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Life cycle, host plants and abundance of caterpillars of the aquatic moth *Cataclysta lemnata* (Lepidoptera: Crambidae) in the post-glacial lake in central Poland

Krzysztof PABIS

Department of Invertebrate Zoology and Hydrobiology, University of Lodz,
Banacha 12/16, 90-237 Lodz, Poland, E-mail: cataclysta@wp.pl

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Abstract. Two full generations of *Cataclysta lemnata* were recorded in a post-glacial lake in central Poland. The presence of pupae in mid-September demonstrated possibility of occurrence of the third partial generation at the beginning of autumn. This study also includes information on copulation time, egg laying, and tube building by caterpillars based on the field and laboratory observations. Caterpillar host plants were investigated in the laboratory. Significant differences in caterpillar densities were recorded between the macrophyte zone (1.6 (1SD: 1.8) ind./0.25m^2) and the open waters of the lake (0.1 (1SD: 0.3) ind./0.25m^2).

Key words: Acentropinae, Lemnaceae, macrophytes, host plants.

Only a small number of Lepidoptera is associated with aquatic environment. The most important group of aquatic moths is Acentropinae (Crambidae) with more than 700 species and worldwide distribution (Mey & Speidel 2008). Most of them are associated with freshwater. Only a few have colonize the brackish lakes or river mouths (Ward 1992). Mey and Speidel (2008) highlighted a great need of further studies on aquatic moths and a serious lack of knowledge about this group of insects. It resulted in greater attention dedicated to research on aquatic Acentropinae in recent years, including their importance in management of aquatic macrophytes, especially biological control of invasive species (Gichuki et al. 2012), as well as taxonomic studies (Agassiz 2012). There are only twelve native species of Acentropinae in Europe (Slamka 2008). Despite some earlier studies (e.g. Chapman 1905, Berg 1941, Reichholf 1970, Petrischak 2000), data on life histories, ecology and biology of common European species are still incomplete. Only a few research included both, field studies and laboratory observations. The aim of this study was to describe life cycle and abundance of caterpillars of the common aquatic moth, *Cataclysta lemnata*, as well as provide some new data on the host plants derived from the laboratory experiment.

Studies were done from April to November 2003 in a small (100 m in diameter, maximal depth of 3 m) post-glacial lake situated at the edge of the Vistula River urstromtal, close to the town of Gostynin (central Poland). Samples were collected at regular intervals directly from the surface of the water using a rectangular wooden frame (50 cm length of each side, 0.25 m^2 catching area). Two sampling areas were distinguished: coastal vegetation zone and open waters of the lake. Ten random samples (frames) were collected in each of those two areas, during each of 16 field trips. In the analysis of density, each frame was treated as a separate sample. For the life cycle analysis, the number of larvae and pupae were summarized for each sampling trip. Samples collected between 8 May and 8 October were used in the density analysis because the whole surface of the lake was covered with duckweed at that time. Additional data were gathered during many hours of observation in the laboratory conditions (water temperature of 17°C). In order to check the feeding preferences, 25 caterpillars were placed in separate containers for 48 h. Each of the plants (*Ceratophyllum demersum, Myriophyllum spicatum, Stratiotes aloides, Utricularia vulgaris, Wolffia arrhiza* and *Lemna gibba*) was given to a caterpillar separately and together with the basic host plant *Lemna minor*. Head capsules of caterpillars obtained from the field studies were measured (accuracy of 0.01 mm) in order to provide information on size classes throughout the year.

Two full overlapping generations of *C. lemnata* were recorded (Fig. 1, 2). The presence of pupae in the second half of September demonstrated the occurrence of the third partial generation. It was also reflected in the dominance structure of the caterpillar size classes (Fig. 2). During the field studies, imagines were observed mostly in the macrophyte zone, in the close distance from the shore. Copulations were observed at the surface of the water covered with duckweed, as well as on the large macrophytes like *Typha latifolia*. Only two full copulations were recorded (41 and 35 minutes). Females lied eggs while sitting on the surface of the water covered with host plants. The

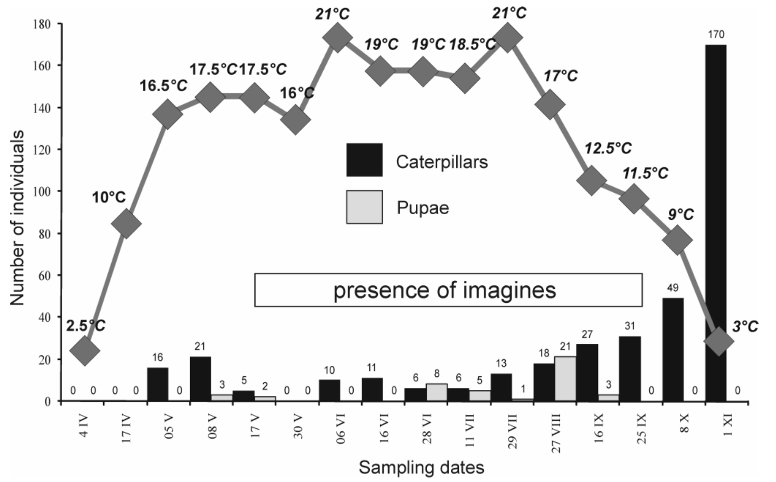

Figure 1. Number of caterpillars and pupae collected throughout the year and the water temperature at investigated site.

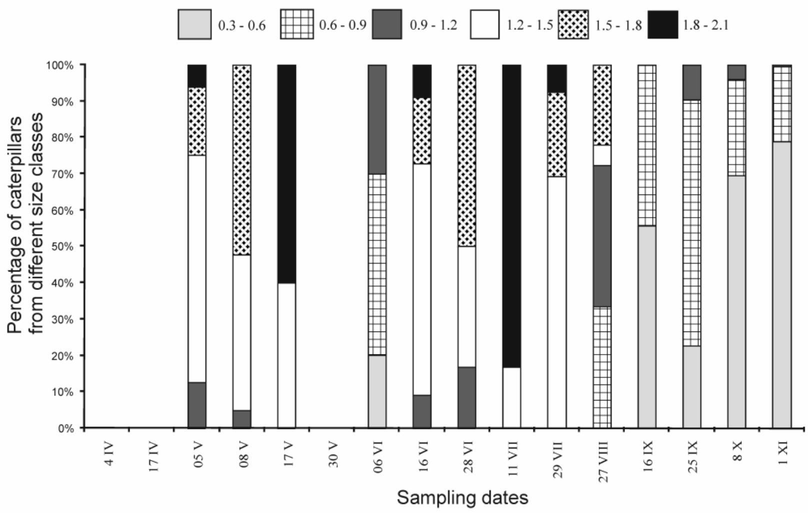

Figure 2. Proportions of caterpillars from different size classes throughout the year.

eggs were placed under the leaves of *S. polyrhiza* or rarely also *L. minor* and *Hydrocharis morsus ranae*. Complete egg laying was observed two times. It lasted for 16 and 22 minutes and resulted in 257 and 187 eggs, respectively. Further observation concerned the caterpillars obtained from eggs laid by first female on the 21 May 2003. All the eggs hatched 7 days after oviposition. Caterpillars were eating the parenchyma of the *S. polyrhiza* and *L. minor* and started consuming the whole leaves on the same day. Larvae were semitransparent, and they live entirely submerged. First type of tubes were made by hydrophilic caterpillars after 5 days, on the 2 June 2003. It were constructed of small parts of the *L. minor* and *S. polyrhiza*. After another 9 days (11 June 2003), the caterpillars became hydrophobic and changed to a brown color. The tubes were created from the whole leaves of *L. minor*, *L. gibba* and *L. trisulca* or from decaying fragments of *T. latifolia*. Pupation took place in the cocoons made of a dense pack of *S. polyrhiza* and *L. minor*. Pupal stage lasted from 5 to 8 days (N=9) in males and from 9 to 12 days (N=3) in females. *C. demersum* and *S. aloides* were used as host plants only exceptionally. Three other species (*M. spicatum, U. vulgaris* and *W. arrhiza*) were rejected. The only species which was used by the caterpillars without any exceptions was *L. gibba*. Mean density of caterpillars in the open water was low 0.1 (1SD: 0.3) ind./0.25m². Maximal value was as high as 2 ind./0.25m². In the macrophyte zone it was significantly higher (Mann-Whitney U test $p<0.0000001$) and averaged 1.6 (1SD: 1.8) ind./0.25m². Maximal value reached 10 ind./0.25m².

Early papers concerning development of *C. lemnata* included only fragmentary observations (Chapman 1905, Wojtusiak & Wojtusiak 1960). The most comprehensive study of this species was done by Petrischack (2000). However, the laboratory breeding was done in the water temperature ranging from 20 to 23°C. That kind of procedure could have influenced the phenology, resulting in biased data. A study done in central Poland showed that emergence of the second generation is prolonged, which is most probably due to decrease of water temperature. The presence of pupae in mid-September demonstrated also the presence of a partial third generation. Such a phenomenon is known in Lepidoptera, for example in common nymphalid, *Araschnia levana*, in central Europe. It might also suggest occurrence of the full third generation of *C. lemnata* in southern Europe. Petrischack (2000) mentioned that copulation may last from 19 to 21 minutes. Results from the two observations showed that this time can even be doubled. Petrischack (2000) observed also that the time from pupation to emergence lasted for 6 days. Observations made during this study demonstrated that it can last up to 12 days and that it is longer in females. It might suggest the presence of protandry in *C. lemnata*. Such behavior is increasing the possibility of quick fertilization and minimizing mortality before reproduction (Thornhill & Alcock 1983). This conclusion was based on a small number of observations (N=12), and it needs further studies.

First studies of *C. lemnata* suggested that this species can feed only on Lemnaceae (Chapman 1905, Wojtusiak & Wojtusiak 1960). Thus, it is not surprising that *L. gibba* was also accepted as a host plant, although it was the first observation of this species in the diet of *C. lemnata* caterpillars. *W. arrhiza* was not consumed by the larvae. This species has chemical composition similar to other Lemnaceae and has high nutritive value (Kotowska et al. 2013). However, it is an alien species in Poland (Balsevicius 2011), and it might be the reason of not using it as a host plant. This plant was also not used to construct tubes. Tube building from such small leafs could last longer, resulting in higher pressure of predators (Mueller & Dearing 1994). Wojtusiak and Wojtusiak (1960) showed that fish attacked caterpillars more often when they were extracted from tubes. Caterpillars of *C. lemnata* can consume various macrophytes (Van Der Velde 1988). However, *C. demersum* was never mentioned before as an element of *C. lemnata* diet. Two other plants were rejected by caterpillars. *M. spicatum* contains many chemical compounds which deter herbivory (Baron & Ostrofsky 2010). *U. vulgaris* is a carnivorous plant, but it can be used as host plant by other insects (Stratman et al. 2013). Caterpillars of *C. lemnata* did not consume this macrophyte, but they were also not trapped in its trapping apparatus.

There are no data on abundance of *C. lemnata* in natural conditions. This species was recently analyzed in the context of grazing pressure on Lemnaceae. In the laboratory the pressure of *C. lemnata* caterpillars on *Lemna* was high, but the experiment was carried out on 500 caterpillars placed in five small aquaria (Van der Heide et al. 2006). A study from central Poland showed that the density of caterpillars in natural conditions is much lower, and probably could not compensate for the high growing rates of Lemnaceae (Zhang et al. 2014). Higher density of caterpillars in the macrophyte zone can be associated with preferences of the adult moths. Imagines were observed mostly in this zone. It could be associated with the pressure of various entomophagous birds, such as *Hirundo rustica*, occurring at the open water surface (Binka 2005). Wojtusiak and Wojtusiak (1960) demonstrated also that various species of fish could consume caterpillars of *C. lemnata*. Nevertheless, the intensity of this pressure is probably low. Foraging activity of fish increased when temperature increased above 20°C. In the lake studied, such temperatures were recorded only in June and July.

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