ON MORPHOLOGICAL VARIATION IN KERATELLA COCHLEARIS POPULATIONS FROM HOLSTEIN LAKES (NORTHERN GERMANY)

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Abstract

Keratella cochlearis occurs in many Holstein lakes (northern Germany) as three well defined and separated forms: *'cochlearis'*, *'hispida'*, and *'tecta'*, each showing very little variation between the lakes. The present data show that the *'tecta'* form did not originate from a Lauterborn cycle.

Introduction

The morphological variation in the widely distributed rotifer *Keratella cochlearis* (Gosse) has resulted in extensive studies on its taxonomic and ecological implications. However, as Koste (1978) mentioned in his recent revision of the European rotifers, many problems still exist.

Very little is known about the *K. cochlearis* populations of northern Germany lakes. Voigt (1903, 1905) and Naber (1933) hinted that besides the typical *cochlearis* form, other forms like *hispida* and *tecta* may occur in Holstein lakes.

During summer 1975 a limnological investigation of 13 lakes in the vicinity of Plön was carried out. The wide range of ecological conditions, as for example mean depth, conductivity, nutrient content, and productivity, represented by the lakes under study led to an examination of the distribution of the various *K. cochlearis* forms, especially because in this species a close correlation between morphological characters and ecological conditions is generally assumed (Ruttner-Kolisko, 1972).

These lakes may roughly be divided into three groups with respect to mean depth (2 to 18 m) and mean secchi depth during summer (0.2 to 4.0 m) (Fig. 1). Likewise, there were tremendous differences in PO_4-P content of the upper water layer ranging from 0 to 953 μg P/l.

With the exception of a brackish water lake and a shallow water, *K. cochlearis* was found in high numbers in all of the lakes and was dominant among the rotifers (relative abundance > 10%) in ten of them.

Examining the samples, three forms could easily be distinguished regarding their morphological characters. They are called here *'cochlearis'*, *'tecta'*, and *'hispida'*, and refer to *K. cochlearis cochlearis* (Gosse), *K. cochlearis* var. *tecta* f. *typica* (Lauterborn), and *K. cochlearis* var. *hispida* f. *typica* (Lauterborn) (Koste, 1978).

Table 1 lists the lakes in the decreasing order of secchi depths: *hispida* was not found in the sites with maximum algal biomass, whereas *tecta* was absent in the samples from the least productive lake. In ten lakes all three forms were co-occurring and these populations were subjected to biometric analysis.

In Fig. 2 the mean values of lorica length and the length of the caudal spine of five syntopic populations are compared. In each case, the same relationship in body length between the three forms is seen, *cochlearis* being the smallest one, *hispida* the largest one and *tecta* in beween. As shown by the standard deviations, the differences between these forms are valid in most cases. As to the length of the caudal spine, *hispida* generally surpassed *cochlearis*. There was, however, great variation in this respect.

The impression of a constant pattern concerning the relations of dimensions of the forms from different lakes is confirmed when the individual values are considered and body length is plotted against spine length. In this way for each lake emerged an almost identical point cluster. This pattern is also discernable when the values from several lakes are plotted together (Fig. 3): The three forms are

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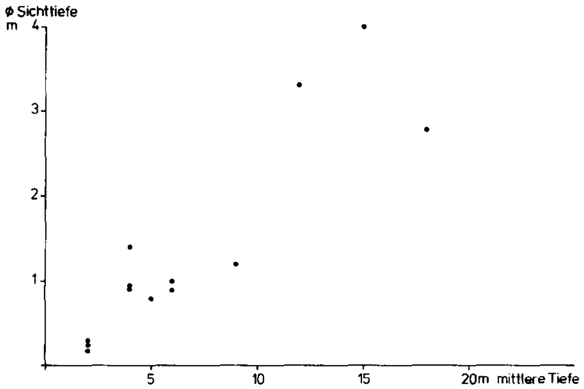

Fig. 1. Mean secchi depths of 13 Holstein lakes during summer 1975 plotted against mean depths.

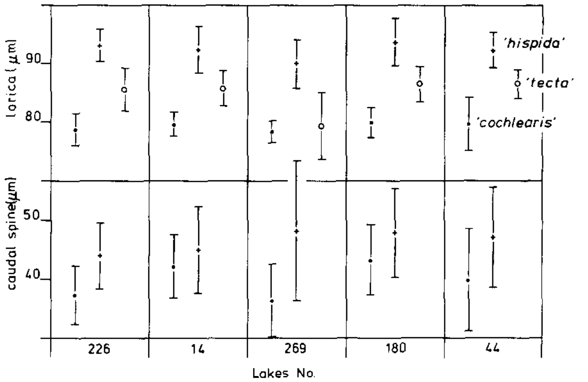

Fig. 2. Mean lengths of lorica and of caudal spine (and standard deviations) of syntopic 'populations' of *cochlearis, hispida* and *tecta* from five lakes.

each represented by a clearly separated point cluster.

As mentioned above on the basis of the mean values, body length increases from the *cochlearis* form over *tecta* to the *hispida* form. Moreover, the individual values show that there is hardly any overlapping between *cochlearis* and *hispida* even if populations from different lakes are compared. This pattern of size relations was not only found in the five lakes considered in Fig. 3 but in all lakes inhabited by these *K. cochlearis* forms.

However, in the first sample series (July) from the deep and less productive lakes (Fig. 1) an additional form was found which had no particular morphological characteristics but is clearly separated from the above mentioned *cochlearis* form by its larger size of both lorica and caudal spine (Fig. 4). So far it resembles *K. cochlearis* f. *macracantha* (Lauterborn). This form disappeared during summer.

Comparing the body lengths in *cochlearis* and *hispida* at the two sampling dates in July and October, it is obvious that both forms increased in size in nearly the same proportion with decreasing water temperature. The point clusters remained in the same position relative to each other and were quite well separated in both cases. This separation is more distinct if syntopic forms from the same lake are compared than if population of different lakes are involved (Figs. 3, 4).

Table 1. Occurrence of *Keratella cochlearis* forms in 11 Holstein lakes arranged in decreasing order of Secchi depth.

	'cochlearis'	*'hispida'*	*'tecta'*
Selenter See (250)	x	x	
Stocksee (255)	x	x	x
Schluensee (229)	x	x	x
Belauer See (14)	x	x	x
Tresdorfer See (269)	x	x	x
Dobersdorfer See (44)	x	x	x
Passader See (180)	x	x	x
Schierensee (226)	x	x	x
Stolper See (256)	x		x
Postsee (198)	x		x
Rottensee (210)	x		x

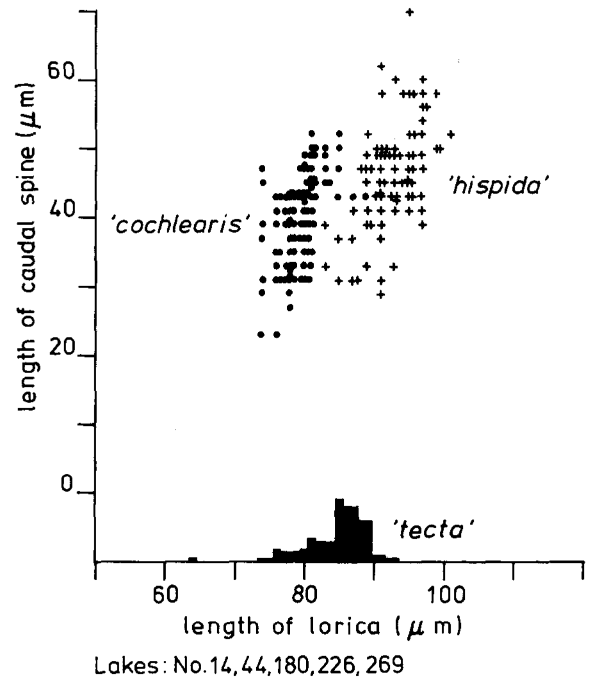

Fig. 3. Individual values of lorica length and spine length of syntopic 'populations' of *cochlearis, hispida,* and *tecta* from five lakes (same lakes as in Fig. 2).

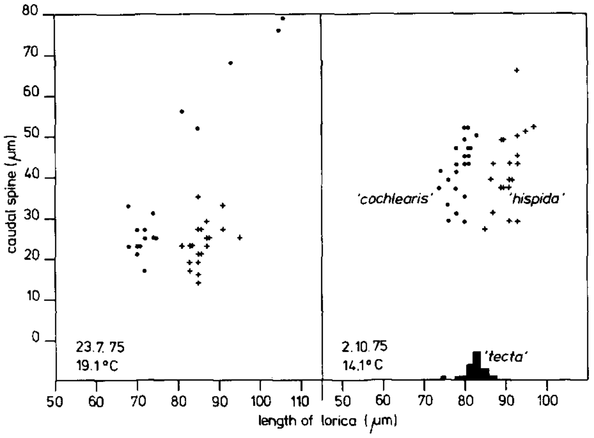

Fig. 4. Individual values of lorica length and spine length of syntopic 'populations' of *cochlearis, hispida,* and *tecta* in one lake in July and October.

Discussion

Recapitulating the situation, in the lakes in question distinct forms of *Keratella cochlearis* co-occur, which are clearly separated by morphological characteristics both qualitative and quantitative. If it were not *K. cochlearis* these results would lead to the assumption of three distinct species. However, Lauterborn (1900) found the above mentioned forms *cochlearis, hispida,* and *tecta* developing from one morphologically uniform type occurring through the winter. Up to now the taxonomy of *K. cochlearis* is based on such transitional series in the sense of Lauterborn (Koste, 1978).

In the case of *tecta* continuous transitions from long spined *macracantha* forms to the spineless *tecta* proved this view (Lauterborn, 1900; Pejler, 1962).

The variation in spine length was explained by allometric growth: When growth is accelerated this will result in small specimens with short spines or without spines. Conversely, retarded growth leads to large specimens with relative longer spines (Buchner *et al.,* 1957; Pejler, 1962; Lindström & Pejler, 1975).

On the other hand, cases are known where the spineless *tecta* form did obviously not derive from a typical *cochlearis* form (Ahlstrom, 1943; Pejler, 1957; Nauwerck, 1978). This holds also true for the *tecta* forms under discussion: Their descent from the syntopic *cochlearis* form is unlikely because (1) no transitional forms were found, because (2) they were significantly larger than *cochlearis,* and (3) because *tecta* forms were very abundant in late summer and autumn when spine length in *cochlearis* was increasing (Fig. 4). Hence, the view mentioned by Pejler (1957) about polyphyletic origin of the spineless forms called *tecta* in the literature is supported. It seems as if there are forms which derive from *micracantha* forms and others which show no relation to spined *cochlearis* forms. Therefore, *tecta* is obviously no taxonomic unit.

It is interesting from the competition point of view that in the syntopic populations under discussion *tecta* was intermediate in size relative to *cochlearis* and *hispida,* which might show a mechanism of reducing niche overlap.

Unfortunately, no samples were taken in spring and autumn. So there is no information on the origin of the *hispida* form. Thus, it can be stated only that during summer *hispida* appeared as a distinct and well separated form, which was rather uniform when populations form different lakes were compared.

A discontinuous morphological variation in *cochlearis* forms, as shown in Fig. 4, was also found for instance by Pejler (1957, 1962) in Swedish lakes and by Nauwerck (1978) in Lake Ontario. Such discontinuities question the validity of the theory that the different *cochlearis* forms in general originate from Lauterborn cycles. But even if the theory holds, the taxonomic ranks of these forms remain doubtful: Lauterborn (1900), faced with the fact that the different forms may develop in the same biotope under identical ecological conditions, presumed that the homogenous phenotype of the winter form masks different genotypes. Hence, the crucial point is to decide if those genotypes are genetically isolated, e.g. if these forms are morphs of one polymorphic population or if they represent different species. This is known to be a puzzling problem in the case of *K. cochlearis,* because in lake populations bisexual periods are often absent. It is this reproductive isolation which could preserve discontinuities, as mentioned by Pejler (1957). This would imply that the splitting up into different forms would have evolved endemically in each of the lakes, which seems inconsistent with the homogeneity of the particular forms from different lakes.

Further studies are required, which in the sense of the biological species concept (Mayr, 1968; Pejler, 1977) concentrate on syntopic populations (or assemblages of forms) in order to look for the existence of Lauterborn cycles and their relation to bisexual periods in *K. cochlearis.* In addition, as Nauwerck (1978) claimed, experimental studies are needed in this respect.

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