·079
,, ,, *schmeili hastatus*	Kiefer	1·0 : 2·836	2·591	0·916	0·665
,, ,, *dybowskii*	Gurney	1·0 : 2·717	2·046	0·565	0·744
,, ,, *inopinus*	Kiefer	1·0 : 2·6	2·220	0·597	..
,, ,, *schmeili schmeili*	Kiefer	1·0 : 2·5 2	2·060	0·565	0·744
	Lindberg	1·0 : 2·40	1·977	0·60	0·665
,, ,, *schuurmanae*	Kiefer	1·0: 2·33	1·611	0·445	1·314
,, ,, *pachysetosus*	Lindberg	1·0 : 2·83	2·14	0·674	1·039
,, ,, *neglectus neglectus*	Kiefer	1·0 : 2·178	1·714	0·552	1·035
,, ,, *hyalinus hyalinus*	Lindberg	1·0 : 1·783	1·510	0·471	1·720
	Mann	1·0 : 1·54	1·164	0·334	..
,, ,, *consimilis*	Kiefer	1·0 : 2·186	1·760	0·52	1·140
,, ,, *trichophorus*	Kiefer	1·0 : 2·155	1·539	0·369	..
,, ,, *iwoyiensis*	Onabamiro	1·0 : 2·078	1·417	0·421	1·039
,, ,, *mahéensis*	Lindberg	1·0 : 2·008	1·259	0·361	2·067
,, ,, *rylovi*	Lindberg	1·0 : 1·897	1·378	0·385	0·963
,, ,, *vermifer*	Lindberg	1·0 : 1·701	1·335	0·360	1·212
,, ,, *mongolicus*	Kiefer	1·0 : 1·626	1·176	0·376	1·597
,, ,, *retroversus*	Kiefer	1·0 : 1·473	1·312	0·389	1·721
,, ,, *microspinulosus*	Lindberg	1·0 : 1·497	1·260	0·401	1·304

It is clear from the above that there is a progressive lengthening of seta 1 in proportion to seta 2 and not quite so regular a lengthening in respect to seta 3.

The present examples come near to *tinctus* and *schmeili hastatus* as regards the proportions of seta 1 to setae 2 and 3, and as regards the proportions of seta 1 and 4 they come near to *inopinus* and of seta 4 to 6 near to *iwoyiensis* and *pachysetosus*.

In a number of species the proportions of seta 1 to seta 3 fall into a progressive series, as follows :—

Species	Seta 1 : seta 3
M. (*Th.*) *operculatus aberrans* . .	1·0 : 4·05
,, ,, Present examples . .	1·0 : 3·029
,, ,, *tinctus* .	1·0 : 2·696
,, ,, *schmeili hastatus* .	1·0 : 2·591
,, ,, *inopinus*	1·0 : 2·220
,, ,, *pachysetosus* .	1·0 : 2·14
,, ,, *schmeili schmeili* . .	1·0 : 2·066 or 1·977 (Lindberg)
,, ,, *dybowskii* . . .	1·0 : 2·046
,, ,, *trichophorus* .	1·0 : 1·539
,, ,, *iwoyiensis*	1·0 : 1·417
,, ,, *vermifer*	1·0 : 1·345
,, ,, *rylovi* .	1·0 : 1·331-1·482
,, ,, *hyalinus*	1·0 : 1·297 or 1·431 (Gurney)
,, ,, *microspinulosus*	1·0 : 1·291
,, ,, *maheensis*	1·0 : 1·269
,, ,, *mongolicus*	1·0 : 1·175
,, ,, *hyalinus*	1·0 : 1·159 (Mann)

Here we seem to have an indication of a break in the series between *dybowskii* and *trichophorus* : in the top part of the series we have the present examples and the two subspecies of *schmeili* together with *operculatus aberrans, tinctus, inopinus, pachysetosus,* and *dybowskii.*

If we take the proportions of seta 1 to 4 in different species we get the following series in an ascending scale :

M. (*Th.*) *hyalinus*	1·0 : 0·309—0·503
,, ,, *oithonoides*	1·0 : 0·335
,, ,, *rylovi*	1·0 : 0·350
,, ,, *decipiens*	1·0 : 0·353
,, ,, *vermifer*	1·0 : 0·348—0·519
,, ,, *mahéensis*	1·0 : 0·361
,, ,, *trichophorus*	1·0 : 0·369

M. (*Th.*) *microspinulosus*	1·0 : 0·418
,, ,, *iwoyiensis*	1·0 : 0·421
,, ,, *neglectus prolatus*	1·0 : 0·429
,, ,, *schmeili schmeili*	1·0 : 0·523—0·589 or 0·60
,, ,, *dybowskii*	1·0 : 0·569
,, ,, Present examples	1·0 : 0·592
,, ,, *inopinus*	1·0 : 0·596
,, ,, *conspicuus*	1·0 : 0·735—0·870
,, ,, *tinctus*	1·0 : 0·777
,, ,, *schmeili hastatus*	1·0 : 0·87—0·962

Here again we get a progressive series ; but the most interesting point is the great range of the proportions between the two subspecies of the species *schmeili,* in which the range extends from 0·523 to 0·962 and between the two subspecies fall the present examples and the species *dybowskii, inopinus, conspicuus,* and *tinctus.* Clearly no distinction, so far as the proportions of these two setae are concerned, can be drawn between these species.

In the proportions of setae 4 and 6 we again get a progressive sequence as follows :—

M. (*Th.*) *mahéensis*	1·0 : 2·067
,, ,, *retroversus*	1·0 : 1·721
,, ,, *hyalinus consimilis*	1·0 : 1·720—1·14
,, ,, *mongolicus*	1·0 : 1·597
,, ,, *schuurmanae*	1·0 : 1·314
,, ,, *microspinulosus*	1·0 : 1·304
,, ,, *vermifer*	1·0 : 1·212
,, ,, Present examples	1·0 : 1·079
,, ,, *operculatus aberrans*	1·0 : 1·049
,, ,, *pachysetosus*	1·0 : 1·039
,, ,, *iwoyiensis*	1·0 : 1·039
,, ,, *neglectus neglectus*	1·0 : 1·035
,, ,, *rylovi*	1·0 : 0·963
,, ,, *tinctus*	1·0 : 0·950
,, ,, *dybowskii*	1·0 : 0·744
,, ,, *schmeili schmeili*	1·0 : 0·744
,, ,, *schmeili hastatus*	1·0 : 0·665

and here again the species fall into two groups, the group with the lower proportions extending from the present examples with a proportion of 1·0 : 1·079 to the subspecies of *schmeili, schmeili* and *hastatus*, with proportions of 1·0 : 0·665 and 0·744, and between these two extremes fall *operculatus aberrans, pachysetosus, iwoyiensis, neglectus neglectus, rylovi, tinctus* and *dybowskii.*

The antennule (Text-fig. 3 B.), as in other members of the genus is composed of seventeen segments : it reaches back only as far as the posterior margin of the cephalothorax (Th. I). I have been unable to detect any trace of a hyaline membrane on the border of either of the two terminal segments : such a membrane has been recorded in *M (Th.) oithonoides, hyalinus* and *dybowskii* (Gurney, 1933) and in *inopinus* (Kiefer, 1926) and in the last two joints in *tenuis* (Marsh) and the last joint in *minutus* by Lowndes (1934) ; and Lindberg (1935, p. 413) has recorded such a membrane in *vermifer*, but it seems probable that these examples which he was describing were actually examples of *hyalinus*. I have been unable to find any mention of such a structure in any other member of the subgenus.

Lindberg (1947, p. 130) has recorded that in *conspicuus* the proximal 6 segments are ornamented with small pits. It seems probable that this ornamentation is of the same type as that seen in the abdominal segments of some species (*vide supra*, p. 90), namely, *conspicuus* and *microspinulosus*. Gurney (1933, fig. 1904) has shown a short spine at the distal anterior angle of the 6th segment in *dybowskii.* In the present examples there is a somewhat similar one, not on the 6th segment, however, but on the anterior margin about the middle of the length of the 7th segment. In a Table on p. 59 Gurney (1933) has given a comparison of the segmentation of the antennules of *Diaptomus* and *Cyclops*, but in the present examples there seem to be differences from Gurney's arrangement for *Cyclops.*

Antennal segments of female :—

Diaptomus (from Gurney) 1933	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cyclops (from Gurney) 1933		1		2		3	4 sp.			5		6 sp	7	
Present examples		1		2		3	4 sp.		5		6		7 sp.	8

Diaptomus (from Gurney) 1933	15	16	17	18	19	20	21	22	23	24	25
Cyclops (from Gurney) 1933	8	9	10	11	12	13	14	15	16	17	
Present examples	9	10	11	12	13	14	15	16		17	

In the present specimens the 4th segment appears to correspond to 7th and 8th of *Diaptomus*, not 7th, 8th and 9th as indicated by Gurney ; the 5th corresponds to the 9th and 10th, the 6th to the 11th, the 7th to the 12th and 13th, the 8th to the 14th, and the 16th to the 22nd and 23rd, and the 17th to the 24th and 25th segments. Thus the spine on the middle of the anterior margin of the 7th segment corresponds with the spine on the 12th segment in *Diaptomus*, and that on the 6th segment in *M. (Th.) dybowskii.*

The proportional lengths of the various antennular segments, taking the total length of the appendage as 1000, are as follows :—

Segment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
	186	49	24	64	49	25	62	39	36	39	40	47	45	46	63	88 •	98	=1000
	188	46	23	64	50	27	64	32	37	37	46	50	41	46	64	83	100	=1000
	192	45	27	64	50	27	64	32	36	36	45	50	41	45	64	82	100	=1000
Average	189	47	25	64	50	26	63	34	36	37	44	49	42	46	64	83	99	=999

Unfortunately in their descriptions of most species in this subgenus the authors have omitted giving any measurements of the individual segments. I give below a few such measurements and I have added an estimate of the lengths in the subspecies *schmeili hastatus* based on Kiefer's illustration (1952, fig. 77).

Segment	1	2	3	4	5	6	7	8	
vermifer	164	41·5	25·5	67	43·5	25·5	75·5	33	41·5
ylovi	174	44	25	75	44	34	75	25	42
schmeili hastatus	183	35	22	74	46	38	67	34	34
Present examples	189	47	25	64	50	26	66	34	36
tinctus	175	30	65	55	38	44	44	38	33
iwoyiensis	210	34	29	38	38	29	38	38	34

Segment	10	11	12	13	14	15	16	17	
vermifer	43	52	49·5	44	55	57	98·5	83·0	1,000
rylov	42	48	48	44	52	52	80	94	1,000
schmeili hastatus	32	49	53	40	45	53	96	99	1,000
Present examples	37	44	49	42	46	64	83	99	1,000
tinctus	38	44	44	33	49	60	93	109	1,000
iwoyiensis	42	55	42	50	46	71	97	109	1,000

The present examples thus appear to come between *rylovi* and *iwoyiensis* and close to *schmeili hastatus*. It appears that in the above series there is a tendency towards a gradual increase in the length of the 1st segment and of the 17th. The species *vermifer* differs from the others in that the terminal segment (17th) is considerably shorter than the previous one (16th).

The antenna (Text-fig. 3C.) is composed of the usual four segments, of which the 1st is slightly longer than the 2nd and 3rd and the 4th a little shorter : the segments in two specimens have the following average lengths :—

Segment	1	2	3	4	
	29	24	24	23	=100

The 3rd segment bears six or seven setae on its anterior border and the 4th segment bears seven terminally. Most authors give no account of this appendage in their description of the species but Sars (1909) states that in *M.* (*Th.*) *neglectus* the 3rd joint bears 9 setae and Gurney (1933, fig. 1907) shows 6 only in *dybowskii*.

The mandible (Text-fig. 3 D, E) is strongly built and consists of a stout basal segment that is produced internally into a long curved gnathobase that terminates in a somewhat oblique biting edge, armed from the upper margin downwards with a strong tooth with three terminal pointed projections ; this is followed after a gap by a similar but less strongly-formed tooth, then comes a simple spine-like tooth and finally there are two setae at the lower end of the biting margin.

The maxillula (Text-fig. 3 F) is strongly built and exhibits the usual form.

The Maxilla (Text-fig. 3 G) has the usual shape and armature but exhibits an interesting variation : in some examples the posterior border of the 2nd basal segment is perfectly straight and without any protuberances : but in other specimens (Text-fig. 3 H) it exhibits a quite distinct corrugation near the proximal end, thus resembling the condition found in *M.* (*M.*) *leuckarti* (Claus). A similar variation appears to be occasionally present in *M.* (*Th.*) *hyalinus* (Rehberg) for, according to Gurney (1933, p. 298) this segment is "not ribbed" ; but Andreae (1955, p. 287) found that in this species there are "a few minor protuberances" Gurney (1933, fig. 1908) figures a single protuberance in this position in *M.* (*Th.*) *dybowskii* (Lande).

In the four pairs of Swimming legs the two rami are composed of three segments and the spine formula is, as in all other species in the subgenus, 2,3,3,3. The setae arising from the various parts of these limbs usually appear to be smooth and devoid of the usual fringing lateral hairs ; but in each leg, certain setae are slightly modified ; they are somewhat stouter than those arising from the more distal segments and have an appearance of being fringed along the more proximal part by rows of small thickenings of the cuticle. In the 1st leg (Text-fig. 3 I) the 1st basal segment bears a modified seta at its distal inner angle ; basal 2 bears a simple seta on its outer margin and a modified seta at the distal end of its curved inner border. In the possession of this last seta these examples resemble specimens of *M.* (*Th.*) *hyalinus* (Rehb.) (*vide* Gurney, 1933, fig. 1886) and *dybowskii* (Lande) (*vide* Gurney, 1933, fig. 1910) and also what I took to be *M* (*Th.*) *rylovi* Smirnov (*vide* Sewell, 1934, p. 93) and differ from *oithonoides*, in which this inner seta is wanting (*vide* Sars 1913-1918, Pl. XXXVI, fig. pl). The inner seta on the 1st segment of the exopod is also modified.

In the 2nd leg (Text-fig. 3 J) the inner seta of basal 1 is modified : basal 2 bears an outer seta and at its distal inner angle it is produced into a conical prominence that is tipped with a short spine-like projection ; there is also a short spinous process on the distal margin of the segment between the articulations of the rami : the 1st segment of the exopod bears a modified inner seta.

The 3rd leg (Text-fig. 3 K) resembles the 2nd in all respects.

In the 4th leg (Text-fig. 3 L) basal 1 bears a modified inner seta : basal 2 bears an outer seta that instead of projecting outwards runs along the face of exopod 1 almost as far as its distal margin, thus resembling *M.* (*Th.*) *hyalinus, dybowskii* and *rylovi*. There is a spine-like projection on the distal margin between the attachments of the rami, and the inner distal angle is produced into a spine-tipped conical process, as in the 2nd and 3rd legs. The 1st segment of the exopod bears a modified seta. The proportions of the 3rd segment of the endopod have been utilised by previous observers as a specific character ; in the present specimens this segment is of moderate length and the proportions of length to maximum breadth are as follows :—

Length :	Breadth	
2·82 :	1·0	
2·80 :	1·0	average 2·65 : 1·0
2·73 :	1·0	
2·25 :	1·0	

In this character we again find a gradual change in the proportions in the different species and in many of them there is a wide range of variation. I give below the proportional measurements as recorded in a series of species by various observers :—

Species	Data from	Range of variation Length : breadth	Average
M. (Th.) macracanthus	Kiefer, 1929, p. 314	....	3·50 : 1·0
„ „ *hyalinus persicus*	Lindberg,	....	3·50 : 1·0
„ „ *neglectus*	Kiefer, 1952, Table X	3·22—3·4 : 1·0	3·31 : 1·0
„ „ *vermifer*	Lindberg, 1942, p. 185	2·32—4·0 : 1·0	3·248 : 1·0
„ „ *mahéensis*	Lindberg, 1941, p. 263	3·05—3·4 : 1·0	3·152 : 1·0
„ „ *hyalinus*	Gurney, 1933, p. 299	2·34—3·52 : 1·0	3·102 : 1·0
	Mann, 1940	2·88—3·07 : 1·0	2·94 : 1·0
	Kiefer, 1952, Table XI	2·06—3·03 : 1·0	2·68 : 1·0
„ „ *tenuis*	Lowndes, 1934, p. 111	....	3·2 : 1 0
„ „ *asiaticus*	Kiefer, 1932	....	3·0 : 1·0
„ „ *dybowskii*	Gurney, 1933, p. 305	2·90—3·16 : 1·0	3·06 : 1·0
„ „ *decipiens*	Kiefer, 1952	....	3·0 : 1·0
„ „ *analogus*	Kiefer, 1936, p. 230	....	3·0 : 1·0
„ „ *infrequens*	Kiefer, 1929, p. 316	....	3·0 : 1·0
	Kiefer, 1952, Table X	2·79—3·02 : 1·0	2·895 : 1·0
„ „ *pachysetosus*	Lindberg, 1951	2·5—3·0 : 1·0	2·75 : 1·0
„ „ *rylovi*	Lindberg, 1942, p. 181	2·33—3·09 : 1·0	2·75 : 1·0
„ „ *inopinus*	Kiefer, 1926	....	2·72 : 1·0
Present specimens		2·25—2·82 : 1·0	2·65 : 1·0
„ „ *microspinulosus*	Lindberg, 1942, p. 187	2·22—3·04 : 1·0	2·55 : 1·0
„ „ *schmeili hastatus*	Kiefer, 1952, Table X	2·33—2·50 : 1·0	2·55 : 1·0
„ „ *schmeili schmeili*	Kiefer, 1952, Table X	2·08—2·65 : 1·0	2·40 : 1·0
„ „ *operculatus aberrans*	Lindberg, 1952	....	2·29 : 1·0
„ „ *tinctus*	Lindberg, 1941, p. 264	1·40—1·951 : 1·0	1·594 : 1·0

Thus the present specimens come near to *inopinus* and *rylovi* on the one hand and *microspinulosus* and *schmeili* on the other in the lower part of the table. In some species there is a wide range of variation, as for instance, in *vermifer* and *hyalinus*, especially in the former with a range 2·32—4·0, covering all the other species in the Table with the exception of the last two, *operculatus aberrans* and *tinctus*.

Another character used by previous observers to assist in discriminating between species has been the proportional lengths of the distal segment of the endopod of the 4th leg and of the inner terminal spine on the distal extremity of the joint. I give below the various proportions that have been recorded :—

Species	Data from	Proportional lengths Inner spine : endopod 3	Average
M. (Th.) oithonoides	Gurney, 1933, p. 299	....	1·56 : 1·0
,, ,, *rylovi*	Lindberg, 1942, p. 121	1·0—1·27 : 1·0	1·24 : 1·0
,, ,, *tinctus*	Lindberg, 1941, p. 264	1·11—1·33 : 1·0	1·221 : 1·0
,, ,, *asiaticus*	Kiefer, 1932	....	1·22 : 1·0
,, ,, *mongolicus*	Kiefer, 1937, p 297	....	1·159 : 1·0
,, ? ,, *operculatus aberrans*	Lindberg, 1952	....	1·103 : 1·0
,, ,, *schmeili hastatus*	Kiefer, 1952, Table XII	1·04—1·20 : 1·0	1·12 : 1·0
,, ,, *iwoyiensis*	Onabamiro, 1952	1·0—1·1 : 1·0	1·083 : 1·0
,, ,, *mahéensis*	Lindberg, 1941 p. 263	1·05—1·09 : 1·0	1·072 : 1·0
,, ,, *vermifer*	Lindberg, 1942, p. 182	0·813—1·124 : 1·0	0·990 : 1·0
	Lindberg, 1938, p. 235	0·714—1·137 : 1·0	0·975 : 1·0
,, ,, *microspinulosus*	Lindberg, 1942, p. 182	0·855—1·124 : 1·0	0·947 : 1·0
,, ,, *inopinus*	Kiefer, 1926	....	0·941 : 1·0
,, ,, *tenuis*	Lowndes, 1934, p. 111	....	0·941 : 1·0
,, ,, *decipiens*	Kiefer, 1952, Table VI	....	0·915 : 1·0
,, ,, *trichophorus*	Kiefer, 1930, p. 82	....	0·885 : 1·0
,, ,, *hyalinus*	Gurney, 1933, p. 299	0·73—1·04 : 1·0	0·795 : 1·0
	Lindberg, 1938, p. 235	0·699—1·042 : 1·0	0·870 : 1·0
	Kiefer, 1952, Table XI	0·750—0·915 : 1·0	0·847 : 1·0
Present specimens	....	0·786—0·891 : 1·0	0·855 : 1·0
,, ,, *infrequens*	Kiefer, 1929, p. 315	....	0·50 : 1·0
	Kiefer, 1952, Table VI	0·818—0·905 : 1·0	0·849 : 1·0
,, ,, *schmeili schmeili*	Kiefer, 1952, Table XII	0·808—0·990 : 1·0	0·895 : 1·0
,, ,, *dybowskii*	Gurney, 1933, p. 305	....	0·74 : 1·0

In this series we again find a gradual reduction in the proportional lengths of the inner spine and the endopod 3 of the 4th leg, ranging from 1·56 in *oithonoides* to 0·74 in *dybowskii*. If, as I believe, the present specimens are examples of the species *M. (Th.) schmeili* Poppe and Mrázek then the extreme range of variation in these proportional lengths extends from 0·786 : 1·0 in the present form through 0·808—0·990 : 1·0 in the subspecies *schmeili* (s. str.) to 1·20 : 1·0 in *hastatus* Kiefer, and such a range covers the proportions found in all the other species with the exception of *oithonoides*, at the head of the Table and *dybowskii* at the bottom. Another character that has been used in the discrimination of species in this subgenus is the proportional lengths of the two end-spines on the terminal segment of the endopod of the 4th leg. In the Table below I give the average proportions of these in most of the species and subspecies, and, where the data have been given by previous authors, the extremes of variation :—

Species	Data from	Proportional lengths of terminal spines of endopod 3 of P4 Inner : Outer.	Average
M. (*Th.*) *oithonoides*	Gurney, 1933, p. 299	....	4·100 : 1·0
,, ,, *retroversus*	Lindberg, 1951	3·32—4·01 : 1·0	3·86 : 1·0
,, ,, *twoyiensis*	Onabamiro, 1952, p. 257	2·4—3·1 : 1·0	2·60 : 1·0
,, ,, *hyalinus*	Kiefer, 1937, p. 296	2·20—2·22 : 1·0	2·21 : 1·0
	Lindberg, 1937, p. 235	2·80—3·33 : 1·0	2·51 : 1·0
	Gurney, 1933, p. 299	1·60—2·70 : 1·0	2·207 : 1·0
,, ,, *persicas*	Lindberg	2·8—2·9 : 1·0	2·85 : 1·0
,, ,, *ndalaganus*	....	2·12—2·17 : 1·0	2·145 : 1·0
,, ,, *hivucnsis*	....	....	2·08 : 1·0
,, ,, *hyalinus*	Kiefer, 1952	1·81—2·16 : 1·0	2·10 : 1·0
,, ,, *byzantinus*	....	2·03—2·11 : 1·0	2·058 : 1·0
,, ,, *macrolasius*	....	1·93—2·14 : 1·0	2·055 : 1·0
	Mann, 1940	1·92—2·44 : 1·0	2·18 : 1·0
,, ,, *neglectus*	Sars, 1909	3·5—4·0 : 1·0	3·75 : 1·0
bcipiens	Kiefer, 1952	....	2·67 : 1·0
neglectus		2·0—2·78 : 1·0	2·39 : 1·0
prolatus	...	....	1·79 : 1·0
,, ,, *infrequens nigerianus*	....	....	2·33 : 1·0
eduardensis	Kiefer 1952	....	2·20 : 1·0
infrequens	....	1·76—2·07 : 1·0	1·864 : 1·0
,, ,, *mongolicus*	Kiefer, 1937, p. 297	....	2·353 : 1·0
,, ,, *mahéensis*	Lindberg, 1941, p. 261	2·14—2·48 : 1·0	2·324 : 1·0
,, ,, *vermifer*	Lindberg, 1942	1·89—2·83 : 1·0	2·28 : 1·0
,, ,, *pachyestosus*	Lindberg, 1951	....	2·12 : 1·0
,, ,, *tinctus*	Lindberg, 1942, p. 22	....	1·96 : 1·0
	Lindberg, 1941, p. 264	1·57—1·89 : 1·0	1·779 : 1·0
,, ,, *rylovi*	Lindberg, 1942	1·45—2·18	1·89 : 1·0
,, ,, *tenuis*	Lowndes, 1934, p. 111	....	1·889 : 1·0
,, ,, *inoptnus*	Kiefer, 1926	....	1·882 : 1·0
,, ,, *operculatus aberrans*	Lindberg, 1952	....	1·50 : 1·0
Present examples	....	1·158—1·545 : 1·0	1·426 : 1·0
,, ,, *conspicuns*	Lindberg, 1947, p. 130	1·05—1·10 : 1·0	1·075 : 1·0
,, ,, *schmeili schmeili*	Kiefer, 1952	1·01—1·125 : 1·0	1·06 : 1·0
,, ,, *schmeili hastatus*	Kiefer, 1952	0·83—0·96 : 1·0	0·895 : 1·0
,, ,, *dybowsaii*	Gurney, 1933, p. 305	0·80—0·895 : 1·0	0·842 : 1·0

Here again we get a gradual sequence without any clear break in the series except at the very top with *oithonoides* and *retroversus*, and, according to Sars, *neglectus*, exceeding a proportion of 3·5 : 1·0. In all the other species the average proportion falls within a range of 0·842 to 2·60; an almost equally wide range appears from the data given by different observers to be present in *hyalinus* (s. lat.), in which it extends from 1·60 to 3·33 and in *vermifer* with a range of from 1·89 to 2·83. In the present examples the range of variation from 1·158 to 1·545 overlaps the range found in *rylovi*, and if linked with the proportions in the subspecies of *schmeili*, the combined range 0·83—1·545, overlaps that of *dybowskii*.

Kiefer (1952) has laid considerable emphasis on the character of the connecting plate between the 4th pair of swimming legs and I have already (*vide supra*, p. 84) pointed out that Lindberg is less dogmatic about this point and has shown that in a given species there may be a very considerable range of difference and even in rare instances the plate may not be symmetrical, one side conforming to the condition in one species, *e.g.*, *rylovi*, and on the other to a different species, such as *vermifer* ; and later (1951) he pointed out that his examples of *M.* (*Th.*) *schmeili* taken in Lake Tanganyika differed from those recorded by Kiefer from the Belgian Congo in that the rounded prominences at the sides of the distal border of the plate were wanting and their place was taken by 2 or 3 spinules on the margin and scattered hairs on the surface.

In the present specimens the connecting plate of the 1st swimming legs has a well rounded prominence, each surmounted by some 5 or 6 small spines and between these prominences the interval is equal in width to the prominence itself. In the 2nd and 3rd legs the prominences are equally well rounded but are narrower than those of the 1st leg and bear only 3 or 4 spinules. In the 4th leg the prominences are narrow but project well beyond the margin of the plate and are separated by a space about twice the width of the prominence ; their margins are devoid of any spinules and in their general appearance resemble those of *M.*(*Th.*) *trichophorus* Kiefer (1930) and *M.* (*Th.*) *oithonoides* Sars, as figured by him (1913-18 Pl. XXXVI, p. 4).

The 5th leg (Text-fig. 3 M) consists of the usual two segments ; the proximal segment bears a single seta at its distal outer angle and the free segment is of moderate length and bears an outer seta on the distal margin and an inner spine near the inner distal angle either on the distal border or on the inner margin. In the present examples in some instances both seta and spine arise from the distal border but in others the spine springs either from the distal inner angle of the segment or from the inner margin close to the distal angle. The spine appears to be denticulate as in both *schmeili schmeili* and *schmeili hastatus* in which it is, according to Kiefer, fringed with minute spinules along the distal two-thirds of its length. In other species it seems that this spine may be either denticulate or smooth. In *hyalinus* Gurney (1933, fig. 1955) has shown the spine as smooth in a specimen from India, but Lindberg (1938, Pl. V, fig. 11) shows it as being denticulate along the distal two-thirds of its outer border ; and Lowndes (1934, p. 111) states that in specimens of *M.* (*M.*) *meridianus* Kiefer from South America this limb was variable, "the inner seta of the second joint," he states, "may be quite stout and bear coarse teeth or it may be quite fine and smooth" The relative lengths of the terminal seta and spine on the free segment have been used as a diagnostic feature between members of the subgenus : but here again there seems to be a great range of variation in certain species and in the Table following I give the relative lengths* of the inner spine to the outer seta as recorded by previous observers :—

Species	Data from	Proportional lengths Inner spine : outer seta	Average
M, (Th.) neglectus	Sars, 1909	....	about 1·0 : 1·0
„ „ *oithonoides*	Gurney, 1933, fig. 1897	....	1·0 : 1·0
„ „ *hyalinus*	Gurney, 1933, p. 298 Gurney, 1933, fig. 1895	....	1·0 : 1·0 1·56 : 1·0
	Gurney, 1938	0·80—1·5 : 1·0	1·07 : 1·0
	Gurney, 1951	1·10—1·49 : 1·0	1·29 : 1·0
	Lindberg, 1935	1·15—1·46 : 1·0	1·33 : 1·0
„ „ *infrequens*	Kiefer, 1938, fig. 31	....	1·07 : 1·0
„ „ *vermifer*	Lindberg, 1942	0·96—1·56 : 1 0	1·10 : 1·0
	Lindberg, 1938	1·0—2·03 : 1·0	1·28 : 1·C
	Lindberg, 1935	1·15—1·46 : 1·0	1·33 : 1·0
„ „ *dybowskii*	Gurney, 1933, fig. 1914	....	1·12 : 1·0
„ „ *retroversus*	Lindberg, 1951	1·09—1·23 : 1·0	1·16 : 1·0
„ „ *emini*	Kiefer, 1938, fig. 49	....	1·20 : 1·0
„ „ *schuurmanae*	Lindberg, 1951	1·08—1·26 : 1·0	1·20 : 1·0
„ „ *rylovi*	Lindberg, 1942, p. 181	1·0—1·76: 1·0	1·26 : 1·0
	Sewell, 1934, fig. 7 b.	....	1·67 :1·0
„ „ *mahéensis*	Lindberg, 1941, fig. 1*a*	1·20—1·33 : 1·0	1·27 : 1·0
„ „ *pachysetosus*	Lindberg, 1951	1·26—1·34 : 1·0	1·30 : 1·0
„ „ *operculatus aberrans*	Lindberg, 1952	....	1·31 : 1·0
„ „ *macracanthus*	Kiefer, 1938, fig. 42	....	1·36 : 1·0
„ „ *tinctus*	Lindberg, 1941, fig. 1*a*	1·3—1·5 : 1·0	1·4 : 1·0
„ „ *analogus*	Kiefer, 1936, p. 229	....	1·40 : 1·0
„ „ *neglectus decipiens*	Kiefer, 1952, fig. 55	....	1·40 : 1·0
„ „ Present examples	....	1·36—1·50 : 1·0	1·43 : 1·0
„ „ *mongolicus*	Kiefer, 1937	....	1·44 : 1·0
„ „ *schmeili schmeili*	Lindberg, 1951	1·46....1·50 : 1·0	1·48 : 1·0
	Kiefer, 1952 fig. 30	....	1·78 : 1·0
„ „ *trichophorus*	Kiefer, 1930	....	1·91 : 1·0
„ „ *schmeili hastatus*	Kiefer , 1952, fig. 73	....	1·91 : 1·0

Here again we find that the species fall into a gradual series in which the outer seta becomes relatively shorter in comparison with the inner spine, and in those species of which we have sufficient data the proportional lengths of these two structures to each other show a wide range, as for instance in *hyalinus*, from a number of different localities, where the extreme range extends from 0·80 to 1·56, thus covering almost the whole series of proportions in all the species in the list. The present examples come near to *tinctus*, *analogus* and *neglectus decipiens*, in all of

* In those species such as *mahéensis* and *tinctus*, in which no actual measurements have been given I have attempted to calculate the proportions of the two appendages from the figures, where such have been given : but these estimates can only be regarded as approximate.

which the average proportion is 1·140 : 1·0 and *macracanthus*, in which the estimated proportion is 1·36 : 1·0 ; on the other hand they are close to *mongolicus*, with a proportion of 1·44 : 1·0 and *schmeili schmeili* which according to Lindberg has an average of 1·48 : 1·0.

♀ *Copepodid Stage V* (Text-fig. 4)

The total length of the animal in this stage is 0·9 mm. The proportional lengths of the anterior and posterior regions of the body are as 1·80 or 1·67 : 1·0 ; average 1·735 : 1·0. The proportional lengths of the various segments of the body are as follows :—

Ceph.—Th. I	Th. II	III	IV	V	Abd. 1	2	3	4-5	Furca
368	99	94	58	45	63	58	49	71	95 =100
369	100	95	60	50	60	56	50	65	95 =1000
Average 368·5	99·5	94·5	59	47·5	61·5	57	49·5	68	95=1000

The furcal rami are parallel and the proportional dimensions of length to breadth are :—

22 (14·5+7·5) :	6·5 or 3·38	: 1·0
23 (15·0+8·0) :	6·5 or 3·54	: 1·0
Average	3·46	: 1·0

In the above table I have given the lengths of the proximal and distal portions of the length of the ramus from the point of origin of the 5th seta.

The furcal setae have the following proportional lengths :—

	Seta 1	2	3	4	5	6
	24·0	100	73·3	16·0	6·7	..
	24·3	100	78·3	22·9	8·6	21·4
Average	24·15	100	75·8	19·45	7·65	21·4

The proportional lengths of the various setae to each other in this stage are as follows :—

Proportional lengths of furcal setae

	1—2	1—3	1—4	4—6
Present examples, Stage V	1·0 : 4·14	3·139	0·805	1·10

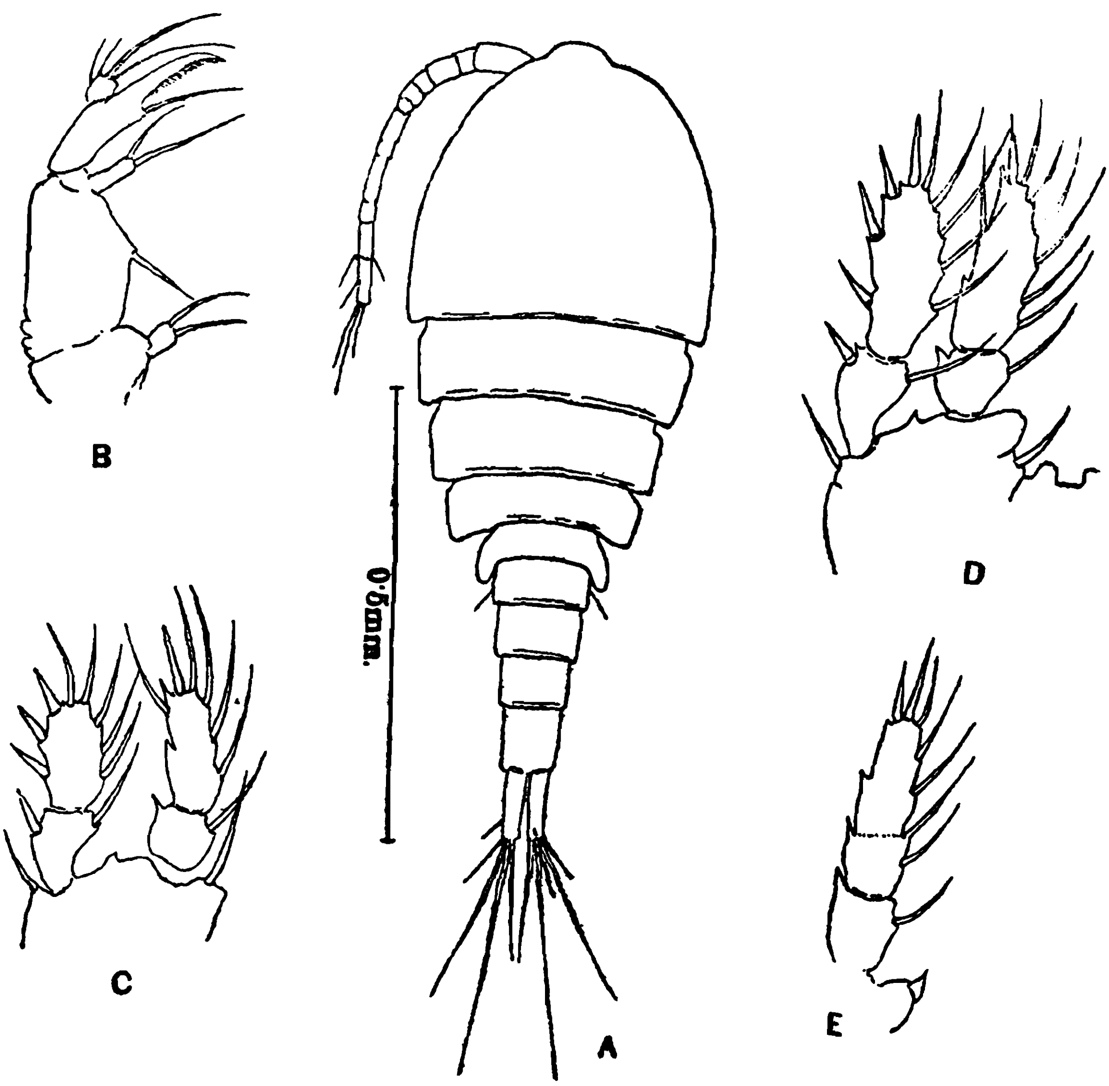
The antennule in this stage is composed of only eleven free segments that have the following proportional lengths :—

Segment	1	2	3-4	5	6	7	8-9-10-11	12-13-14	15	16	17
	195	43	76	49	27	59	146	124	59	92	130
	172	40	75	46	23	63	161	128	69	98	125
Average	183·5	41·5	75·5	47·5	25·0	61·0	153·5	126·0	64	95	127·5

The antenna and the mouth-parts are already fully developed and resemble those of the adult.

In the maxilla (Text-fig. 4 B) the same corrugation in the posterior margin of the 2nd basal segment, as has been noted in certain of the adults (*vide supra*, p. 99 , Text-fig. 3, H), may be present at this stage also.

In the swimming legs (Text-fig. 4 C and E) the rami are composed of only two free segments, the 2nd and 3rd not having as yet separated, though the line along which separation will take place at the next moult can clearly be seen in the endopod running across the face of the undivided segment to terminate in a notch on the outer margin. None of



TEXT-FIG. 4.—*M.* (*Th.*) *schmeili* f. *marmagoensis*, Stage V.
A. Whole animal dorsal view. B. Maxilla. C. 1st swimming leg. D. 2nd swimming leg. E. Endopod of 4th swimming leg.

the setae arising from the basal segments or the proximal segment of the rami of any of the limbs is modified in the manner found in the adult. In the 4th leg the inner of the two spines on the distal margin of the terminal segment of the endopod is, as in the adult, considerably shorter than the length, as estimated, of that portion of the still fused 2nd and 3rd segments that at the next moult will separate off as segment 3 ; the tactual proportions are as 0·84 to 1·0. The two end-spines have between them selves the following proportional lengths :—

Inner spine : outer spine.

1·545 : 1·0

In the 5th leg the inner spine is about one-and-a-third times the length of the outer seta on segment 2, the proportions being 13 : 10 or 1·3 : 1·0.

♀ *Copepodid Stage IV* (Text-fig. 5)

Total length 0·717 mm. The proportional lengths of the anterior and posterior regions of the body in this stage are as 64 to 36 or 1·78 : 1·0 ; and the proportional lengths of the various segments are as follows :—

Ceph.—Th.	Th. II	III	IV	V	Abd. 1	2	3—5	Furca:	
375	100	95	75	50	65	55	90	95	1000

The furcal rami are long and narrow, having the proportion of length to breadth as 3·2 : 1·0, thus closely resembling the adult *schmeili hastatus*. In this stage the 5th furcal seta appears to arise somewhat nearer the base of the ramus, the lengths of the proximal and distal parts of the ramus being in the proportions of 7·5 : 12·5. The furcal setae have the following proportional lengths :—

Seta	1	2	3	4	5	6
	24	100	77	16	7	16
	24	100	73	16	7	..
Average	24	100	75	16	7	(16)

The proportional lengths of the setae in this stage are as follows :—

	Proportional lengths of setae			
	1—2	1—3	1—4	4—6
Present specimens, Stage IV	1·0 : 4·167	3·125	0·667	1·0

The antennule is, as in the adult, short and barely reaches to the level of the posterior margin of the cephalothorax. In this stage there are only eight separate joints in the appendage, though indications of future separation can be detected in the 2nd joint. The proportional lengths of the segments are as follows :—

Segments	1—2	3-4-5	6-7	8-9-10-11	12-13-14	15	16	17	
	176	120 (80, 40)	80	160	160	64	104	136	=1,000

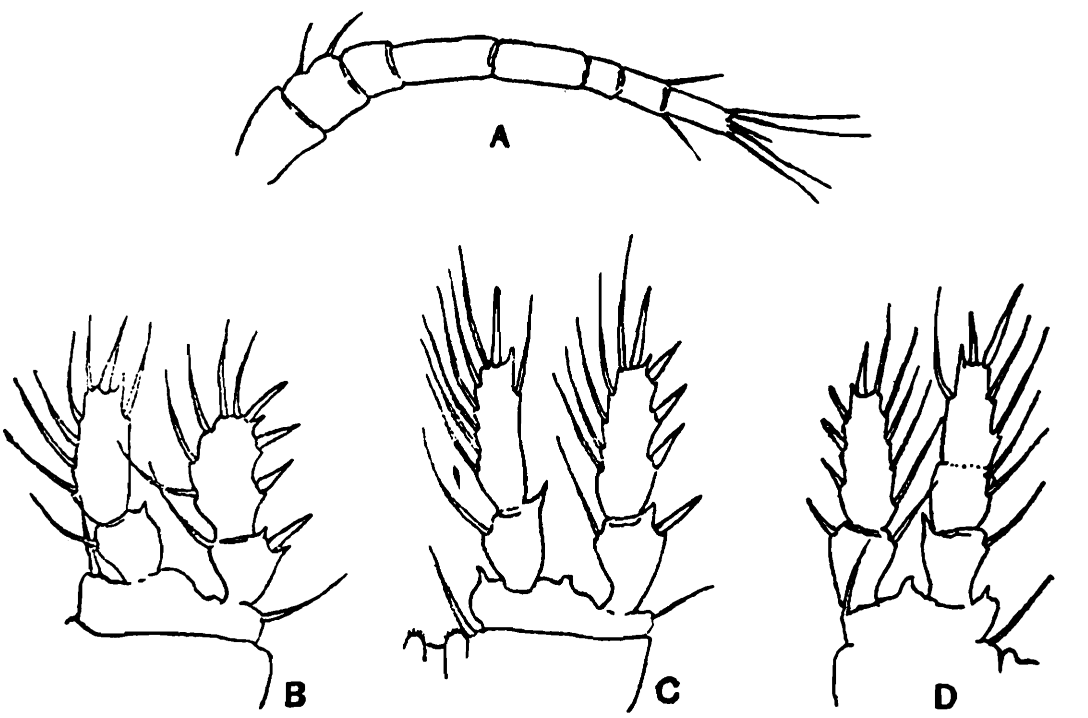
The antenna and mouth-parts are very similar to those of the adult.

In the 4th swimming legs (Text-fig. 5 D) the proportional lengths of the inner and outer spines on the distal end of the endopod are as 9 to 5 or 1·80 : 1·0.

In the 5th leg the main structure was already similar to that of the adult and the inner spine at the distal end of the free segment was longer than the outer seta, but I was unable to get an exact measurement of either.

IV—DEVELOPMENTAL CHANGES

Although the total number of specimens was small, it seemed to be worth while to study the various changes that had taken place during the course of development in the final three stages of the life-history During the successive moults both the body as a whole and the various parts undergo changes that result in an alteration in the proportions of the various parts. The whole body increases in size at each moult but individual segments may increase at a higher rate than others. In



TEXT-FIG. 5.—*M. (Th.) schmeili* f. *marmagoensis*, Stage IV.
A. Antennule. B. 1st swimming leg. C. 2nd swimming leg. D. 4th swimming leg.

the present individuals the proportional lengths of the anterior and posterior regions change as follows :—

	Anterior region Ceph.-Th. I-IV		Posterior region Th. V, Abd. 1-5, furca
	mm.		
Stage IV	1·79	:	1·0
V	1·67	:	1·0
VI	1·47—1·52	:	1·0

It is thus clear that at each moult the posterior region increases in length at a greater rate than the anterior region ; but individual segments may also increase at a higher rate than others so that the proportional lengths of the segments of the body alter at each moult, as follows :—

	Ceph.-Th.I	Th.II	III	IV	V	Abd. 1	2	3	4	5	Furca
Stage IV	375	100	95	75	50	65	55		90		95=1000
Stage V	368·5	99·5	94·5	59	47·5	61·5	57	49·5	68		95=1000
Stage VI	351	86	85	79	50	124		58	55	27	86=1000

In the cephalothorax and the first two free thoracic segments there is a reduction in the proportional lengths of the region which is most marked in the moult from stage V to VI and in segments Th. IV and V the proportional lengths appear to decrease in the first moult from Stage IV to V and then increases again in the next moult from Stage V to VI. In the abdomen alterations in the length of the segments are complicated by the fusion of the two anterior segments at Stage VI to form the adult genital segment, and the separation of the combined posterior three segments, 3, 4 and 5, into two at Stage V and finally into 3 at Stage VI. The furcal rami do not appear to change between Stages IV and V but are reduced in length at Stage VI : as in the Calanoida, when a segment divides at a moult into two daughter-segments the combined lengths of these is greater than the length of the parent, so that at the moult from Stage IV to V the three fused abdominal segments 3, 4, and 5 increase in length from 90 to two segments having the lengths of 49·5 and 68 (=117·5). At the anterior end of the abdomen the two segments 1 and 2 remain separate between Stages IV and V, having a combined length of 65+55(=120) in Stage IV and 61·5 and 57(=118·5) in Stage V and at Stage VI these fuse to form the genital segment which has a total length of 124. Andreae (1955, p. 292) has observed a similar change in length of abdominal segments 1 and 2 in the moult from Stage IV to V in *M (Th.) hyalinus* (Rehberg) : in this species examples of Stage IV can be divided into two groups according to the number of segments in the antennule, one group having 10 segments and the other only 9, the difference being apparently a sexual one, the 10 segment group being females and the 9 segment group males. In the females the proportional lengths of the first 2 segments of the abdomen are given as follows :—

	Length in μ Segment 1	2	Combined length 1-2	Proportions of segment 2 to 1
Stage IV	48·3	43·4	91·7	1·0 : 1·113
Stage V	50·1	52·5	102·6	1·0 : 0·954

In the males with only 9 segments in the antennule the proportions are as follows :—

	Length in μ Segment 1	2	Combined length 1-2	Proportions of segment 2 to 1
Stage IV	49·7	41·3	91·0	1·0 : 1·203
Stage V	53·2	47·3	100·5	1·0 : 1·125

In the present collection I have only females and in these the measurements are as follows :—

	Length in μ Segment 1	2	Combined length 1-2	Proportions of Segment 2 to 1
Stage IV	46·6	39·4	86·0	1·0 : 1·193
Stage V	55·4	51·3	106·7	1·0 : 1·080

The proportions found in the present examples are thus of much the same order as in *hyalinus* and cannot be regarded as having any specific significance ; such slight differences may well be due to different environmental conditions.

Similar changes are to be seen in the successive stages in the proportions of length to breadth in the furcal ramus ; these are as follows :—

	Length	:	Breadth	Mean
Stage IV	3·20	:	1·0	
Stage V	3·38—3·54	:	1·0	3·46 : 1·0
Stage VI	3·38—3·83	:	1·0	3·633 : 1·0

Thus at Stage IV the proportions fall within the range found in the adults of *vermifer*, *dybowskii* and *rylovi* and only extremely little above the upper limit found in *schuurmanae* and *schmeili hastatus* : in Stage V it falls within or overlaps the range found in *rylovi*, *mahéensis*, *tinctus*, *analogus* and *inopinus* : and in Stage VI it lies between the ranges found in *schmeili schemeili* and *schemeili hastatus* in a group of species that includes the species in Stage V and also *conspicuus* and *operculatus aberrans*.

The position of origin of the 5th furcal seta appears to change at each moult, the proportions of the distal and proximal parts of the ramus being as follows :—

	distal	proximal
Stage IV	1·0	1·667
Stage V	1·0	1·904
Stage VI	1·0	2·007

The relative proportions of the various furcal setae to each other in the last three stages of development are as follows :—

	Stage IV	Stage V	Stage VI
Seta 1 to seta 2	1·0 : 4·167	4·1475	3·788
Seta 1 to seta 3	1·0 : 3·125	3·1275	3·049
Seta 1 to seta 4	1·0 : 0·667	0·596	0·592
Seta 1 to seta 6	1·0 : 0·667	0·564	0·639
Seta 3 to seta 4	1·01 : 0·213	0·191	0·203
Seta 3 to seta 6	1·0 : 0·213	0·180	0·218
Seta 4 to seta 6	1·0 : 1·0	0·945	1·079

Thus at the moult between Stages IV and V there is a fall in the proportions of seta 1 to setae 2, 3 and 4 and this is continued at the next moult between Stages V and VI : but in the proportions of seta 1 to seta 6, seta 3 to 4 and 6, and seta 4 to 6 there is a drop at the moult from Stage IV to V but this is followed by rise at the moult between Stages V and VI.

In the present form the antennule is composed of 8 segments in Stage IV and 11 in Stage V, increasing to 17 in the adult. Gurney (1933, p. 48) has shown what he terms the normal development of the antennule in *Cyclops*, in which there are 9 segments in Stage III, 10 segments in Stage IV, 11 in Stage V and the usual 17 in Stage VI. In the Table below

I give the actual measurements of these various segments in the three last Stages of the life-history :—

Segment		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Stage	IV	175		120			80				160			160		64	104	126
,,	V	183·5	41·5		75·5	47·5	25·60				153·5			126		64	95	127·5
,,	VI	189	47	25	63	50	26	66	34	36	37	44	49	42	45	64	83	99

Andreae (1955, p. 292) has confirmed the statement made by Gelmini that in *hyalinus* in Stage V there are 10 segments in the antennule of the females and 9 in the males : in the present examples the number at this stage was 11 and the mode of separation of the segments appears to be as follows :—

Segment		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Nauplius			1				2											
Copepodid Stage	III		1				2				3				4	5	6	7
,,	IV	1		2			3				4				5	6	7	8
,,	V	1	2	3		4	5	6			7			8		9	10	11
Adult	VI	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

It would thus appear that in this species the condition at Stage III must correspond with that at Stage II in the normal method of development as given by Gurney : at the moult from Stage III to IV the proximal segment is the only one that undergoes division, thus raising the number of segments from 7 to 8. In the moult from Stage IV to V, segment 2 divides into segments 2 and 3 and segment 3 divides into segments 4, 5 and 6 ; and in the final moult from Stage V to the adult, segment 3 divides into segments 3 and 4, segment 7 into 8, 9, 10 and 11 and segment 8 into segments 12, 13, and 14. The distal three segments remain unchanged throughout these last stages.

Minor changes in the proportions of various parts of the legs can also be detected at each moult. The terminal segment of the endopod of the 4th leg becomes somewhat narrower in proportion to its length and the inner terminal spine becomes slightly shorter in proportion to the end-joint at each moult : the inner spine also becomes progressively shorter in respect to the outer spine. The changes noted are as follows :

Proportions of :	Stage IV	V	VI
Length to breadth of endopod 3 of P_4	2·11 : 1·0*	2·53 : 1·0*	2·65 : 1·0
Inner spine to endopod 3 of P_4	0·79 : 1·0	0·84 : 1·0	0·855 : 1·0
Inner spine to outer spine of endopod 3 of P_4	1·80 : 1·0	1·545 : 1·0	1·426 : 1·0

* As in these stages the endopod is composed of only two segments, 2 and 3 not having separated, the length of the distal portion that will ultimately separate off as segment 3 has been estimated by the length of that part of the combined segments between the extreme distal end and the notch on the outer margin which marks the point where the line of separation will be formed in the final moult.

Thus the proportions of the terminal segment of endopod 3 of the 4th leg fall at all three stages within the limits of variation found in the adult of *schmeili schmeili* namely, 2·08—2·65 : 1·0. The proportions of the inner and outer spines of the distal segment fall within the limits of variation found in the species *rylovi* and *tinctus*, namely, 1·45—2·18 : 1·0 ; and in the proportions of the inner spine to the length of endopod 3 the observed proportions fall within the limits of variation found in the species *vermifer*, *hyalinus*, *infrequens* and *schmeili schmeili*.

In the 5th leg the inner spine arising from the neighbourhood of the inner distal angle of the 2nd segment appears to get longer in proportion to the outer seta at the last moult, but I was unable to get an accurate measurement of the seta in Stage IV.

	Stage V	Stage VI
Proportional lengths of inner spine to outer seta of distal segment of P_5	1·30 : 1·0	1·43 : 1·0

At both Stages the proportions fall within the limits of the proportions found in *hyalinus*, *vermifer*, *rylovi* and *tinctus* and at Stage VI come near to the average in *analogus*, *pachysetosus*, *macracanthus*, *neglectus decipiens* and *mongolicus*. The proportions as given in *macracanthus* lie exactly between the proportions in Stages V and VI.

V—Discussion

From the foregoing pages it must be obvious to anyone that in the subgenus *Thermocyclops*, with the increase in our knowledge of the finer details of structure and of the degree of variation that may be found to occur between one specimen and another, it becomes, as Lowndes pointed out, more and more difficult to lay down any definite characters by which we can separate one set of examples from another and so draw a hard and fast line of demarcation between one species and another. In the following pages I have taken a number of the points listed above (*vide* p. 73) which have been taken by previous authors as indicative of specific difference and have commented on the resemblance of the present specimens to those belonging to other closely related, or at least very similar 'species' :—

1. *The total length of the adult and the proportions of length to breadth of the genital segment.*—In the present examples the total length of the adult is from 0·95 to 1·05 mm. Reference to the Table given on p. 74 reveals that these specimens fall within the range of variation exhibited in the following species :—

rylovi	*tinctus*	*trichophorus*
hyalinus	*mahéensis*	*emini*
schuurmanae	*decipiens*	*vermifer*
schmeili (s. lat.)	*brehmi*	

and it seems clear that if more examples had been measured this list would have been extended even further to include :—

dybowskii	*pachysetosus*	and *infrequens*.

In the proportions of the length to breadth of the genital segment the present examples have a range of 0·816—1·03 : 1·0, and so fall into line with the following species :—

tinctus		*schmeili* (s. lat.)
operculifer		*operculatus aberrans*
	and	*trichophorus.*

The observed variation in *tinctus* covers the range in all the above species, and also in *conspicuus* and *inopinus*.

2. *The proportions of length to breadth of the furcal rami.*—The present examples (*vide supra*, p. 92) come nearest to the following species :—

rylovi		*inopinus*
mahéensis		*conspicuus*
tinctus		*operculifer*
analogus	and	*operculatus aberrans.*

Here again the range recorded by Lindberg in *tinctus* covers the proportions in all the above species.

3. *The proportional lengths of the furcal setae.*—The present examples come nearest to *tinctus* in the proportions of seta 1 to 2 ; in the proportions of seta 1 to 3 near to—

tinctus		*inopinus*
operculatus aberrans		*pachysetosus*
schmeili hastatus	and	*schmeili schmeili.*

In the proportions of seta 1 to 4 they are near to—

dybowskii		*schmeili schmeili*
inopinus	and	*neglectus prolatus*

and come between these and—

pachysetosus and *tinctus.*

As regards the proportions of seta 4 to 6 the present examples fall close to the following species :—

operculatus aberrans		*rylovi*
pachysetosus		*tinctus*
iwoyiensis	and	*dybowskii,*
neglectus neglectus		

the proportions of all the above and the present examples lying between 1·0 : 0·64—1·11.

4. *The proportions of the 3rd segment of the endopod of the 4th swimming leg.*—The average proportions of length to breadth of this segment in the present examples come nearest to that of—

pachysetosus	*schmeili hastatus*
rylovi	*schmeili schmeili*
inopinus	*operculatus aberrans.*
microspinulosus	

The proportions fall in all these species between 2·55 : 1·0 and 2·75 : 1·0 but the range of variation in the present specimens also falls within or at least overlaps the range found in *vermifer*, *hyalinus*, *infrequens* and *operculatus aberrans*.

5. *The proportional lengths of the inner spine and the distal segment of the endopod of the 4th leg.*—The present examples come near the bottom of the list (*vide*, p. 101) with *decipiens*, *trichophorus* and *hyalinus* just above and *infrequens*, *schmeili schmeili* and *dybowskii* immediately below.

6. *The proportional lengths of the inner and outer spines on the distal end of the 3rd segment of endopod 4.*—Here the present examples (*vide supra*, p. 102) overlap with *rylovi* and come very near to *tinctus* and the two subspecies of *schmeili*, forming with these latter an almost continuous range from 0·83-0·96, 1·01-1·125 and 1·158-1·545.

7. *The proportional lengths of the inner spine and outer seta on the free segment of the 5th leg.*—Here the present examples (*vide supra, p.* 104) agree closely with—

tinctus		*mongolicus*
analogus	and	*schmeili schmeili,*
neglectus decipiens		

and also overlap with the range in *vermifer*, *rylovi*, *macracanthus* and *hyalinus*.

Between *schmeili schmeili* and *s. hastatus* there is a wide gap, the proportions in this latter form being as great as 1·91 : 1·0, and between these two subspecies lies *trichophorus*.

In the subgenus *Thermocyclops* there is, as we have now seen, in most of the morphological characters of the body, such as the relative proportions of the length and breadth of the parts, a gradual change, without any very definite break, as we pass from one species or subspecies to another. Gurney (1933, p. 306) commented on the similarity that exists between *M.* (*Th.*) *rylovi* Smirnov, *dybowskii* (Lande) and *schmeili* Poppe and Mrázek and remarks that *schmeili* Poppe and Mrázek and *rylovi* Smirnov might be regarded as subspecies of *dybowskii* (Lande). How great is the difficulty in distinguishing one species from another with any degree of certainty is clearly seen in accounts that have been given us by previous workers and especially by Kiefer and Lindberg. Lindberg (1935) when he first described *vermifer* regarded it as a subspecies of *rylovi*, but he later separated it as a new species : he admits, however, that none of the characters enumerated by him served for the absolute discrimination of these forms and claims that it is only the existence of several of these characters that permits of their separation. Kiefer (1937, p. 298) considered that the shape of the receptaculum seminis in the female is one of the main characters that serve for the discrimination between species and subspecies in this subgenus : but Lindberg (1938, p. 212) in a paper in which he compares *M.* (*Th.*) *vermifer* with *hyalinus* comes to the conclusion that the shape of the receptaculum seminis is not always a reliable character, for in certain specimens he found that the shape of this organ was intermediate between those characteristic of the two species and in these examples other characters were also found to be intermediate : he concluded that these specimens must be hybrids produced by the crossing of the two species. Lindberg (1942) came to the conclusion that there are distinct differences between *decipiens* Kiefer and certain other species but admits that in *vermifer*, *rylovi*, *analogus* and *mongolicus* the receptaculum seminis is very similar and he suggests that *analogus* Kiefer is manifestly a *vermifer* with a longer furcal ramus, while *mongolicus* Kiefer seems to represent a form of passage between *vermifer* and *rylovi*.

Lindberg (1942, p. 153) has commented on the resemblances that exist between *rylovi* and *microspinulosus* in the character of the receptaculum seminis but claims that they differ in the character of the connecting plate between the fourth pair of legs : in *rylovi* the spines on the rounded prominences at the two sides of the plate are strong, whereas in *microspinulosus* they are small ; but he concludes that though these two forms represent distinct species they are closely related. The present examples also closely resemble *rylovi* in the shape of the receptaculum seminis but differ in that there are no spines on the connecting plate : so that in this respect *rylovi*, *microspinulosus* and the present specimens appear to form a gradual series, in which these spines are reduced and finally abolished.

Kiefer (1937*b*) in his earlier account of the various forms from the Belgian Congo created several new species and subspecies among which were *M.* (*Th.*) *consimilis* and *decipiens* ; but in his later work (1952) he concludes that these are to be regarded as subspecies of other species, the former being a subspecies of *hyalinus* and the latter of *neglectus*. In this review he admits that in Southern and Eastern Asia there are not a few *Thermocyclops* species, which in the shape of the receptaculum seminis, as well as in other characters, so strongly resemble one another that they are not easy to separate and as examples of this he mentions *Thermocyclops rylovi* Smirnov, *vermifer* Lindberg and *analogus* Kiefer and he remarks that these also show a resemblance to *decipiens* Kiefer. As characteristics of this group he enumerates the form of the seminal vesicle, the long dorsal furcal seta (seta 6), the prominences on the free margin of the connecting lamella between the 4th pair of legs, the long inner spine on the distal border of the terminal segment of the endopod of the 4th leg and the longer inner spine on the free segment of the 5th leg : but, as we have already seen, throughout the whole subgenus there is a gradual change in the proportions of these spines and setae to each other or to the dimensions of the segment that bears them, while Lindberg himself (1938, p. 213) remarks, " les auteurs, tel que Kiefer, qui attachent une importance fondamentale à des aspects même légèrement différents du réceptacle séminal en vue de la distinction d' espèces, seront peut-être enclins à considérer que les divers types de réceptacle séminal que j'ai donnés, correspondent à autant d'espèces distinctes "

It thus appears that we have very nearly reached the stage, foreshadowed by Lowndes (*vide supra*, p. 70) that the inclusion of more and more detail in the description of any of the known forms has rendered it almost impossible to discriminate between a number of forms as distinct species. In quite a number of so-called species the published descriptions are anything but full. Very few authors have given, for instance, the relative lengths of the various segments of the antennule or the characters of the mouth-parts, or any descriptions of the various stages during the course of development.

Mann (1940, p. 80) pointed out in his account of his work on the fauna of the Turkish Lakes that both *Mesocyclops leuckarti* and *Eucyclops serrulatus* exhibited variation in the proportions of several parts of the body in different lakes in the same year and in the same lake in different years ; and he concludes that his data certainly show that the present scheme for the determination of the species of the Cyclopoids is not yet finally established, and that it is probable that they will have to be arranged in larger groups. Charles Darwin (1897, p. 294) himself pointed out that, " It should be constantly borne in mind that any linking variety between two forms which might be found, would be ranked unless the whole chain could be perfectly restored, as a new and distinct species ; for it is not pretended that we have any sure criterion by which species and varieties can be discriminated "

Kiefer (1952) has arranged a number of species and subspecies into groups, namely :

I. The ' Hyalinus ' group , which includes—

M. (*Th.*) *hyalinus hyalinus* (s. str.)
,, ,, ,, *ndalaganus*
,, ,, ,, *consimilis*
,, ,, ,, *kivuensis*
,, ,, ,, *macrolasius*
,, ,, ,, *byzantinus*

II. The ' Infrequens ' group, which includes—

M. (*Th.*) *infrequens infrequens* (s. str.)
,, ,, ,, *nigerianus*
,, ,, ,, *eduardensis*

III. The ' Neglectus ' group, including—

M. (*Th.*) *neglectus neglectus* (s. str.)
,, ,, ,, *decipiens*
,, ,, ,, *prolatus*

and IV. The ' Schmeili ' group, including.—

M. (*Th.*) *schmeili schmeili* (s. str.)
,, ,, ,, *hastatus.*

All that it seems possible to say is that the present examples appear to come so near to *M.* (*Th.*) *schmeili* Poppe and Mrázek, that they may well be a local variety of that species for which I propose the name of *marmagoensis* and I regard the two forms of this species described by Kiefer (1952) under the names *schmeili schmeili* and *schmeili hastatus* as representing local races, rather than subspecies of the same species : the close resemblance between the present form and such other forms as those described under the names *tinctus* Lindberg, *operculifer* Kiefer, *operculatus aberrans* Lindberg, *conspicuus* Lindberg, *trichophorus* Kiefer and *inopinus* Kiefer suggests that they are all members of a group, the ramifications of which extend through India and Africa and to this group the name *schmeili* may be given.

VI—Summary

The paper deals with a review of the subgenus *Thermocyclops* Kiefer of the genus *Mesocyclops* Sars, and includes the description of a new form *marmagoensis* of the species *Mesocyclops* (*Thermocyclops*) *schmeili* Poppe and Mrázek based on the material collected from a fresh water pool on a small island about a mile off the coast of Marmagoa.

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