Abnormalities in a *Pleuroxus aduncus* (Jurine, 1820) population (Crustacea: Cladocera: Chydoridae)

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ABSTRACT: The morphological variation in a population of *Pleuroxus aduncus* (Jurine, 1820) from a well in Germany is described. The number of denticles at the postero-ventral corner of the valve are more numerous than normal and abnormalities occur regularly. The observations are discussed in the context of the described variation in number of postero-ventral denticles of this species and the causes given for abnormalities in recent literature.
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KEY WORDS: Cladocera, morphology, variation, isolation, Germany, The Netherlands.

Морфологические аномалии в популяции *Pleuroxus aduncus* (Jurine, 1820) (Crustacea: Cladocera: Chydoridae)

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РЕЗЮМЕ: Исследована морфологическая вариабельность популяции ветвистоусого ракообразного *Pleuroxus aduncus* (Jurine, 1820) из колодца в Германии. Количество зубцов на задне-нижнем углу створок было больше обычного для вида, регулярно наблюдались отклонения от нормального строения. Обсуждаются обнаруженная вариабельность вооружения задне-нижнего угла створок и ранее отмеченные в литературе случаи морфологических аномалий у ветвистоусых.
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КЛЮЧЕВЫЕ СЛОВА: Cladocera, морфология, изменчивость, изоляция, Германия, Нидерланды.

Introduction

Jurine (1820) described *Monoculus aduncus* very briefly. A detailed description was given by Frey (1991) to compare closely related species with it. More of the variation in *Pleuroxus aduncus* is described by Frey (1993), Smirnov *et al*. (2006) and Smirnov (2014). The number of denticles at the postero-ventral corner of the valve is normally 1–3 and exceptionally 0 or 4

denticles, notated as (0) 1–3 (4) (Lilljeborg, 1900; Keilhack, 1909; Herbst, 1962; Smirnov, 1974; Margaritora, 1985; Frey, 1991; Alonso, 1996; Flößner, 1974, 2000).

Morphological abnormalities in Cladocera have recently been described for the genera *Ilyocryptus* (Kotov, Dumont, 2000; Elmoor-Laurero, 2004), *Daphnia* (Zanata *et al*., 2008; De Melo *et al*., 2017), *Coronatella* (Sousa *et al*., 2011), *Ceriodaphnia*, *Chydorus* and *Bosmina* (De Melo *et al*., 2017). For *Pleuroxus* gynandromorphism is recorded (Frey, 1965). This article describes morphological variation of *P. aduncus* that has not been described before.

Materials and methods

The material is from a well in Bamberg (Germany) and was collected during the excursion of Cladocera XI. For comparison five populations, with abundant *P. aduncus*, were chosen from the collection of the author. A comparison is made with five Dutch populations from different habitats.

Material examined

Pleuroxus aduncus: 257 adult and 354 juvenile females from Bamberg, Germany, well (49°53′28.6″ N; 10°52′53.2″ E), collected 26-IX-2017.

For comparison: 174 adult and 75 juvenile females from Koopmanspolder (1), ditch (52°44′11.3″ N; 5°10′10.8″ E) collected 5-IX-2017 / 205 adult and 131 juvenile females from Lelystad, rain puddle (2) (52°32′32.2″ N; 5°28′25.6″ E) collected 21-VI-2014 / 152 adult and 27 juvenile females from Heiloo (3), wood pond (52°34′57.0″ N; 4°41′28.4″ E) collected 10-VIII-2013 / 146 adult and 39 juvenile females from Lelystad, ditch (4) (52°32′35.7″ N; 5°28′36.6″ E) collected 21-VI-2014 / 150 adult and 40 juvenile females from Lelystad, canal (5) (52°32′33.0″ N; 5°28′09.1″ E) collected 29-IX-2014.

Counting was done, using an Olympus inverted microscope IM70, at 400x magnification. Photographs were made from animals mounted in glycerin on an Olympus BH2 microscope with Olympus CellSense. The number of denticles at the postero-ventral corner was counted in 100 animals for each population. Only animals without abnormalities were included in counting. The mean number of denticles for the populations was calculated. From the populations the percentage of abnormalities is determined. The German population was compared with five Dutch populations.

Results

The number of denticles in the Bamberg population reached from 0 to 5 and had remarkably often 4 (43%) or 5 (10%) denticles (Fig. 1). The distribution of denticles number in the five Dutch populations was normal, as described in the introduction, with (0) 1 – 3 (4) denticles. 50 – 60 % of the animals had 2 denticles. Only one population with four denticles (4%) was observed.

The differences between the populations are summarized (Table 1). The number of denticles in the Bamberg population ranged from zero to five denticles. Only in the Dutch population from Koopmanspolder the range exceeded 3 denticles. The mean number of denticles observed for the German population was 3.28 ± 1.26. This is much higher than in the Dutch populations.

Besides the higher number of normal denticles several kinds of abnormalities were observed. They can be grouped in five main types (Figs 2–3): furcate denticles (Fig. 3B), higher placed (normal) denticles (Fig. 3B–C), and very small (additional) denticles (Fig. 3D), high placed reduced denticles (Fig. 3E) and high placed feathered setae (Fig. 3F). Combinations of these abnormalities occur frequently. Up to 14 small and larger denticles were observed. 11% of the population in the well in Bamberg had such abnormalities. In one population in the Netherlands 2% abnormalities was found existing of some (bi) furcated denticles. In the other populations no abnormalities occurred.

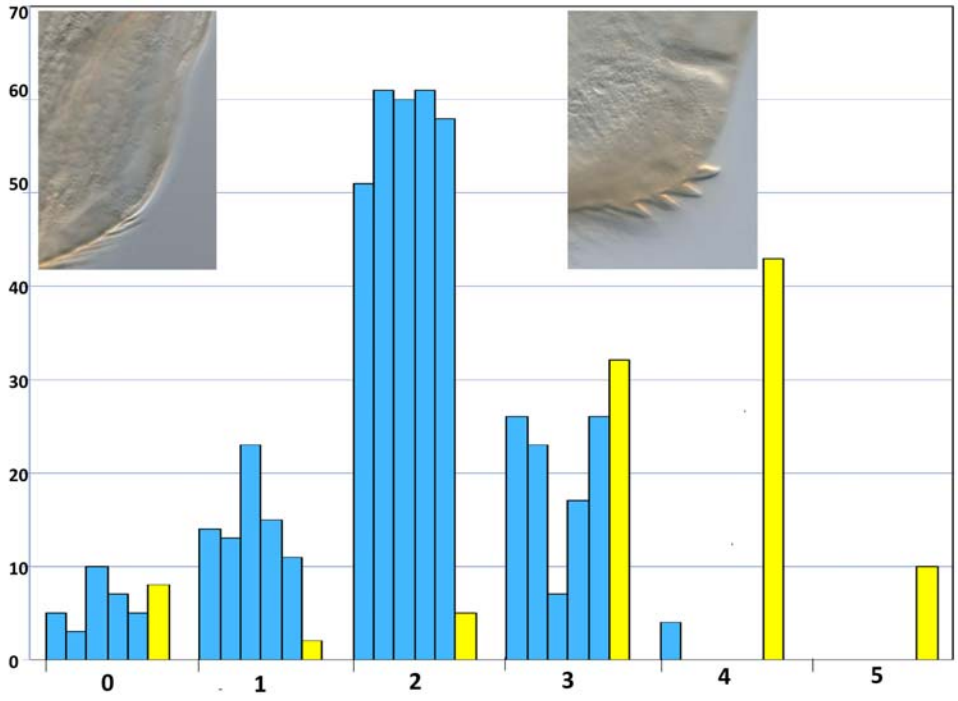

Fig. 1. Percentage of animals in six populations with the number of denticles (0–5) on postero-ventral corner of valves in the Dutch (blue) populations and the German (yellow) population. Consecution of the Dutch population is as in material examined.
Рис. 1. Распределение особей с разным количеством зубцов на заднем нижнем углу створок (0–5) в исследованных голландских (синий) и германской (желтый) популяциях. Порядок расположения голландских популяций как в перечне материала.

Discussion

The population from Bamberg is characterized by a high number of postero-ventral denticles and abnormal denticles at the postero-ventral corner of the shell. More than 50% of the animals has 4 or 5 denticles. This is an exceptional high number in comparison with the normal number of 1–3 (Lilljeborg, 1900; Keilhack, 1909; Herbst, 1962; Smirnov, 1974; Margaritora, 1985; Frey, 1991; Alonso, 1996; Flößner, 1972, 2000). Only Hudec (2010) mentions 5 denticles. Together with the high number of postero-ventral denticles the population showed a high percentage of abnormalities.

Table 1. Differences between the studied populations of *Pleuroxus aduncus*.
Таблица 1. Различия между исследованными популяциями *Pleuroxus aduncus*.

Population	**Habitat**	**Mean number of denticles (n = 100)**	**SD**	**Range**	**Abnormal (%)**
Koopmanspolder	Ditch	2.10	0.87	0–4	0
Lelystad	Puddle	2.04	0.70	0–3	0
Heiloo	Pond	1.64	0.76	0–3	0
Lelystad	Ditch	2.05	0.76	0–3	0
Lelystad	Canal	1.88	0.77	0–3	2
Bamberg	Well	3.28	1.26	0–5	11

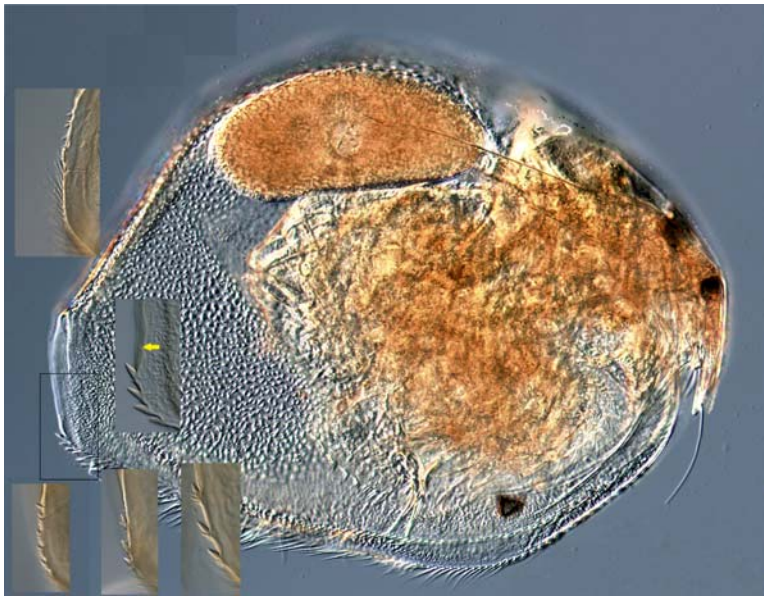

Fig. 2. *Pleuroxus aduncus* (Jurine, 1820) female (Bamberg well) with abnormal denticles on postero-ventral corner of valves; yellow arrow indicates row of small setules.
Рис. 2. *Pleuroxus aduncus* (Jurine, 1820), самка из колодца в Бамберге, с уродливыми зубцами заднениженего угла створок; желтая стрелка показывает ряды мелких сетул.

Several causes for abnormalities in cladocerans are suggested. Influences of toxic substances (Elmoor-Laurero, 2004; Zanata *et al*., 2008; Sousa *et al*., 2011), eutrophication (De Melo *et al*., 2017) and the environment in the culture (Kotov, Dumont, 2000). Kotov & Dumont (2000) described some abnormal individuals of the *Ilyocryptus spinifer* species-group found in Sars collection. In some abnormal specimens, the postabdomen showed clusters of lateral spines instead of single spines. These abnormalities were probably due to the conditions of the culture in which they had grown (Kotov, Dumont, 2000). The conditions in the well are like a culture. The environment in the well is characterized by a constant low temperature, low conductivity (78 µS/cm), high pH (8.7), slow flow and little vegetation. It is not an optimal habitat and strongly isolated. An important factor might me the isolation of this population. Colonization by one female can establish a population. Colonization by an animal with a genetic predisposition can result in a higher amount of abnormalities. Abnormalities can have a genetic origin (Brown *et al*., 2009; Fernandes *et al*., 2011). An isolated parthenogenetic population will have none or very little exchange of genetic material.

Conclusions

In most literature used for identification the number of denticles at the postero-ventral corner of the shell in *P. aduncus* is (0) 1–3 (4). The absence of denticles is present in 3–10% of the individuals examined and this should not be regarded as exceptional. The number of postero-ventral denticles should be notated for this species as 0–3 (5).

Pleuroxus is one more genus of Cladocera in which abnormalities are found. In this case isolation combined with a genetic origin and the extreme environment is supposed to be the cause of the high percentage of abnormalities.

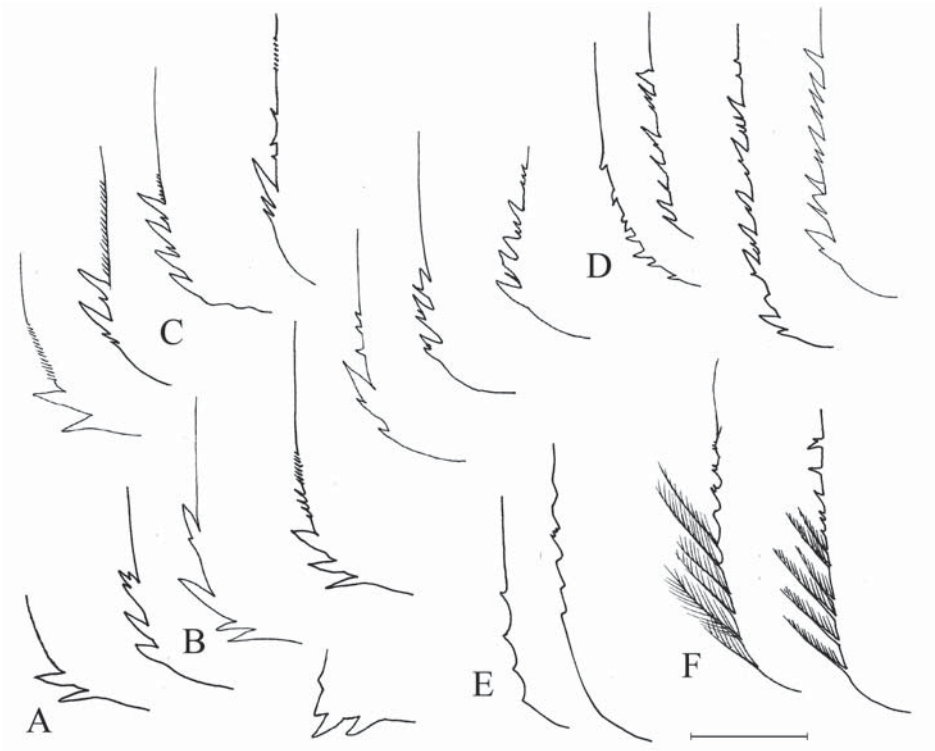

Fig. 3. Different kind of abnormalities of postero-ventral corner of valves in Bamberg well population. A — normal denticles; B — furcated denticles; C — denticles and row of setules; D — with additional small denticles; E — high placed reduced denticles; F — high placed feathered setae. Scale bar 50 μm.
Рис. 3. Разные варианты уродливого строения задне-нижнего угла створок у популяции из колодца в Бамберге. A — нормальное строение зубцов; Б — зубцы с раздвоенными вершинами; C — зубцы и ряды сетул; C — дополнительные мелкие зубцы; D — высоко расположенные зубцы; E — высоко расположенные оперенные щетинки. Масштаб 50 μm.

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