

# **PARTHENOGENETIC AND BISEXUAL POPULATIONS OF *EPHEMERELLA NOTATA* EAT. IN POLAND**

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## **ABSTRACT**

The sex ratio (males: females) of final instar nymphs of *Ephemerella notata* varies from 0.12: 1.00 to 0.92: 1.00 in isolated populations of the Pomeranian Lake District in Poland. These data support the view that facultative parthenogenesis occurs in this species. The incidence of parthenogenesis was inversely related to population density. Parthenogenetic populations were less variable in size (determined by a principal component analysis of a total body-size index) and more synchronous in their development.

## **INTRODUCTION**

Parthenogenesis is found in most animal groups (Suomalainen et al, 1987), including many mayfly species (Degrange, 1960). Mayfly parthenogenesis is usually facultative and automictic. After chromosome reduction during meiosis the nuclear phase in the egg becomes azygoid (haploid). The zygoïd phase is then restored by the fusion of two azygoid nuclei of different mayflies in fertilization or by the fusion of two nuclei of a single individual (auto-mixis). Generally, only a small per cent of unfertilized eggs hatch and their development is slower and not well synchronized, leading Brittain (1982) to argue that parthenogenesis has no importance in population dynamics. However, Landolt et al. (1997) observed that half of the unfertilized eggs of *Palingenia longicauda* develop and so parthenogenesis could be very important.

Parthenogenesis is usually detected by the lack of males in particular populations. Unisexual (female) populations of *Ephemerella notata* were first recorded by Landa (1969) in Czechia, and Jazdzewska (1976) made similar observations in central Poland. *E. notata* males appear only in northern Poland (Pomeranian Lake District) but the sex ratio is variable (Głazaczow, 1994); there is a small predominance of males near the Baltic Coast (the ratio of males to females - 1.00: 0.90) but a very large predominance of females in the southern portion of this region (the ratio of males to females - 0.05: 1.00).

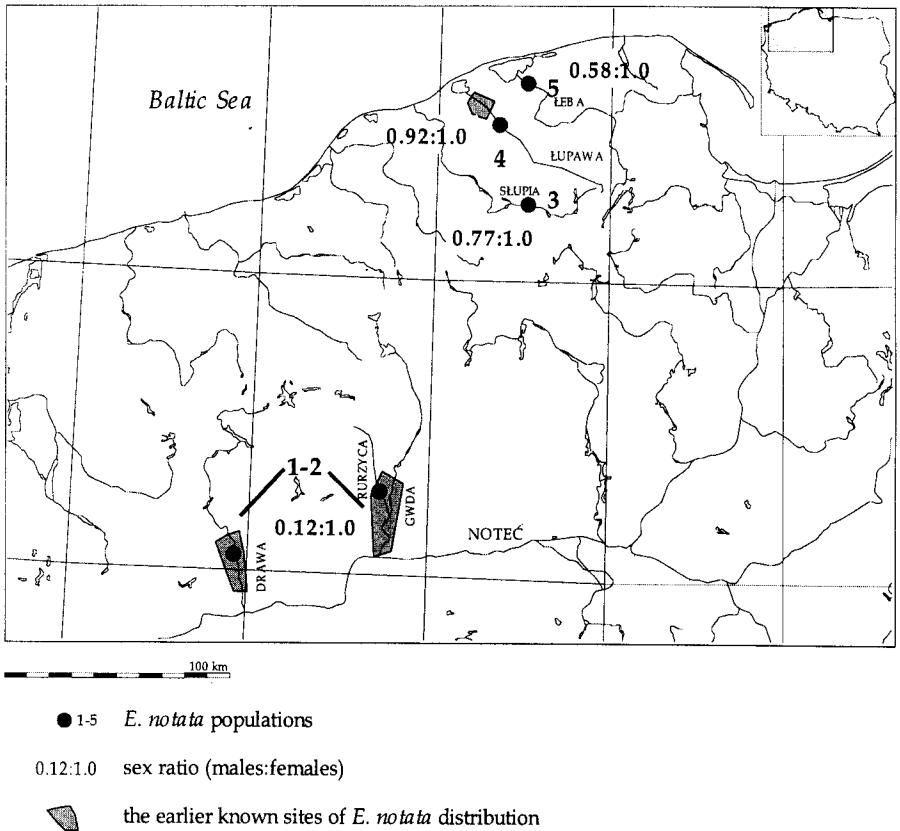


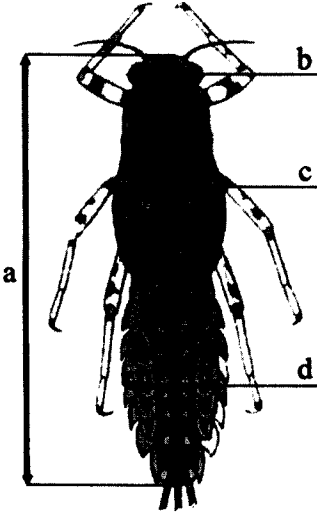
Fig. 1. Distribution of *E. notata* populations in the Pomeranian Lake District.

*E. notata* is widely distributed in Europe, occurring in England and France in the west, through the Central Europe to the Balkans in south and West Russia in the east. It was assigned by Sowa (1975) to the south-central European group. In spite of the species wide distribution, males are known from the northern part of its range only, such as in England (Kimmins and Frost, 1943), Denmark (Jensen, 1961), and northern Poland. In Poland they decrease and disappear over a distance of 150 km and the river Noteć seems to be a southern limit of their distribution.

The purpose of this study was to compare populations over this transition zone in Poland.

## METHODS

Final instar nymphs of *E. notata* were collected in 1998 from five sites in the Pomeranian lake district of Poland (Fig. 1). A bottom scraper was used in which substratum from about 0.05 m<sup>2</sup> was gathered. The sex of nymphs was determined by differences in the structure of their eyes and eighth sternite. Measurements of body length and width of the head, thorax and abdomen were recorded. To analyse the differences in the nymphal sizes between the populations, a total body-size index, derived from principal component analysis of these four



Variable	Loading on PC1	
	Females	Males
Body length (a)	0.90	0.90
Head width (b)	0.96	0.91
Thorax width (c)	0.91	0.84
Abdomen width (d)	0.94	0.94
Eigenvalue	3.45	3.23
% variance explained	86.3	80.7

**Fig. 2.** Total body-size index in *E. notata* populations derived as first component from principal component analysis.

Loading on PC1 - only 1 principal component is analysed; it shows in which degree various measurements influence (load) on the principal component e.g. new measure of body size (1.00 is the highest degree).

Eigenvalue - self-value of the correlation matrix; it should be  $> 1$  but it can not exceed the value of the number of the analysed variables (in this case 4); if it is higher it explain the grater part of the variance.

% variance explained - informs which % of variation of the all variables (4) is explained by 1 principal component.

measurements, was used. All morphometric variables had positive loadings on their first component (being positively correlated) and similar magnitudes (0.84-0.96) (Fig. 2).

Considering that populations 1 and 2 had low numbers and were not significantly different (HSD Tuckey's test), they were combined. Nymphs that were preserved with the substratum were significantly different in their total body-size from the ones preserved immediately in alcohol, and were not used.

## RESULTS

Pomeranian rivers are divided by a watershed line so that they flow either to the north or the south. *E. notata* does not occupy all water courses, and in the south was found in the lower sections only. These conditions lead to the isolation of populations. *E. notata* is a rheophilic mayfly, occurring mainly in patches of *Elodea canadensis* and *Fontinalis antipyretica* and roots of riparian plants submerged in the current. Their abundance is very variable and in some habitats (roots of alder) difficult to measure.

Density was highest in the river Lupawa (Fig. 1, population 4), where it was the dominant mayfly species and its abundance reached  $30 \times 0.05 \text{m}^{-2}$ . The lowest numbers were in the rivers Drawa and Rurzyca (population 1-2), where densities never exceeded  $3 \times 0.05 \text{m}^{-2}$ . Intermediate densities were observed in the other stations.

Males occurred in the whole area of investigation but the sex ratios in the particular populations were very different and females predominated at all sites. The sex ratio most approached equality - 0.92:1.00 (166 males, 181 females) - in the most abundant population (4). Very low representation of males was typical for southern populations where they were

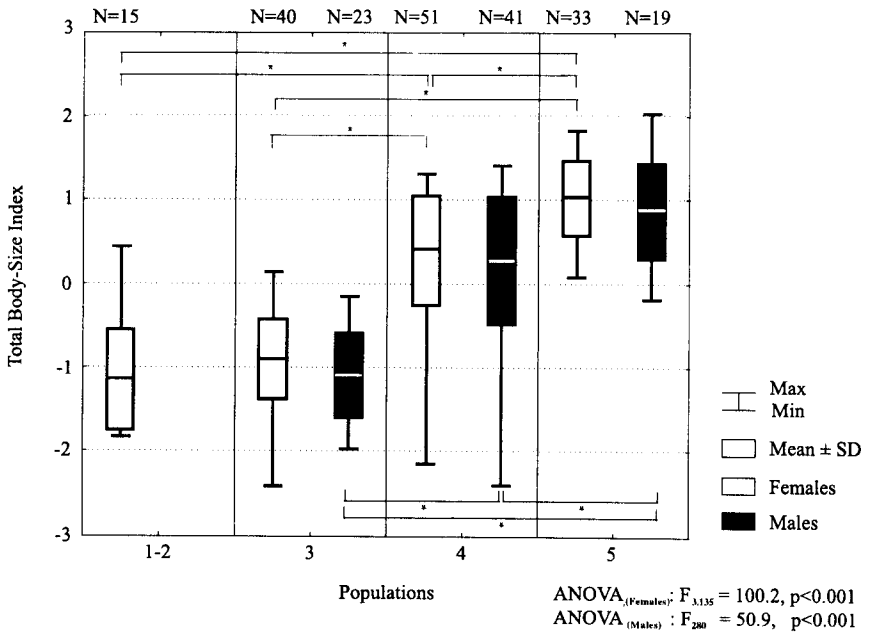


Fig. 3. Changes in total body-size index of *E. notata* in various populations.  
 \* - statistically significant differences;  $p < 0.05$

found only sporadically in ratios of 0.12:1.00 (2 males, 17 females). These populations must have, in part, reproduced parthenogenetically. Changes in the sex ratio were proportional to the changes in the number. When populations were more abundant, the sex ratio was more or less equal, but when their abundances were low, males became scarce.

Because all measurements were correlated, they were calculated as a total body-size index. Populations 1-2 and 3 were geographically distant and differed in the degree of parthenogenesis but their body sizes were not significantly different. Body size was significantly different between populations 3,4 and 5 (Fig. 3). Though their distance of separation was not as great, they were located on separate rivers. The observed changes in the size increase to the North, but the degree of parthenogenesis varies in the other direction. The size of the populations in which males were numerous (3,4) are much more variable than in those where parthenogenetic females predominated (1-2, 5). Somewhat younger and slightly smaller nymphs were lacking in the southern populations, but also in the northernmost population (5).

## DISCUSSION

As expected populations of *E. notata* which develop in the most productive environments, reach the greatest abundance, although it is sometimes difficult to measure accurately. So, considering the patchy distribution of nymphs, maximum density does not reflect the real numbers in the whole river-bed. However, it appears that the highest relative densities were reached in populations 4 and 3 from the rivers Łupawa and Stupia. In these populations both the greatest percentage of males, and the greatest variation in body size were observed. Populations, in which the lower numbers of males were found, so at least partly parthenogenetic, were less variable in body size, although the difference between the populations was statistically significant. Also, development was more synchronous in the partheno-

genetic populations. This study agrees with general suggestion that facultative parthenogenesis is an adaptation to unfavourable conditions, but does not support the view that parthenogenetic populations show a decay in reproductive synchrony, which was also observed by Sweeney and Vannote (1982).

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