Naupliar morphology as related to the taxonomy of the *Cyclops scutifer* group (Crustacea, Copepoda: Cyclopidae)[1]

E.A. Streletzkaja

Streletzkaja, E.A. 2003. Naupliar morphology as related to the taxonomy of the *Cyclops scutifer* group (Crustacea, Copepoda: Cyclopidae). *Zoosystematica Rossica*, **12**(1): 29-38.

Morphology of nauplii is studied in specimens of the *Cyclops scutifer* group, mainly from lakes of North-Eastern Russia. The revealed variability testifies to the species heterogeneity of the group.

E.A. Streletzkaja, Institute of Biological Problems of the North, Portovaya ul. 18, Magadan 685027, Russia.

Introduction

The adult females of *Cyclops scutifer* Sars, 1863 (sensu lato) can be easily distinguished from other representatives of the genus by the following set of characters. The spine formula is 3-4-3-3. The outer lateral furcal seta is attached at 0.65-0.73 of the length from the base to the apex of caudal rami. The apical inner spine of the endopodite of the 4th pair of swimming legs is approximately 1/3 as long as the outer one. Usually the inner coxal seta of P4 is appreciably extended at the base and richly plumaged. Sars (1863, 1918) considered also the shape of the 4th thoracic somite as a taxonomic feature of this species.

Further research of this species has revealed the variability in the shape of the 4th somite, relative lengths of swimming setae of P4, and appearance of the inner seta of P4. As a result, three subspecies were described (Kozminski, 1927; Lindberg, 1956, 1957). A variety of morphological forms possessing the basic taxonomic features of *C. scutifer* testifies to the existence of a group of extremely similar species presently recognized as *C. scutifer* (Streletzkaja, 1987a, 1987b).

Morphometric analysis of 8 populations revealed reliable distinctions between them (Streletzkaja, 1988). The revision of published data and analysis of original samples have proved the species status for three subspecies (*C. wigrensis* Kozm., 1927, *C. laurenticus* Lindb., 1956, and *C. scandinavicus* Lindb., 1957), in addition to *C. scutifer*. The *C. scutifer* group was defined to place in it the fifth species (*C. columbianus* Lindb., 1956), which was included in the group *C. strenuus* previously. In addition, four new species of the *C. scutifer* group were described (Streletzkaja, 1990): *C. shatalovi*, *C. juri*, *C. jasnovi*, and *C. neymanae.* For correct identification of species in the *C. scutifer* group, it is necessary to have more information than is currently on hand. In my opinion, a notion about a species of this group can be correct, if there is a possibility to identify the species in each of the 12 postembryonic stages. The purpose of this work is to obtain data on the morphological variability in the *C. scutifer* group at early postembryonic stages. Further morphological study of species in the *C. scutifer* group may help understanding the extreme flexibility of their life cycles.

Material and methods

I used samples from natural populations of the *C. scutifer* group from several highland glacial lakes: Jack London Lake, Cherski Range (Fig. 22 – 20.VI.1981; Figs 19, 20 – 31.VIII.1981; Figs 1-3, 18, 28-29, 59-61, 74-79, 84-85, 89-92, 97-98, 101-102 – 23.VI.1982; Figs 12-13 – 20.VII. 1982; Fig. 30 – 31.VIII.1982; Figs 27, 31 – 20.IX. 1982; Figs 5-6, 64 – 26.VII.1983; Figs 65-69, 80 – 3.VIII.1983; Fig. 93 – 23.VIII.1983; Figs 7, 14, 23, 32-34 – 31.VIII.1983; Figs 24-26, 35-36 – 8.IX.1983; Fig. 71 – 16.VIII.1984); lake Ekityki, Amguema Basin (Figs 43, 81, 94 – 23.VIII.1989); and lake Koolen, Chukotski Peninsula (Figs 72, 83, 86-87, 96 – 28.VIII.1976). I used also samples from ancient meteorite lake Elgygytgyn, Anadyr Plateau (Figs 55, 107 – 25.VIII.1985; Figs

[1]Paper read at the Symposium “New methods in copepod taxonomy”, St.Petersburg, 6-8 May 1998.

Table. Body lengths in nauplii of the 1st-6th stages, mm

Nauplial stage	A				B			
	min	max	mean	n	min	max	mean	n
First	–	–	0.162	1	–	–	0.107	2
Second	0.238	0.255	0.246	2	0.130	0.196	0.158	3
Third	–	–	0.270	1	0.160	0.205	0.184	4
Fourth	–	–	0.415	1	0.162	0.258	0.206	15
Fifth	0.247	0.427	0.362	8	0.245	0.258	0.253	2
Sixth	0.243	0.548	0.335	5	0.201	0.336	0.283	6

44-45, 47, 54, 111 – 17.VI.1986); thermokarst lake Nuteneut, Anadyr Plateau (Figs 62-63, 70 – 3.VII.1987); thermokarst lakes Nl (Fig. 37 – 20.VI.1982; Figs 4, 8-11, 15-17, 21, 38-41, 48, 50, 82, 99, 103-104 – 20.VII.1982; Fig. 42 – 29.VII.1982; Figs 49, 51, 53, 110 – 31.VIII.1982; Fig. 52 – 15.IX.1982; Figs 58, 73, 88, 95 – 28.VI. 1990), N2 (Fig. 100 – 4.VII.1982) and oxbow thermokarst lake (Fig. 56 – 28.XI.1990) all situated near the station of the Institute of Biological Problems of the North, Chaun Lowland; thermokarst lake in the basin of the Amguema River (Figs 57, 105, 108 – 4.IX.1989); and lake Yamnoe, Pskov Prov. (Figs 46, 106 – 25.IX.1985).

Samples were fixed with the following solution: H_2O – 50 ml, KJ – 10 g, J – 5 g, CH_3COOH (icy) – 5 ml, 40% formaldehyde – 100 ml; fixator was added to samples in the ratio about 1 : 10. Later, the concentration of formaldehyde in samples was increased up to about 4% by addition of 40% formaldehyde. The measurements were carried out on the figures that were made with a drawing device. It was impossible to collect nauplii of all stages (1-6) of one population anywhere because of complex life cycles, which are known in the *C. scutifer* group (McLaren, 1963, 1964; Elgmork, 1965, 1967, 1980; Kurenkov, 1967, 1973, 1975; Belousova, 1970; Nosova, 1970; Davis, 1972; Halvorsen & Elgmork, 1976; Elgmork et al., 1978; Boers & Carter, 1978; Paquette & Pinel-Alloul, 1982).

The following abbreviations are used in the figures: A1 – antennula; A2 – antenna; Ap enp – appendage of endopodite; Ap fur ext – (outermost) caudal appendage; Ap fur int – (innermost) caudal appendage; Ap fur med – middle (middlemost) caudal appendage; Bas – basipodite; Cox – coxa; Cox ap ext – outer coxal appendage; Cox ap int – inner coxal appendage; Dist Al – distal segment of antennule; Enp – endopodite; Exp – exopodite; Lb – labrum; Md – mandible; Mxl – maxillula; Set ext – (outermost) seta; Set int – (innermost) seta; Set med – middle (middlemost) seta; Sp – spine at base of outer caudal appendage; Sp abd – posterior abdominal spines.

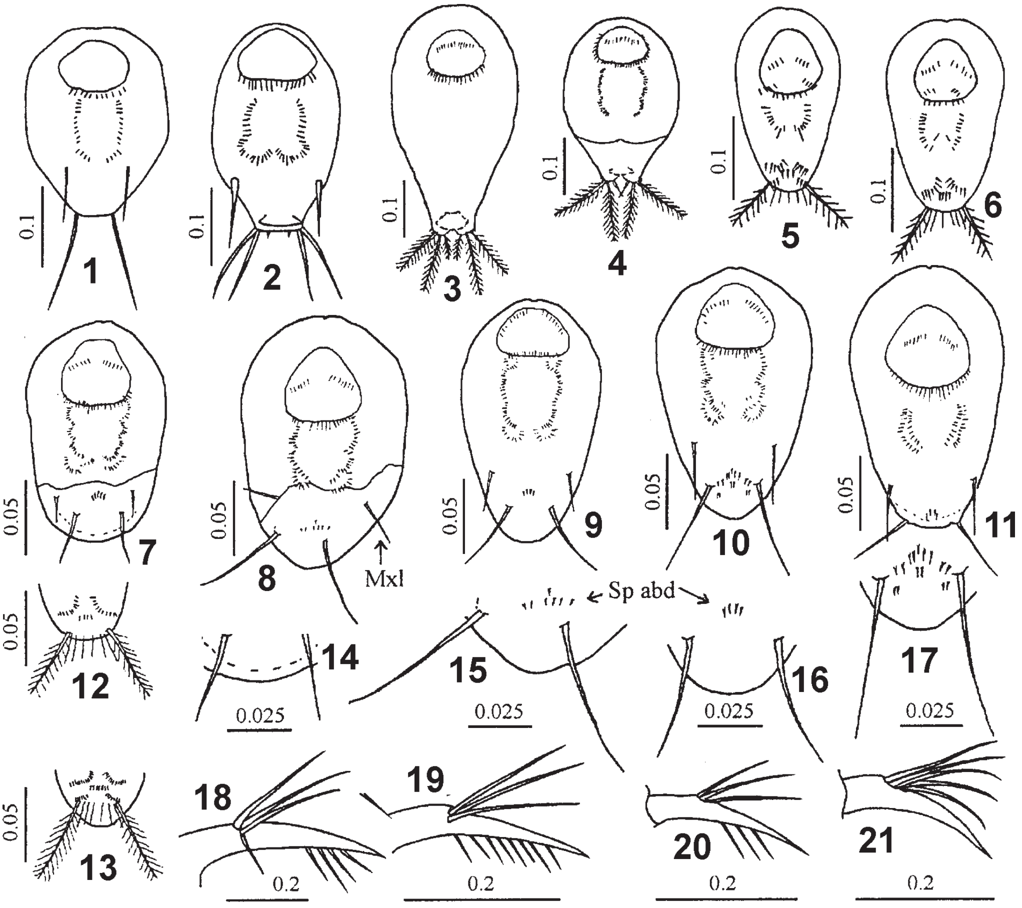
All scale bars are in mm.

Results

Based on structure of the antennula and antenna, all the nauplii are divided into two groups, A and B. The distinction in structure of the antennula is visible starting with the 1st stage, while that of the antenna, starting with 3rd stage only (see below for details). The above groups also differed from each other in the body size (see Table), body shape, armament of the mandible, maxillula, and posterior part of abdomen.

Morphological differences are observed not only between larvae of the same stage belonging to the two groups (Figs 1, 7-11), but also within the group B (Figs 5-6, 22-46, 50-57). The body shape varies from broad oval to egg-shaped (Figs 1, 9, 22, 25, 36, 39) and almost triangular (Figs 23, 34, 40). It differs in nauplii of the same stage from different populations (Figs 22, 43-44) and also within the same population (Figs 22-27, 37-40). The body shape in nauplii from various populations may differ very appreciably (Figs 23, 43). This can be explained by belonging of these larvae to different species. For example, it is already established that the species inhabiting Lake Elgygytgyn is *C. neymanae*, not *C. scutifer.* These two species differ from each other in the structure of the tooth on the 3rd maxillary segment and in other characters (Streletzkaja, 1990).

Nauplii of oval and almost triangular shapes occurred in thermokarst lake N1 (on Chaun Lowland), from which nauplii of the 2nd stage were collected in mid-July. They did not differ in the body size or other characters. This distinction remained at the 3rd larval stage (Figs 37-40). In nauplii of the 4th stage, the body shape was almost the same, unlike the body size (Figs 41-42). Nauplii of the 4th stage of oval and triangular shapes caught in Jack London Lake in late Au-

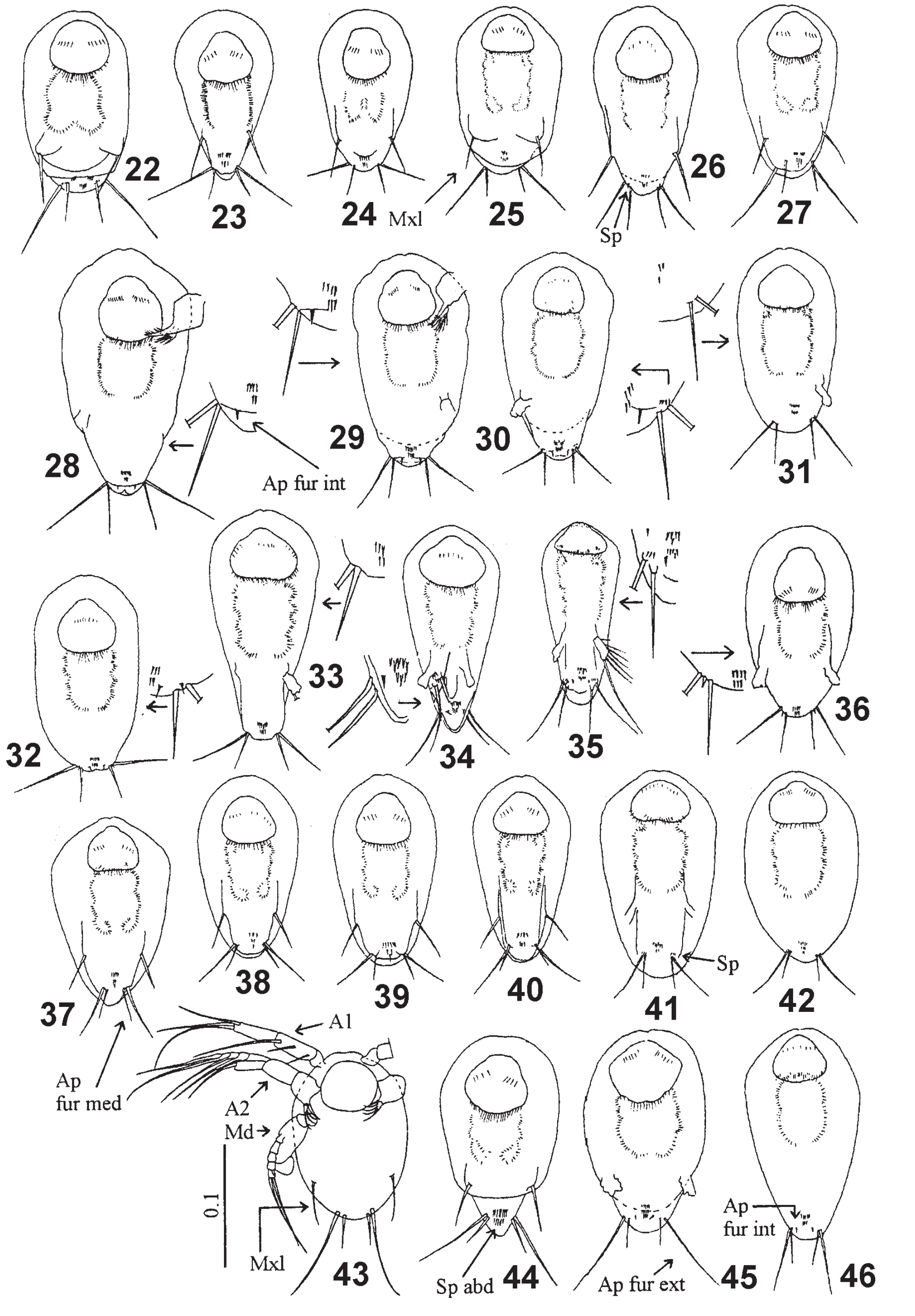


Figs 1-21. Nauplii of the *Cyclops scutifer* group. **1-11**, stage-related changes in the shape of body in the 1st (**5-6**), 2nd (**1**, **7-11**), 3rd (**2**), 4th (**3**) and 5th (**4**) stages of nauplii of the groups A (**1-4**) and B (**5-11**); **12-21**, interpopulational variability of the armament of caudal part of body in nauplii of the 1st (**12**, **13**) and the 2nd (**14-17**) stages of the group B and inner coxal appendage in nauplii of the 1st stage (**18-21**).

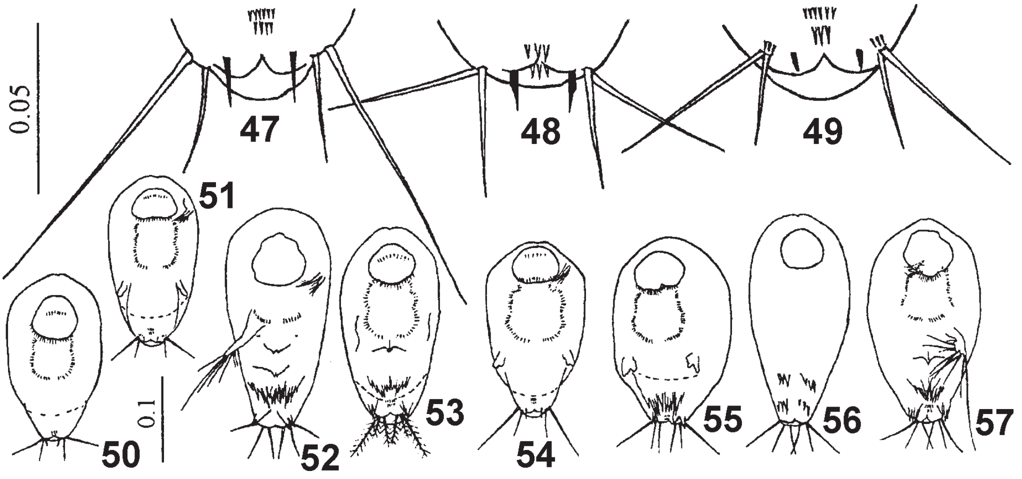
gust 1983 varied appreciably in the body size (Figs 32-34). The variability of the body shape in nauplii of the 4th stage was registered in this lake also in 1982 (Figs 28-31).

The posterior part of the abdomen exhibits the greatest variability. The basic plan of naupliar development is common to all free-living Cyclopidae. However, the development time of the third pair of furcal appendages represented at first by the embryo spines varies. According to the published data (Amelina, 1927; Ewers, 1930; Dukina, 1956; Shuvalov, 1980), they usually appear at the 4th stage. According to our observations, this pair of spines appears at the 3rd stage (Fig. 2) in the group A, but at the 4th stage (Figs 28-30, 32, 34-35, 45-46) or at the 5th stage (Figs 50-51, 54) in the group B. The embryo spines were present in all nauplii of the 4th stage of the group B in Jack London Lake in June 1982 (Figs 28-29). Larvae with spines predominated in August 1982 and in August 1983. Only larvae without spines were found in September (Figs 31, 36). Nauplii of the 4th stage of the group B with spine were not found in thermokarst lake Nl on Chaun Lowland (Figs 41-42). The inner furcal appendages were still represented in this lake population by embryo spines in nauplii of the 5th stage (50-51). The embryo spines were large enough to notice their variability in nauplii of the 5th stage in August (Figs 48-49). Their lengths were about one-fourth to one-third of the lengths of the middle and the outer furcal setae, subequal in size.

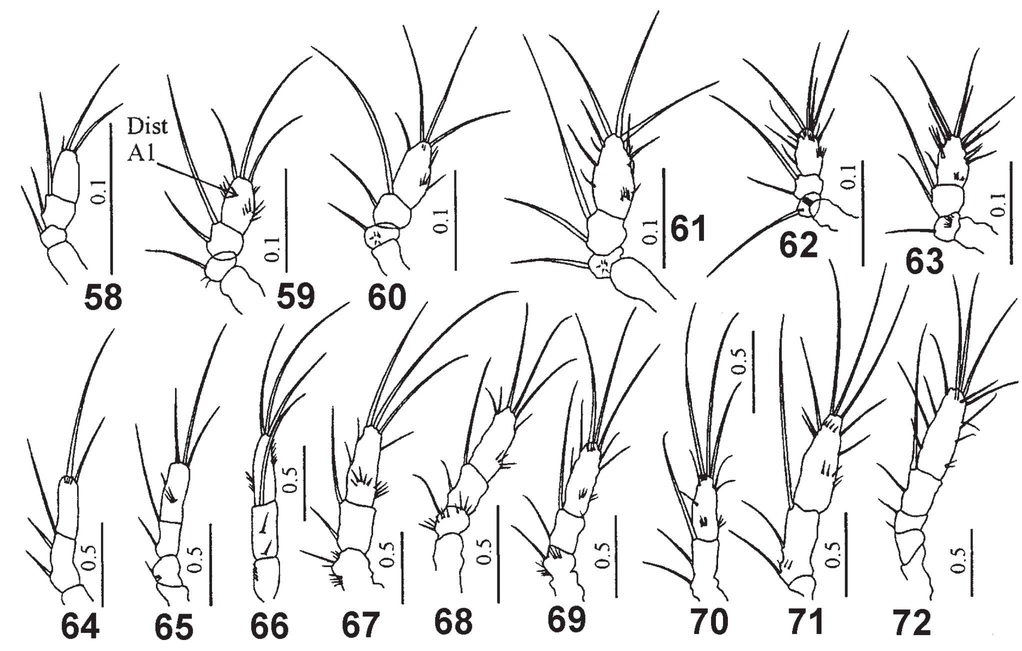
The armament at the bases of caudal setae var-



Figs 22-46. Nauplii of the *Cyclops scutifer* group. Stage-related changes and interpopulational variability in the shape of body in the 3rd (**22-27**, **37-40**, **43-44**) and the 4th (**28-36**, **41-42**, **45-46**) stages.

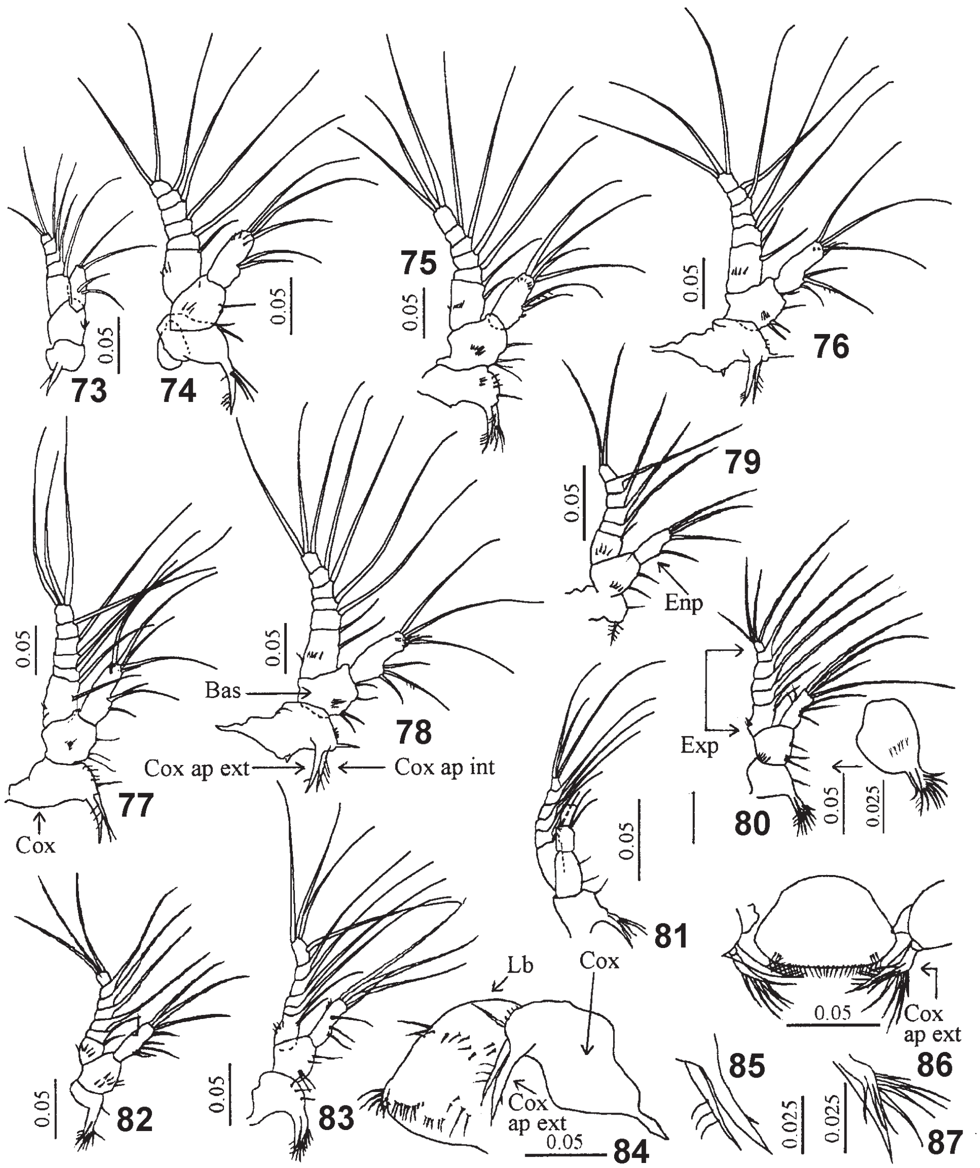


Figs 47-57. Nauplii of the *Cyclops scutifer* group. Stage-related and interpopulational variability in the shape of body in nauplii of the 5th (**50-51**, **56**) and the 6th (**52-55**, **57**) stages in N1 termokarst lake, Chaun Lowland (**50-53**), oxbow-termokarst lake, Chaun Lowland (**54**), termokarst lake in the basin of the Amguema River (**55**), and Egygytgyn Lake (**56-57**) and the shape of caudal spines in nauplii of the 5th stage (**47-49**).



Figs 58-72. Nauplii of the *Cyclops scutifer* group. Stage-related and interpopulational variability of the armament of antennula in the 1st (**58**, **64**), 2nd (**59**, **65**), 3rd (**60**, **66**), 4th (**68-70**), 5th (**61-63**, **71**) and 6th (**72**) stages.

ies as well. It can be represented by one or two large and by 2-4 very fine spines. There are usually two large spines lateral to the base of the outer caudal seta in larvae of the group A starting with the 4th stage (Figs 2-5). One fine spine is sometimes present between the outer and the middle caudal setae in larvae of the group B starting with the 3rd stage (Fig. 26). Very fine spicules were observed rather frequently in front of the base of the outer caudal seta or between the outer and the middle setae. They are more common in larvae of the group B (Figs 30, 35, 41). In the

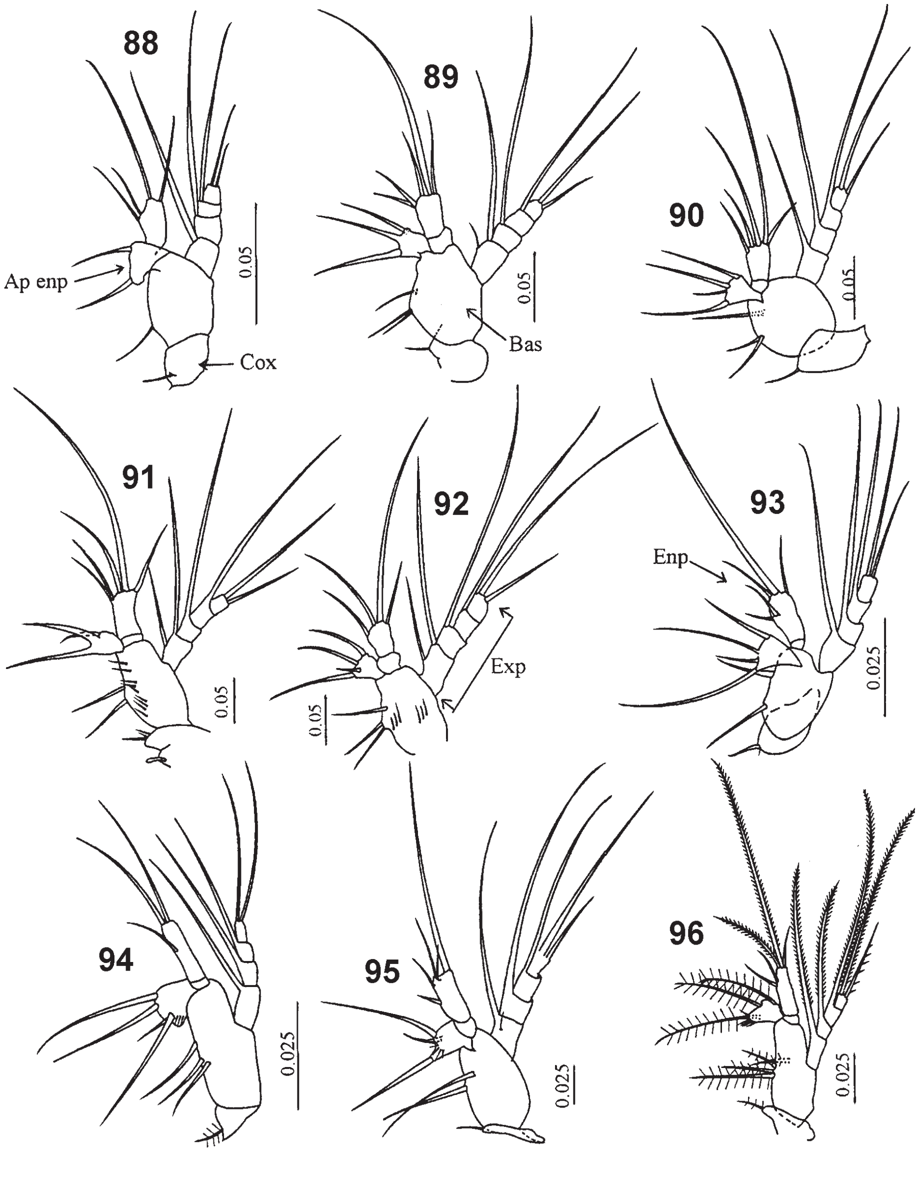


Figs 73-87. Nauplii of the *Cyclops scutifer* group. **73-83**, stage-related and populational variability of the armament of antenna in the 1st (**73**), 2nd (**74**, **79**), 3rd (**75**, **80-81**), 4th (**76-77**, **82**), 5th (**78**) and 6th (**83**) stages; **84-87**, variability of the coxal appendage.

group B, nauplii of any stage are remarkable for the presence of minute abdominal spicules on the median posterior part of the abdomen. Their number and arrangement vary (Figs 12-13, 15-17, 44).

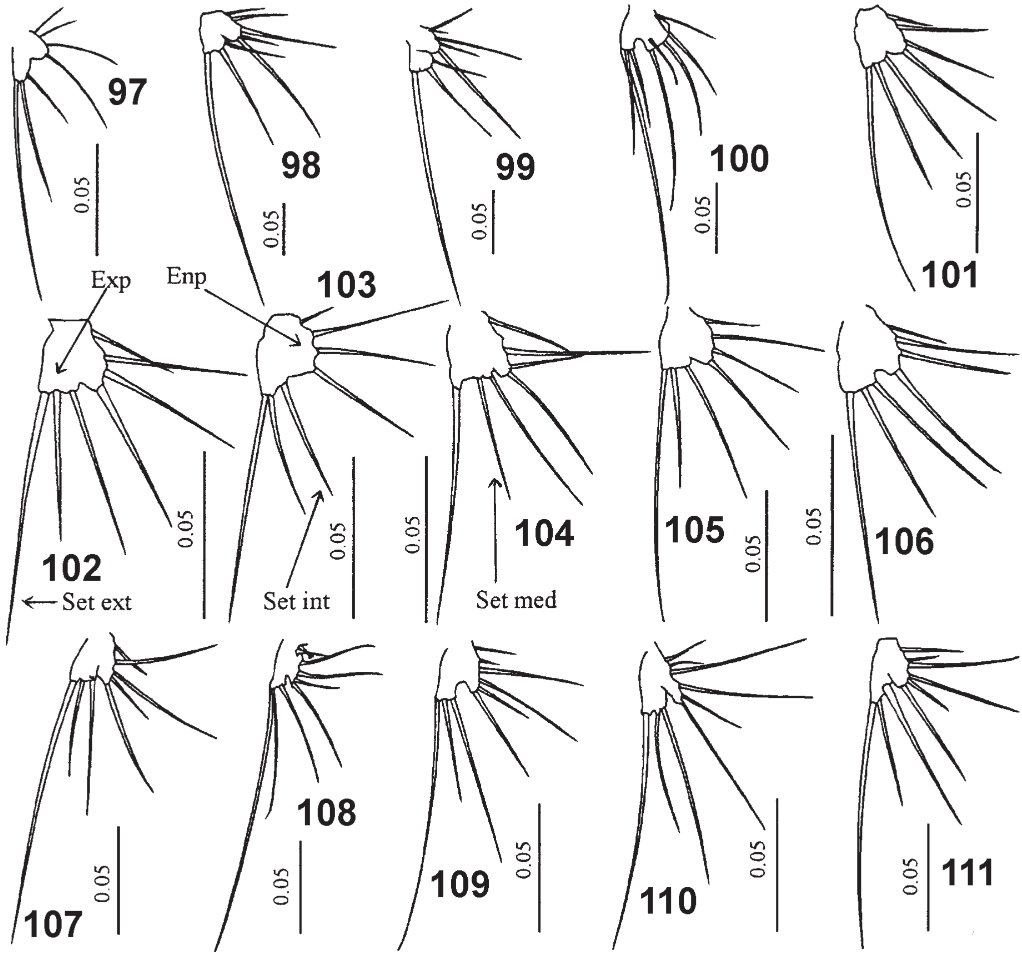
The antennula in the nauplii of the group A at any stage consists of 4 segments (Figs 58-63). In nauplii of the group B, the borders between segments are not always visible, and the antennula looks as composed of 3 or even 2 segments (Figs 64, 66-67, 69, 70-71), but some specimens have a 5-segmented antennula (Fig. 72). One more distinction between the groups A and B is the shape and relative length of the distal antennular segment: it is always rather wide and short in the group A (Figs 58-63); in the group B, it is elongate, always longer than in the group A (Figs 64-72).

A difference between the groups A and B in structure of the antenna is observed starting with the 3rd stage, at which the second coxal append-



Figs 88-96. Nauplii of the *Cyclops scutifer* group. Variability of the armament of mandible in nauplii of the 1st (**88**), 2nd (**89**), 3rd (**90**, **93**, **94**), 4th (**91**, **95**) and 6th (**96**) stages.

age arises. In the group A, it is sword-shaped, like the inner appendage, which arises in nauplii of the 1st and 2nd stages (Figs 18, 74-78, 84-85). In the group B, the outer coxal appendage is dissimilar to the inner one (Figs 19-21, 79-83, 86-87). It is represented by a dilated lobe with long appendages or simple setae, which frame this lobe, when the nauplius is lying on its back (Figs 80). In another position, the appendage may look different, but never sword-shaped. The outer coxal appendages in nauplii of the 5th and 6th stages of the groups A and B sometimes look alike, but this appendage is never extended in the group A as it is in the group B (Figs 75, 78, 80, 87). The antennal exopodite is 5-segmented in nauplii of the 1st stage in both groups, A and B (Figs 73, 79). It consists usually of six segments in nauplii of the 2nd-6th stages, the proximal one bearing two setae (Figs 75-77, 80, 83). However, in some nauplii of the 4th stage from



Figs 97-111. Nauplii of the *Cyclops scutifer* group. Stage-related and interpopulational variability of maxillula in the 4th (**97**, **101-106**), 5th (**98**, **99**, **107**) and 6th (**100**, **108-111**) stages.

the group B, the exopodite is 7-segmented and bears one seta at the proximal segment (Fig. 82).

The mandibular variability in larvae of the same development stage, at first sight, is manifested as the relative length of the endopodite (Figs 88-96). A thorough examination revealed distinction in the size of this appendage not only between larvae of the same stage belonging to a certain group, but also within the group. As shown in Figs 88-96, the mandible in nauplii of the 5th stage of the group A (Figs 88-92) differs not only in the endopodite, but also in structure of its appendages.

The maxillula appears at the 2nd stage as a plumose seta situated posterior to the mandible and remains unchanged at the 3rd stage (Figs 1, 7-11, 22-27, 37-40, 43-44). In nauplii of the 4-6th stages, the maxillula is bilobate, with exopodite and endopodite; the exopodite bears 3 setae (Figs 97-111). The number of setae on the endopodite is strictly stage-specific: four setae in the 4th stage (Figs 97, 101-106), five in the 5th (Fig 98-100, 107) and six in the 6th (Figs. 108-111). Thus, the total number of setae increases from seven in the 4th stage to nine in the 6th stage.

The distinction between nauplii of the groups A and B in the maxillular structure consists in the relative lengths of setae on the exopodite. In both groups, the longest seta, reaching the posterior end of the body and extending beyond it, is the outer seta of the exopodite (Fig. 43). The shortest seta of the exopodite is usually the inner seta in the nauplii of the group A (Figs 97-100) and the middle seta in those of the group B (Figs 102, 104-105, 107, 109-111), but in the latter group the relative lengths of the middle and the inner setae vary, and the middle seta sometimes is not shorter than the inner one (Figs 103, 106, 108). These variations are marked in nauplii of the 4th stage occurring together in Jack London Lake (Figs 101-102) and in thermokarst lake Nl (Figs 103-104). They are also marked in nauplii of the 6th stage from various populations (Figs 105-111) and in nauplii at various stages taken on different dates from one population (Figs 107, 111).

Discussion

The number of nauplial stages was discussed repeatedly (Amelina, 1927; Gurney, 1933; Ewers, 1930; Dukina, 1956; McLaren, 1964; Auvray & Dussart, 1966; Elgmork & Langeland, 1970). McLaren (1964) supposed that *C. scutifer* has five stages, though sometimes it seemed to him, there are six. The last opinion proved to be correct: there are six stages. However, the conclusion about characters distinguishing the 4th and the 5th stages (Elgmork & Langeland, 1970) is, in my opinion, erroneous.

As already mentioned, nauplii of the 4-6th stages can be easily distinguished by the number of setae on the endopodite of maxillula. Distinctions in the size and shape of embryo spines on the inner pair of furcal appendages pronounced in nauplii of the same stage from thermokarst lake N1 on Chaun Lowland presume the existence of no less than three morphological varieties in this lake. Two varieties have the same size and shape of the embryo spines, but in one of these varieties there is a group of fine spinules at the base of the outer furcal seta, which are not found in the other variety (Fig. 49). The relative lengths of the outer and the middle furcal setae are subequal in these varieties. The third variety differs not only in the embryo spines, but also in the relative lengths of furcal setae (Figs 48, 50). Finally, one more variety, different from these three, belongs to the group A.

Jack London Lake is obviously inhabited by several morphological varieties. Of the four nauplii of the 4th stage collected here in late August and September 1982 (Figs 28-31), one lacks the embryo spines on the inner furcal pair of appendages and any armament at the bases of the inner and the middle setae (Fig. 31). Three nauplii have embryo spines, but in one of them a group of fine spicules at the base of the outer furcal seta is present (Fig. 30), and in two other nauplii it is absent (Figs 28-29). The last two nauplii differ in the body shape. Of the five nauplii collected in the same lake in 1983 (Figs 32-36), three have the inner spines (Figs 32, 34, 35), and in two specimens the spines are absent (Figs 33, 36). In one nauplius among the first three, the armament at the furcal base is absent (Fig. 34), in another one a group of fine spinules is present at the base of the outer furcal seta (Fig. 35), and in the third nauplius the spinules are substituted by a spine situated between the outer and the middle furcal setae (Fig. 32).

In addition to all listed variants of the group B, representatives of the group A occur in Jack London Lake (like in thermokarst lake Nl on Chaun Lowland). Nauplii of the group A were common in June 1987 in lake Nuteneut, where the forms of the group B occur as well, and from which *C. juri* was described (Streletzkaja, 1990).

Species of the *C. scutifer* group live in surprisingly wide amplitude of ecological conditions. According to the published data, this representative of the Subarctic and Arctic fauna inhabiting the largest and deepest oligohumic lakes as well as the smallest, shallowest and polyhumic lakes is distributed rather far to the south (Kharin, 1950; Demin, 1955; Dulmaa, 1965; Nechkina, 1965; Vasil'eva, 1967; Dussart, 1969). It occurs in large lakes (Elgmork, 1966), but is met in bogs as well (Ekman, 1904). Probably, the reason for this is the species heterogeneity of the *C. scutifer* group, to which data of this work undoubtedly testify.

References

Amelina, L.G. 1927. Larvae of the freshwater Cyclopidae (Copepoda). *Tr. Kosinskoy biol. Sta. Moskov. Obshch. Ispytateley Prirody*, **5**: 31-39. (In Russian).

Auvray, C. & Dussart, C.B. 1966. Role de quelques facteurs du milieu sur le développement post-embryonnaire des Cyclopides (Crustacés Copépodes), 1. Généralités. Cas des *Eucyclops*. *Bull. Soc. zool. Fr.*, **91**: 477-491.

Belousova, S.P. 1970. The life cycle of *Cyclops scutifer* Sars and *Daphnia cucculata* Sars in Azabach'e Lake. *Izv. Tikhookean. Inst. Rybolovstva i Okeanografii*, **78**: 187-194. (In Russian).

Boers, J.J. & Carter, J.C.H. 1978. The life history of *Cyclops scutifer* Sars (Copepoda: Cyclopoida) in a small lake of the Matamek River System, Quebec. *Can. J. Zool.*, **56**(12): 2603-2607.

Davis, Ch.C. 1972. Plankton dynamics in a Newfoundland lake. *Verh. int. Ver. Limnol.*, **18**: 278-283.

Demin, D.Z. 1955. Materials on plankton of the Samur River. *Tr. Dagestan. selskokhoz. Inst.*, **6**: 181-190. (In Russian).

Dukina, V.V. 1956. Species distinctions in the larvae of cyclopids. *Zool. Zh.*, **35**(5): 680-690. (In Russian).

Dulmaa, A. 1965. Materials to knowledge of zooplankton in the lakes of the Darkhat Depression (northwestern Mongolia). *Tr. limnol. Inst. Sib. Otd. Akad. Nauk SSSR*, **6**(26): 191-205. (In Russian).

Dussart, B. 1969. *Les copépodes des eaux continentales d'Europe occidentale, 2. Cyclopoïdes et biologie.* Paris: Boubée & Cie. 292 p.

Ekman, S. 1904. Die Phyllopoden, Cladoceren und freilebenden Copepoden der nordwestlichen Hochgebirge. *Zool. Jahrb. Syst. Ökol. Geogr. Tiere*, **21**(11): 1-170.

Elgmork, K. 1965. A triennial copepod (Crustacea) in the temperate zone. *Nature*, **205**: 413.

Elgmork, K. 1966. On the relation between lake and pond zooplankton. *Verh. int. Ver. Limnol*., **16**: 216-221.

Elgmork, K. 1967. Ecological aspects of diapause in copepods. *Proc. Symp. Crustacea*, **3**: 947-954.

Elgmork, K. 1980. Evolutionary aspects of diapause in freshwater copepods. *In*: Kerfool, N. (Ed.). *Evolution and ecology of zooplankton communities. Spec. Symp. Limnol. Oceanogr.*, **3**: 411-417. Hannover & London: Univ. Press of New England.

Elgmork, K. & Langeland, L. 1970. The number of naupliar instars in Cyclopoida (Copepoda). *Crustaceana*, **18**: 277-282.

Elgmork, K., Nilssen, J.P., Broch, T. & Ovrevik, R. 1978. Life cycle strategies in neighbouring populations of the copepod *Cyclops scutifer* Sars. *Verh. int. Ver. Limnol*., **20**: 2518-2523.

Ewers, L.A. 1930. The larval development of freshwater Copepoda. *Ohio St. Univ., F.T. Stone Lab. Contr.*, **3**: 1-43.

Gurney, R. 1933. *British fresh-water Copepoda*, **3**. *Cyclopoida*. London: Ray Soc. 384 p.

Halvorsen, G. & Elgmork, K. 1976. Vertical distribution and seasonal cycle of *Cyclops scutifer* Sars (Crustacea, Copepoda) in two oligitrophic lakes in southern Norway. *Norw. J. Zool.*, **24**(2): 143-160.

Kharin, N.N. 1950. On the hydrobiological characteristic of the types of floodplain reservoirs of the lower Don in connection with the project of artificial spawning areas. *Trudy vses. gidrobiol. Obshch.*, **2**: 14-29. (In Russian).

Kozminski, Z. 1927. Über die Variabilität der Cyclopiden aus der *strenuus*-Gruppe auf Grund von quantitativen Untersuchungen. *Bull. int. Acad. Pol. Sci. Lett.*, Suppl. **1**: 1-144.

Kurenkov, I.I. 1967. List of water invertebrates of inner reservoirs of Kamchatka. *Izv. Tikhookean. Inst. Rybolovstva i Okeanografii*, **57**: 202-224. (In Russian).

Kurenkov, I.I. 1973. The biological cycles of pelagic copepods in the lakes of Kamchatka. *Hydrobiologia*, **43**(1/2): 39-44.

Kurenkov, I.I. 1975. Structure of populations of *Cyclops scutifer* Sars in the lakes of Kamchatka. *Izv. Tikhookean. Inst. Rybolovstva i Okeanografii*, **97**: 146-156. (In Russian).

Lindberg, K. 1956. Courtes diagnoses de quelques membres nouveaux ou peu connus du genre *Cyclops* s. str. (Crustaces Copйpodes). *Boll. Soc. entomol. Ital*., **86**(7-8): 112-117.

Lindberg, K. 1957. *Le groupe Cyclops rubens (syn. Cyclops strenuus). Revision du genre Cyclops s. str. (O.F. Müller, 1770) (Crustacés Copépodes).* Lund: Gleerup. 335 p.

McLaren, J.A. 1963. Effects of temperature on growth of zooplankton, and the adaptive value of vertical migration. *J. Fish. Res. Bd. Can.*, **20**: 685-727.

McLaren, J.A. 1964. Zooplankton of Lake Hazen, Ellesmere Island, and a nearby pond, with special reference to copepod *Cyclops scutifer* Sars. *Can. J. Zool.*, **42**: 613-629.

Nechkina, V.V. 1965. Sanitary biological research of Blizhniy Kaban Lake. *Sb. Tr. Vopr. Zool. Kazan. pedagog. Inst.*, **1**: 25-54. (In Russian).

Nosova, I.A. 1970. Data on the biology of reproduction and development of *Cyclops scutifer* Sars in Lake Kurilskoe. *Izv. Tikhookean. Inst. Rybolovstva i Okeanografii*, **78**: 171-185. (In Russian).

Paquette, M. & Pinel-Alloul, B. 1982. Cycles de développement de *Scistodiaptomus oregonensis, Tropocyclops prasinus* et *Cyclops scutifer* dans la zone limnétique du lac Cromwell, Saint-Hippolyte, Québec. *Can. J. Zool.*, **60**(2): 139-151.

Sars, G.O. 1863. Oversigt af de idenlandske Fekskvandscopepoder. *Forh. Vid.-Selsk. Christiania*, **1862**: 212-262.

Sars, G.O. 1918. *An account of the Crustacea of Norway. 6. Copepoda: Cyclopoida.* Bergen: Bergen Museum. 225 p.

Shuvalov, V.S. 1980. Cyclopoid copepods of the family Oithonidae of the World Ocean. *Opred. Faune SSSR*, **125**. Leningrad: Nauka. 198 p. (In Russian).

Streletzkaja, E.A. 1987a. *Dokazatel'stva sbornogo kharaktera Cyclops scutifer Sars (Copepoda, Cyclopida). Chast' 1* [Evidence of the heterogeneous nature of *Cyclops scutifer* Sars (Copepoda, Cyclopoida). Part 1]. Magadan: Inst. biol. problem Severa. 44 p. (In Russian).

Streletzkaja, E.A. 1987b. *Dokazatel'stva sbornogo kharaktera Cyclops scutifer Sars (Copepoda, Cyclopida). Chast' 2* [Evidence of the heterogeneous nature of *Cyclops scutifer* Sars (Copepoda, Cyclopoida). Part 2]. Magadan: Inst. biol. problem Severa. 51 p. (In Russian).

Streletzkaja, E.A. 1988. *Morfometricheskaya kharakteristika tsiklopov (Cyclopoida, Cyclops) gruppy scutifer* [Morphometric characteristic of cyclopids from the *Cyclops scutifer* group (Cyclopoida)]. Magadan: Inst. biol. problem Severa. 17 p. (In Russian).

Streletzkaja, E.A. 1990. The *Cyclops scutifer* group (Cyclopidae) and new species from the North-East of the USSR. *Zool. Zh.*, **69**(6): 31-44. (In Russian).

Vasil'eva, G.L. 1967. Planktonic Crustacea of the water bodies of the southern part of East Siberia. *Izv. biol.-geogr. Inst. Irkutsk. gos. Univ.*, **20**: 130-142. (In Russian).

Received 3 November 1999