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Cyclops heberti n.sp. and *Cyclops singularis n.sp.*, two new species within the genus *Cyclops* ('*strenuus*-subgroup') (Crust. Copepoda) from ephemeral ponds in southern Germany

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Abstract

Some of the species within the genus *Cyclops* O. F. Müller, 1785 can only be determined exactly by combining different methods and techniques. Based on the comprehensive analysis of morphometrical data, some populations in periodical ponds near Lake Constance were examined for their pattern of chromatin diminution and were compared by enzyme electrophoresis. These studies provided evidence of two new species. Together with *C. furcifer* Claus, 1857 and *C. vicinus* Uljanin, 1875 one of the ponds ('Litzelsee') was inhabited by four *Cyclops* species. In addition to morphological differences and distinct electrophoretic characteristics, *C. furcifer* and the new species differ in the timing of their chromatin diminution: *C. singularis* in the fourth, *C. heberti* in the fifth, and *C. furcifer* in the sixth cleavage. The qualitative course of chromatin diminution is rather similar in all three species.

The same combination of three *Cyclops* species (without *C. vicinus*) was also found in an older sample (1990) from another ephemeral pond near Lake Constance. A close genetical relationship between the three species seems probable.

Introduction

The taxonomy of the genus *Cyclops s.str.* is known to be bewildering also for taxonomists. Z. Kozminski (1936) introduced the value of detailed morphometrical analysis, which was carried to extreme by K. Lindberg (1957). This taxonomist also complicated the situation by changing the name '*strenuus*' into the older '*rubens*', a taxonomical revival without qualification. The very laborious method of morphometry results in a rather correct description of an individual and a population, but reveals little information on the systematical position of the taxon under study.

Motivated by a long-term program concerning the species *C. strenuus* Fischer, 1851, a number of populations from smaller lakes and ponds in the vicinity of Lake Constance were studied; the course of chromatin diminution, the most important criterion for the recognition of species, was compared with the results of enzyme electrophoretic studies, together with comprehensive morphometrical data.

One of the local '*strenuus*'-types (not presented here) seemed similar in some respects to another *Cyclops* living in a pond nearby ('Nägelsee'), but the latter also had characteristics of *C. furcifer*. This new species, now described as *C. heberti*, was observed in the 'Litzelsee' in collections from earlier years. Due to the similarities in the course of chromatin diminution they were regarded at that time as temporal variants of *C. furcifer* (Einsle, 1963, 1993), as the different cleavage stages of the diminution (4th, 5th, or 6th) were not recorded and the technique of enzyme electrophoresis was not available. Therefore the old samples were studied again and some of the populations were measured.

The ponds

The 'Nägelsee' consists of a shallow depression in a meadow area, 3 km west of Lake Constance, near the village of Steisslingen. The pond appears in late autumn and normally exists until April or May. The water body covers an area of about 40 metres of width and 80 metres of length, with a maximal depth of 40 to 50 cm.

The 'Litzelsee' near Radolfzell/Markelfingen (at lower Lake of Lake Constance) normally develops during winter and covers a depression in a cultivated field. The pond can be present for several months or disappear after a few weeks in January, only enabling the development of a single generation of *C. furcifer*. The habitat is dry in some years and permanently filled with water in other years. Its maximal depth is about 1 meter with a length of about 100 metres and a width of 40 metres (Kiefer & Einsle, 1963).

The samples from the ponds were taken with a net at different time intervals, once a week in 1994, whenever possible.

Methods

Morphometry: As recommended by Kozminski (1936), the thoracic and abdominal segments were measured separately and then added (long.corp.) to compensate for any contraction or stretching of the body. The cyclopids were examined in dorsal view, and measurements (normally 15 per specimen) were used to calculate a number of proportions (indices), depending on the experience and personal evaluation of the taxonomist.

For preparation, the cyclopids were first placed into small dishes containing a mixture of formalin-water and glycerine. After one or two days the water evaporates, and the specimens can be dissected in the concentrated glycerine.

In 1994 about 430 specimens (exclusively females) collected in both ponds were measured.

Chromatin diminution: During chromatin diminution, firstly described for cyclopids by S. Beermann (1959), the chromosomes of the species belonging to the genus *Cyclops s.str.* undergo a diminution of chromatin in the presumptive soma cells in either the 4th, or the 5th, or 6th cleavage division. The particles of eliminated heterochromatin are arranged in a specific pattern in the different stages of the mitosis. The practical problem, which needs a certain experience, is to hit the time (some minutes) of the diminution cleavage (Einsle, 1962).

The eggs are fixed in alcohol-acetic acid, stained by a small drop of lactic-acetic-orcein and gently squashed by a coverslip. The results are documented by photography.

Enzyme electrophoresis: The technique was clearly described by Hebert & Beaton (1989). Firstly used in *Daphnia* genetics, it has also provided important information on copepod taxonomy (Boileau & Herbert, 1988; Einsle, 1988). Although the smallest species of cyclopids (below about 1.2 mm of body length) do not yield enough substance for analysis, *Cyclops* species are large enough to permit 3 to 6 different enzyme analyses per specimen.

The investigations of this paper are based on a total number of about 360 specimens originating from both localities mentioned, collected in spring 1994.

Results

Morphometry

In a general comparison, some morphometrical data may give an idea of the measurable differences between the new species in their typical localities and, in addition, to *C. furcifer* and *C. heberti n.sp.* from the 'Litzelsee'. Both in *C. heberti* from the 'Nägelsee' and *C. singularis n.sp.* from the 'Litzelsee', different sampling dates are listed in order to demonstrate the extent of temporal variation mainly in total length (long.tota) (average values with mean deviation).

1. *C. heberti* in the 'Nägelsee' increased in body size from November to January; but, beginning in March, specimens became smaller, down to the last generation in May 1994, when they were more than 30% smaller than the highest average values (Table 1).
   The differences in some of the proportions (15 indices were calculated) are most remarkable, too, between March and May populations. The relative length of the median furcal setae (2 and 3, Fig. 3), compared with body and furcal length, decreased from December to March, but increased remarkably in the May generation; the proportion of the inner furcal seta (1), however, proved to be rather constant.
2. *C. singularis* was noticed for the first time in April 1994 in the 'Litzelsee', but was later also found in older samples. The females are similar in size to those of *C. heberti*. Compared with this species, *C. singularis* possesses a longer inner furcal seta (1) in proportion to furcal branches and to body size (Table 2). The median apical setae (2 and 3) are relatively shorter, while the proportion of the inner furcal seta to the outer (seta 1: seta 4) is higher.

Table 1. Morphometrical analysis (part.) of *Cyclops heberti n.sp.* compared with *C. furcifer.*

	C. heberti 'Nägelsee'					*C. heberti* 'Litzelsee'	*C. heberti* 'Kalkofen'	*C. furcifer* 'Litzelsee'
	02.11.1993	11.12.1993	25.01.1994	28.03.1994	17.05.1994	28.03.1994	26.03.1990	28.03.1994
Long.tota (μm)	1880±80	1925±95	2290±100	2125±105	1540±55	1960±115	1930	1825±35
Long.:lat.furc.	6.8±0.6	6.9±0.5	7.4±0.4	6.9±0.6	5.8±0.3	6.4±0.5	6.0	7.6±0.6
Seta 1: long.furc.	0.67±0.04	0.67±0.05	0.68±0.04	0.66±0.04	0.71±0.03	0.71±0.04	0.74	0.67±0.05
Seta 2: long.furc.	2.01±0.16	2.04±0.13	1.97±0.12	1.69±0.10	2.29±0.10	1.79±0.11	1.90	2.12±0.16
Seta 3: long.furc	1.68±0.14	1.73±0.12	1.62±0.10	1.44±0.09	1.89±0.10	1.52±0.08	1.68	165±0.09
Seta 1: seta 4	137±6	132±5	136±5	138±5	135±4	137±7	134	120±7
Seta 1 % lo.corp.	9.2±0.4	9.2±0.4	9.7±0.4	9.6±0.4	9.1±0.2	9.9±0.4	9.8	10.1±0.5
Seta 2 % lo.corp.	27.5±1.5	27.9±1.6	28.2±1.2	24.8±1.1	29.4±0.9	25.3±1.3	25.1	32.0±1.0
n =	45	37	23	34	17	60	2	26

Table 2. Morphometrical analysis (part.) of *Cyclops singularis n.sp.* compared with *C. furcifer.*

	C. singularis 'Litzelsee'				*C. singularis* 'Kalkofen'	*C. furcifer* 'Litzelsee'
	27.07.1982	11.04.1994	17.05.1994	24.05.1994	26.03.1990	28.03.1994
Long.tota (μm)	1705±50	2320±75	1970±65	1925±40	2225	1825±35
Long.:lat.furc.	5.6±0.2	6.9±0.3	6.1±0.2	6.8±0.3	6.8	7.6±0.6
Seta 1: long.furc.	1.00±0.04	0.84±0.05	0.90±0.04	0.82±0.03	0.91	0.67±0.05
Seta 2: long.furc.	2.00±0.08	1.64±0.07	1.76±0.07	1.66±0.07	1.80	2.12±0.16
Seta 3: long.furc.	1.70±0.06	1.42±0.05	1.53±0.06	1.44±0.06	1.55	1.65±0.09
Seta 1: seta 4	196±7	174±7	182±9	179±7	174	120±7
Seta 1 % lo.corp.	13.6±0.5	12.9±0.7	12.9±0.3	12.5±0.4	13.9	10.1±0.5
Seta 2 % lo.corp.	26.7±1.1	25.1±1.1	25.4±0.7	25.5±0.7	27.5	32.0±1.0
n =	35	40	12	36	2	26

3. For comparison some data are given (the same ones in both tables) of the coexisting *C. furcifer*. Individuals of this species were also much smaller inMay 1994 than in April. The inner furcal seta (1) is as short as in *C. heberti*, the inner median seta (2) is longer than in both the new species.
Normally *C. furcifer* is colored red, *C. heberti* seems brownish, *C. singularis* greenish-brown. Due to these differences the species can be recognized in the samples with living animals. A further criterion to separate the individuals was found in the incredible speed of *C. singularis*: the adult specimens showed jumps over about 10 cm, where they suddenly stopped (to be picked up with the pipette).

Taxonomic account

Family	*Cyclopidae* Sars, 1913
Subfamily	*Cyclopinae* Kiefer, 1927
Genus	*Cyclops* O. F. Müller, 1785
	Cyclops heberti n.sp.

Specimens examined: From 1986 to 1994 more than 400 females of the 'Nägelsee' population were measured according to the rules given by Kozminski (1936) (Table 1). The population from 25.01.1994 has been designated as type, since both chromatin diminution and enzyme electrophoresis were studied on this sample (holotype mounted on slides, allotypes and paratypes in tubes with formalin-glycerine-water, deposited in the Staatlichen Museum für Naturkunde Karlsruhe, Nr. CR. 11501).

Type locality: The 'Nägelsee', a depression in a meadow area, was described above.

Female: (Fig. 1) Body length (without furcal setae) variable from about 1400 μm to 2500 μm; width cephalosome 35% of body length. Antennule reaching the caudal end of second thoracomer. Lateral margins of pediger 4 pointed outward, of pediger 5 broadly pointed. From ventral view this segment presents two lobes laterally from the genital segment (typical also for *C. furcifer*). Seminal receptacle without specific characteristics. Furcal branches from about 5.5:1 (length to width) to 8.7:1 (specimens from 20.02.1993), divergent, with a chitinous crest on the surface. The hairs at the inner margin beginning with a group of longer hairs directed to the middle, caudal following hairs inserted oblique (this aspect is also found in *C. furcifer*).

The inner furcal seta (1) with a proportion of about 0.65 to 0.72 compared with furcal length and 9.0 to 10.5% of long.corp.; often with a bend in the second third, also in the 'Litzelsee' population. In several individuals this bend also was observed in the outer furcal seta (4). The proportion inner (1) to outer (4) furcal setae seems rather constant with an average value between 1,35 and 1,38. The inner median apical seta (2) makes about twice of the furcal branch or less; the dorsal furcal seta (5) is shorter than the outer apical seta (4).

Antennule (A1) (Fig. 2) composed of 17 articles, covered with small, deepened circles (tiny 'craters') on the dorsal frontside of the first four articles. Esthetask on article 12, rows of tiny teeth on articles 15 to 17.

Antenna (A2) with exopodite seta slightly longer than the extremity, first article with ornamentation of robust spines (with local variation). Third article with 9 setae on outer margin. Mandible (md) with long setae, also palp of maxillula (mxl). Maxilliped (mxp) with only a small field of point structures on the caudad side of the first article.

Swimming legs 1 to 4 triarticulated, spine formula 3433, setal formula 5555. Basipodit of P1 with a seta reaching to the end of second article endopodite. Couplers P1 to P3 without ornamentation, coxa P2 and P3 with groups of spines laterally. Coupler P4 with one or two rows of setulae, humps surpass the margin of the coupler. Coxa P4 with a row of spines near the basis, and a group of spines near the margin beginning with one or two strong spines. Endopodite article 3 normally longer than twice of width, inner apical seta about as long as article, length of outer spine half of inner spine. Leg 5 with a rather short seta at the first article, a strong spine inserting at the middle of second article with remarkable individual variation, apical seta relatively long. Leg 6 with two short spines and a longer seta (about 1:3).

Male: Body size about 75 to 80% of female length. Antennule of 17 articles, 3 esthetasks at first article, another on article 4, 8 and 14, respectively. Dorsal frontside of article 1 and 2 with the tiny 'craters'. Third article of Antenna with 7, 8 or 9 setae on outer margin, normally with 9. Mouthparts and swimming legs similar to that of female. Leg 5 with apical seta at second article as long as first abdominal segment, lateral spinule at second article more slender than in female. Leg 6 with spine and two setae, the dorsal about three times as long as ventral spine.

Ecology: Soon after the habitat ('Nägelsee') refills with water in autumn, the species reappear from diapause in the fourth copepodid stage; a resting stage in the fifth copepodid instar seems probable, but is still in question. Individuals reach their maximal body size during the winter generations, most of the descendants falling into diapause in March and April; only a small proportion of the population form a spring generation of smaller individuals in May.

The number of eggs per clutch depends on the time of occurrence: the winter generation often has 120 to 140 eggs per eggsac, while specimens in May typically have only 20 to 30.

Etymology: The new species is named to P.D.N. Hebert (Guelph, Ontario), who was the first to recognize the species character of the 'Nägelsee' population, comparing the results of enzyme electrophoresis studies at out institute. It is also an acknowledgement for his kindness in introducing me to the techniques of enzyme electrophoresis.

Genus Cyclops O. F. Müller, 1785
Cyclops singularis n.sp.

Specimens examined: As in *C. heberti*, the cyclopids were first found some years ago in the 'Litzelsee', but only in spring 1994 a careful identification was possible. Together with specimens originating from older samples, 130 females were examined morphometrically. The holotype is mounted on slides, the allotypes are stored in tubes with formalin-glycerine-water and

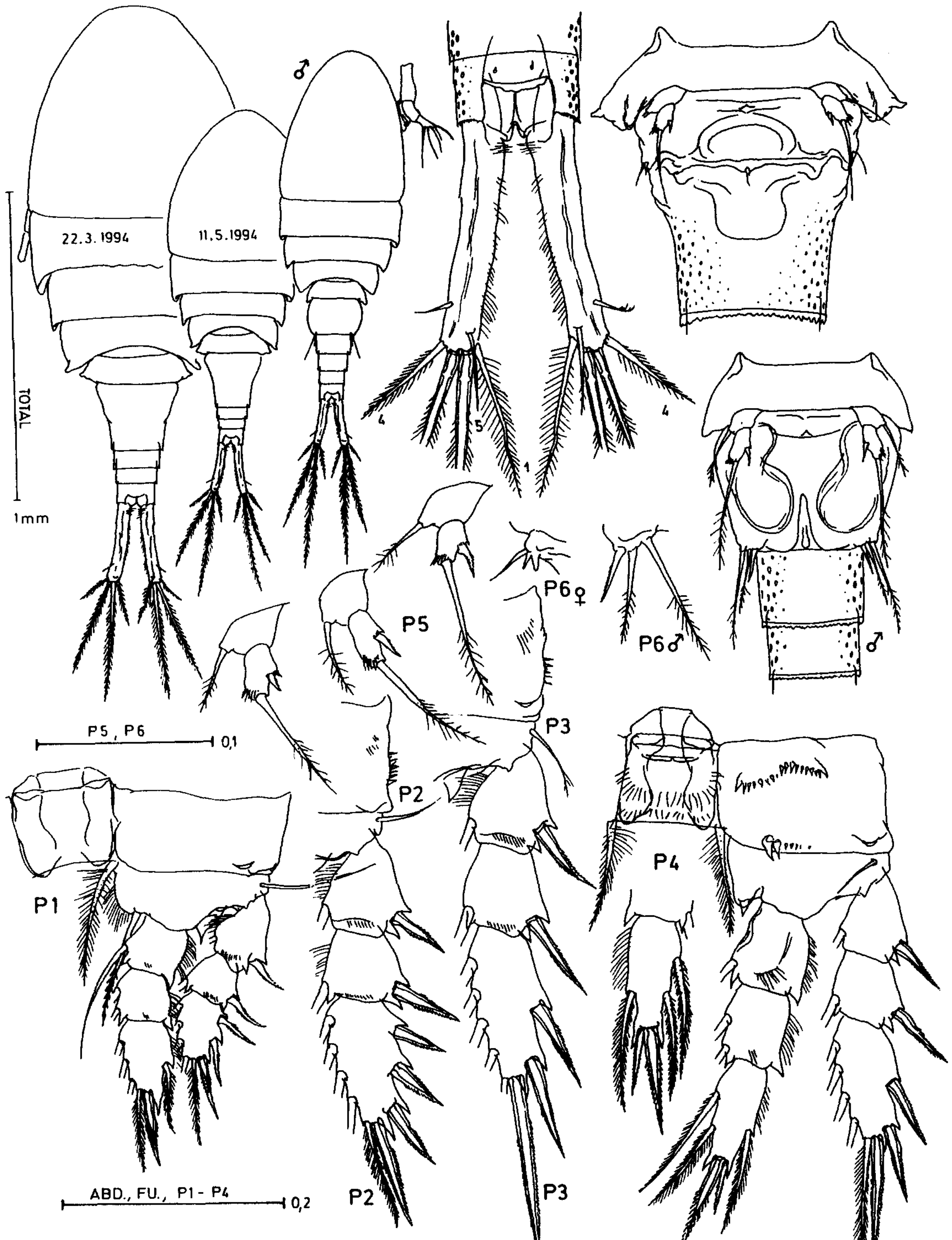

Fig. 1. *Cyclops heberti n.sp.*: type locality: 'Nägelsee' (near Lake Constance), April 1994 adult females with temporal variation, male; furca (hairs near basis), pediger 5 and first abdominal segment, leg 5 of different females, leg 6 female and male, leg 1 to leg 4.

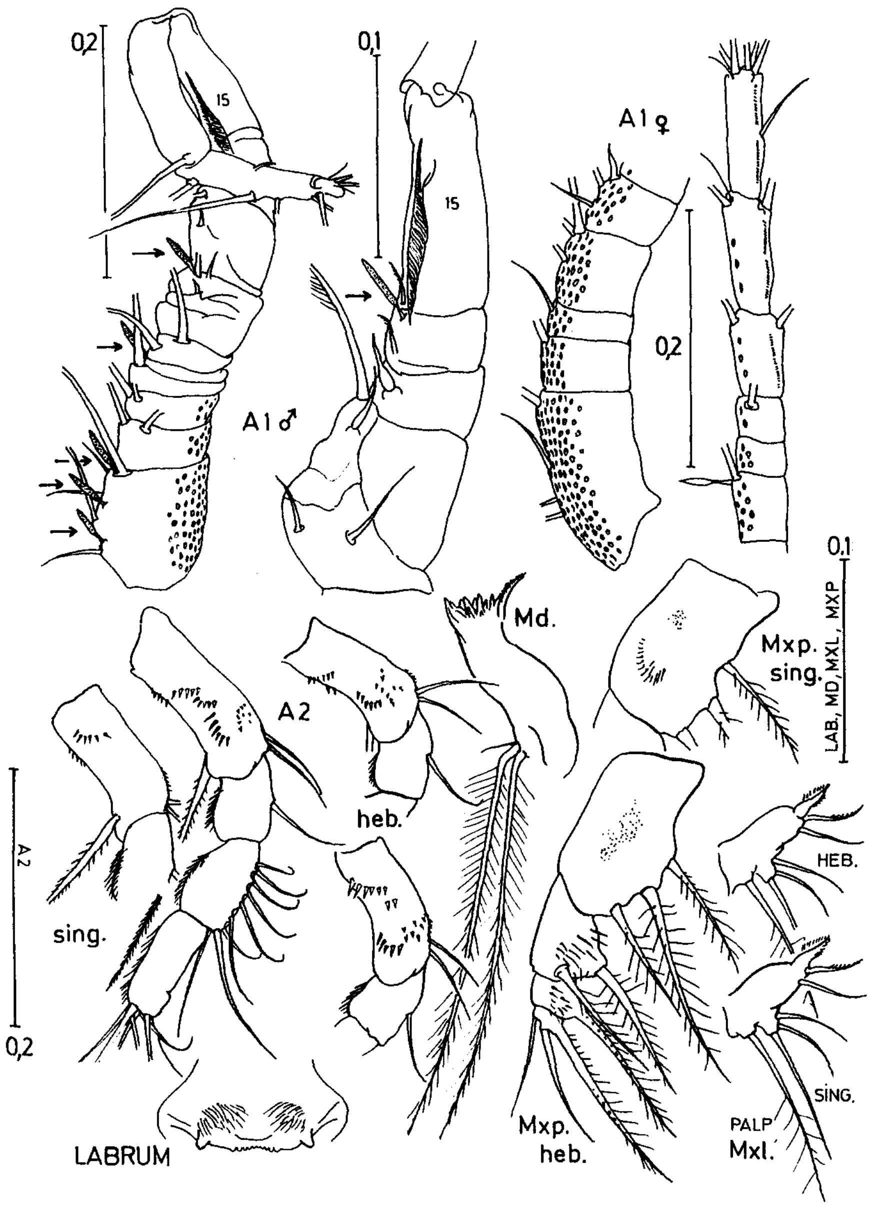

Fig. 2. Cephalothoracic extremities: antennule (A1): *C. singularis*; antenna (A2): *C. singularis, C. heberti* with variation in ornamentation of first article; first article maxilliped with row of setulae in *C. singularis*; mandible, maxillule, labrum identical in both species.

deposited in the Staatlichen Museum für Naturkunde Karlsruhe, Nr. CR 11502, both taken from the population collected in April 4, 1994. This 'typical' population was studied for its chromatin diminution and for its enzyme phenotypes.

Type locality: The 'Litzelsee', an ephemeral pond near Lake Constance, was described above.

Female: (Fig. 3) Body length (without furcal setae) variable from about 1660 μm (July 1982) to 2450 μm (April 1994). Antennule (A1) reaching the margin of second thoracomer, lateral margin of pediger 3 strikingly pointed caudad, of pediger 4 and 5 pointed outward. As in *C. heberti*, the fifth thoracal segment presents two lateral lobes in ventral view. Furcal branches with proportion length to width from about 5,1:1 to 8,2:1, divergent, hairs at inner margin inserted

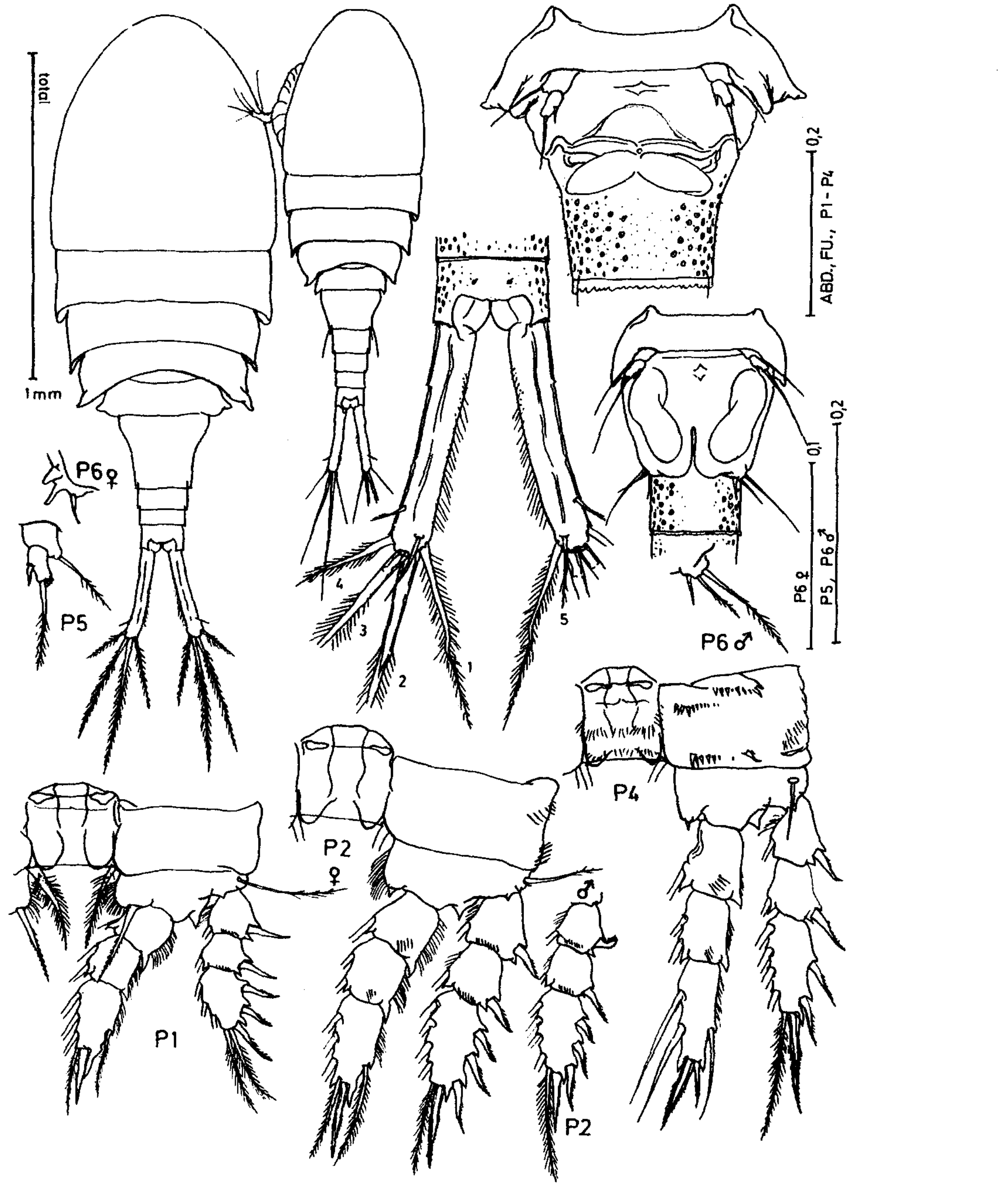

Fig. 3. *Cyclops singularis n.sp.*: type locality: 'Litzelsee' (near Lake Constance), April 1994 adult female, male, furca, pediger 5 and first abdominal segment, leg 5, leg 6 female and male, leg 1, 2 and 4.

oblique. In only few specimens a group of hairs was inserted near the basis, directed to the middle as in *C. heberti*. The chitinous crest on the surface of branches well developed. Inner furcal seta (1) longer than in *C. heberti*, compared with furcal and body length. Some of the animals also present the bend in the middle of the seta 1) as was observed in *C. heberti*. Median apical setae (2 and 3) morphometrically within the dimension of the other species, proportion seta 1:4 different and

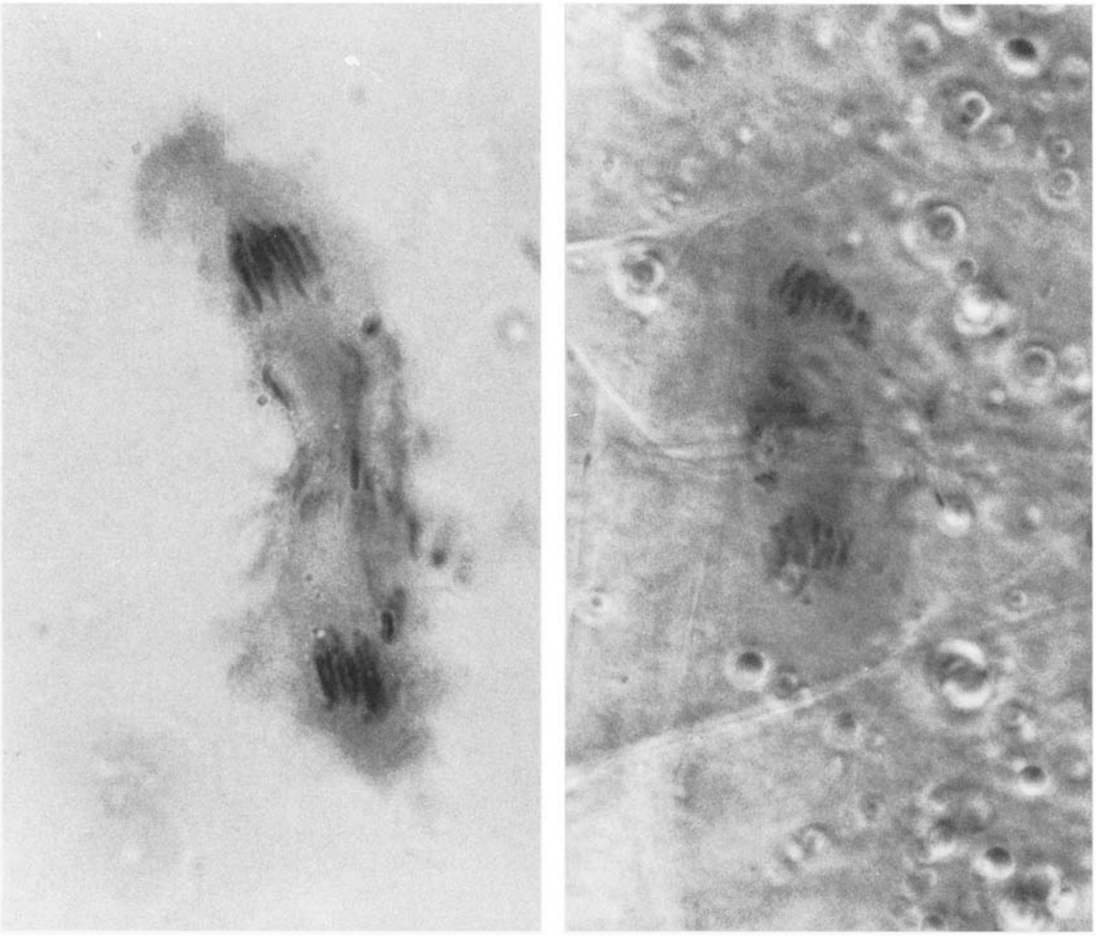

Fig. 4. Chromatin diminution: *C. singularis* anaphase, 4th cleavage; *C. heberti* anaphase, 5th cleavage.

varying from about 1.7 to 2.0. Dorsal furcal seta (5) shorter than outer apical seta (4).

Antennule (Fig. 2) composed of 17 articles, esthetasc on article 12, last three articles with rows of tiny teeth as in *C. heberti*. Articles 1 to 4 covered with chitinuous 'point structures' on the surface of the frontside, smaller than the 'tiny craters' of *C. heberti*. First article of antenna with strong ornamentation, third article with 9 setae on outer margin. Mandible (md) with long seta, maxilliped (mxp) with small field of point structures and – in addition to *C. heberti* – a curved row of tiny setulae on the caudad side of first article.

Swimming legs triarticulated, spine formula 3433, setal formula 5555. Seta on basipodit P1 hardly reaching end of second article endopodite. Coupler P1 to P3 without setae, coxa P2 and P3 with two rows of spines and setae laterally. Coupler P4 with one or two rows of setae, humps surpassing margin of coupler. Coxa P4 with a line of spines basically, another group of spines near the upper margin, and a group of small setulae laterally (not observed in *C. heberti*). Last article endopodite P4 with a proportion length to width of about 2.5:1, inner apical spine shorter than article, outer longer than half of inner spine. Second article of leg 5 with lateral spine inserting in the middle or nearer to basis of article. Leg 6 consisting of 2 short, blunt spinulae and a short seta (1:2).

Male: Body size about 80% of female. Antennule similar to those of *C. heberti* (Fig. 2), concerning position and numbers of esthetascs. Small round notches forming the chitinuous structures on the frontside. Mouthparts had P1 as in female, lateral spine of first article exopodite P2 curved backward (caudad). Setae of leg 5 shorter than first abdominal segment, leg 6 with

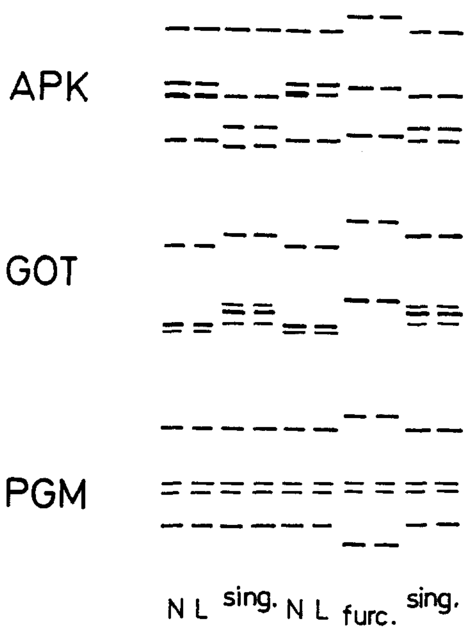

Fig. 5. Enzyme electrophoresis: N: *C. heberti* 'Nägelsee; L: *C. heberti* 'Litzelsee'; sing.: *C. singularis* 'Litzelsee'; furc.: *C. furcifer* 'Litzelsee'.

ventral spine and two setae, the inner half of length of the outer.

Ecology: In 1994, in the 'Litzelsee' this species appeared later than either *C. furcifer* or *C. heberti*. In the samples available it was normally found in early April. The details of diapause behavior are not yet clear. The generation in April consists of the large females with a body size of 2300 to 2400 μm, but following cohorts are smaller, with the summer generation in 1982 averaging 1700 μm in length.

The number of eggs per eggsac varied from a high of 80 to 120 in April 1994 to only 20 eggs per eggsac in May 1994 or July 1982.

The most striking pecularity of this species, its extremely high swimming speed, was mentioned above. This too may be seen as species character of remarkable importance.

Etymology: The latin word 'singularis' expresses exactly what is meant with the English word 'singular'. Indeed the new species is remarkably by its occurrence in ephemeral ponds, by its chromatin diminution in the fourth cleavage division, and by its striking swimming behavior.

Chromatin diminution

a. The diminution of *C. furcifer* was well described by S. Beermann (1966, 1977): the cleavage divisions occur synchronously up to the 16 cell stage; then one cell divides earlier, so that only 15 cells enter the 5th cleavage division. The first diminution occurs in the 6th cleavage of these 30 cells, resulting in 60 diminuted cells, two cells of the germ line and one of primordial entoderm (63 cells). In the 7th division a further diminution occurs except in the primordial germ cells.

In the prophase of the 6th division the heterochromatic particles are quite distinct. They arrange during the anaphase between the daughter nuclei in thick, chromosome-like portions, which are stretched during the early telophase.

b. The eggs of *C. heberti* divide synchronously until the end of the 4th division (16 cells). During the 5th cleavage 15 of the cells undergo diminution, while another one divides later. At the end of the 5th cleavage therefore 32 cells can be found.

The different phases of mitosis are similar to *C. furcifer*. Both populations ('Litzelsee' and 'Nägelsee') of *C. heberti* showed a comparable (estimated) quantity of eliminated heterochromatin.

c. The diminution of *C. singularis* takes place in the 4th cleavage stage. All 8 cells divides rather synchronously; in contrast to the other species the nucleus volume seemed filled with fine granulae, most strikingly in the late anaphase (Fig. 4). The large heterochromatic particles, stretched during the beginning telephase, obviously composed a very large share of the total chromatic content of the nucleus.

d. The surprising result of these comparisons, a similar course of chromatin diminution in different phases of cell cleavage, found in three coexisting species, has not been previously described. This fact is still more singular, as the external conditions in the ephemeral ponds normally exclude the immigration of other *Cyclops* species, except *C. vicinus*.

Enzyme electrophoresis

In the present article only the differences between the species and populations are figured (Fig. 5). To facilitate mobility of comparisons the different species were placed alternating one with the other on the well plate. The following enzymes were tested: Arginine phosphokinase (APK), glutamateoxaloacetate transferase (GOT) and phosphoglucomutase (PGM), as

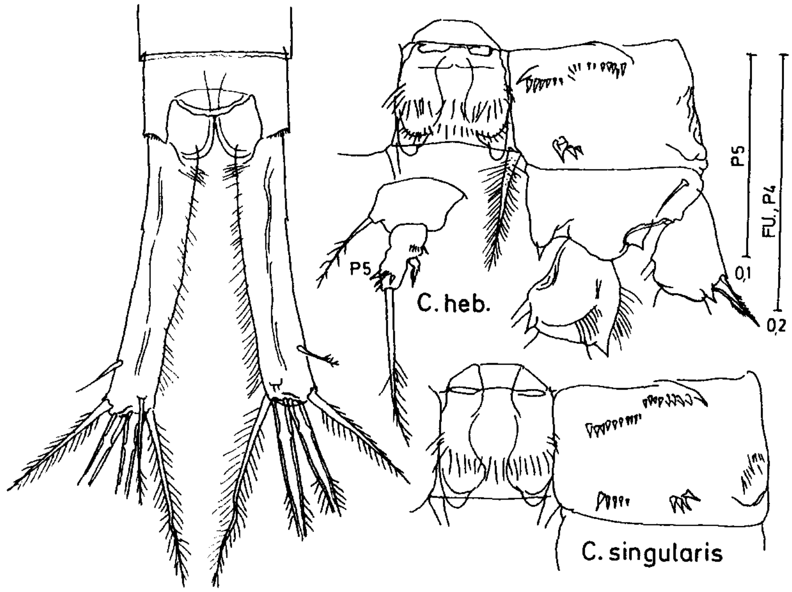

Fig. 6. Pond 'Kalkofen': *C. heberti* furca, coupler and coxa leg 4, leg 5 (see Fig. 1); *C. singularis*: coupler and coxa leg 4.

these enzymes yield the best and clearest results in *Cyclops*.

Both populations of *C. heberti* ('Litzelsee' and 'Nägelsee') have some fourbanded phenotype at APK. By contrast *C. furcifer* possessed only three bands, the population of *C. singularis* has four bands, but two were in a different position than those of *C. heberti*.

GOT often shows reliable differences between distinct species. In the present materials the identity of both populations of *C. heberti* was obvious, as well as their divergence from other species. *C. furcifer* was very distinct from both species.

No differences between *C. heberti* and *C. singularis* were found in PGM, but the genetic peculiarity of *C. furcifer* was also evident at this locus.

These comparisons suggest a closer relationship between *C. heberti* and *C. singularis*, while *C. furcifer* is genetically divergent. The differences in morphology and enzyme electrophoresis are significant and justify the range of species for the 'Litzelsee' populations. *C. heberti* is occuring isolated in the 'Nägelsee', another indication for its species character.

Discussion

The discovery of two new species of *Cyclops*, in an area which has been studied for a long time by a taxonomist, demonstrates either the failing courage of the author or the deficiency of traditional taxonomic work, only based on morphometrical criteria, or it means a signal for a new concept in the taxonomical treatment at least of the genus *Cyclops*.

The singularity of an ephemeral pond depends on its history. Both the 'Litzelsee' and the 'Nägelsee' have been known for centuries (local names in old maps). They are also inhabited by *Diaptomus castor*, which is restricted in its geographical distribution to periodical waters. The extreme conditions of the habitat has prevented its colonization by other *Cyclops* species, apart from *C. vicinus*. This species has occupied most of the lakes and ponds in the northern prealpine region during the last decades, and was first found in 1982 in the 'Litzelsee'.

A second site for these species was obtained through reanalysis of a sample from March 1990, collected from a pond in a depression in agricultural fields 15 km north of 'Litzelsee' near the village of Kalkofen/Hohenfels ('Lehen', Flurstück Nr. 307) with *Diaptomus castor* and – provisionally – *C. furcifer*. The reexamination this sample, however, showed, that in addition to this species specimens of *C. heberti* and three females of *C. singularis* were present. As only few morphometrical data are available (Tables 1 and 2), the taxonomical identity with the species from the 'Litzelsee' had to be confirmed by morphological comparisons (Fig. 6).

This shallow pond was present in 1990 for only a few weeks. The occurrence of this association of copepods is an indication, that formerly this emphemeral water appeared since a long time ago, and that this group of three *Cyclops* species may be common in ephemeral ponds. One can assume, that there had been time enough to develop an association between the three *Cyclops* species (including *Diaptomus castor*).

In the three cyclopids presented here the qualitative aspects of the chromatin diminution are rather similar, but there is divergence in the timing of the cleavage division. Apart from this, the species also present some morphological similarities (i.e. inner furcal seta, ventral lobes at pediger 5); the existence of females of *C. singularis* with characteristics of *C. heberti* (basal furcal hairs) was already mentioned above. The close relationship between these species is further confirmed by the results of enzyme electrophoresis, as is the more separate position of *C. furcifer*.

A remarkable difference can be seen in the speed of its swimming movements, which are really singular for *C. singularis*.

Further conclusions must be supported by experimental work, which could be a problem given the rarity and brief occurrence of these *Cyclops* species.

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