# Mortality of early instars in the highly endangered butterfly *Euphydryas maturna* (Linnaeus, 1758) (Nymphalidae)

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The scarce fritillary *Euphydryas maturna* (Linnaeus, 1758) is one of the most seriously threatened European butterflies (Kudrna 2002; van Swaay & Warren 1999). The ecology of this inhabitant of sparse deciduous woodlands is increasingly understood for both the ecologically distinct populations in Fennoscandia (e.g. Eliasson 1991, 2001; Wahlberg 1998, 2000, 2001; Wahlberg et al. 2002) and the widely isolated populations in Central Europe (Cizek & Konvicka 2005; Freese et al. 2006). However, the factors affecting mortality have not been described in detail.

At two study sites in Czechia, Bohemia (in 2003) and Germany, Bavaria (in 2000, 2001 and 2003), randomly selected egg batches were visited at intervals of 2–4 days to assess mortality of autumn larvae, i.e. the numbers of larvae surviving up to the young third instar relative to the number of eggs. This recording at intervals was to observe the development and mortality of young caterpillars. During the third instar it becomes impossible to distinguish mortality from migration. Then, third-instar larvae leave ash trees for hibernation. Estimation of mortality is not easy because the larvae aggregated together inside the nest are difficult to count. As disturbance has to be avoided, estimated values are performed with a certain inaccuracy.

The combined mortality of eggs and autumn larvae (L1–L3) per egg batch or nest was close to 70% both in Germany (73.7 ± 18.4%, see Fig. 1) and in Czechia (68.8 ± 32.0%). No difference was found between years in Germany (Kruskal-Wallis ANOVA: $H_{(2df)} = 1.59$, $p = 0.45$) and between countries (Mann-Whitney $U = 1000$; $p = 0.91$). Interestingly, similarly high values apply to a population in Sweden. Eliasson (2001) stated that egg-batches contain about 200-300 eggs. A calculation using mean batch size of 250 eggs and data on pre-hibernating larvae from Eliasson & Shaw (2003) gives a mortality of 69 ± 20.2% (Fig. 1). Mortality of eggs only (Germany, 2003) was 13 ± 27.6% ($n = 80$ egg batches). During egg maturation some became black and others collapsed. There are no data available for mortality during hibernation. Breeding results of Eliasson & Shaw (2003) show a survival rate of 69.3% for larvae attempting diapause and surviving hibernation ($n = 687$ larvae).

These observations document that high immature mortality is frequent in the species, causing remarkable oscillations in abundance over subsequent years (cf. Konvicka et al. 2005). Ford & Ford (1930) reported a loss of about 90% of the larvae for the related *Euphydryas aurinia*, and similar findings exist for *E. editha bayensis* (Ehrlich 1984).

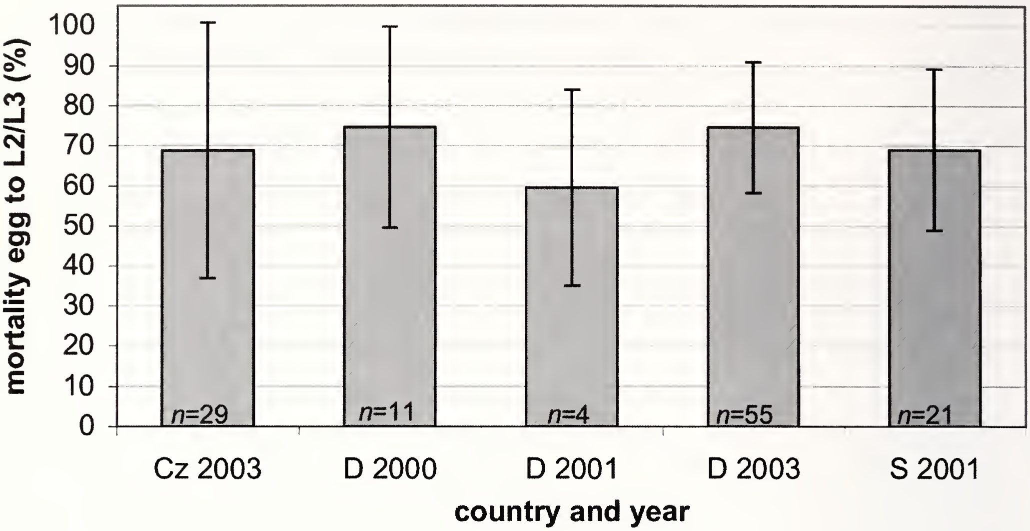


**Fig. 1.** Combined mortality of eggs and autumn larvae (L1–L3) per egg batch or nest in different countries and years. Mean and standard deviations are shown. n = number of observed egg batches / nests; Cz = Czechia; D = Germany; S = Sweden. Data from Sweden calculated after Eliasson (2001) and Eliasson & Shaw (2003).

These oscillations are usually attributed to the pressure of parasitoids. At our study sites in Austria, Czechia, and Germany the observed causes of larval mortality include the parasitic Braconidae, *Cotesia melitaearum* (Wilkinson, 1937) and *C. acuminatus* (Reinhard, 1880) (species identification for Austrian specimens) and Ichneumonidae. We observed up to five *Cotesia* females sitting for days near an egg batch waiting for young *E. maturna* larvae to hatch. Newly hatched caterpillars were attacked immediately, still being defenceless. However, *Cotesia* females seem to avoid direct contact with older caterpillars. *Cotesia* larvae were observed leaving *E. maturna* caterpillars at instar six (seven *C. melitaearum* larvae from one caterpillar at the end of May) and at instar four (three *C. acuminatus* larvae after hibernation). Wahlberg (1998, 2001) also describes *C. melitaearum* and *C. acuminatus* as parasitoids in Finnish *E. maturna* populations with unknown importance to the population dynamics. Additionally, the dipteran parasitoid *Erycia fatua* (Meigen, 1824) (Tachinidae) has a great impact on *E. maturna* in Finland (Wahlberg 2001). In Sweden, *C. acuminatus* seems to be the only important parasitoid attacking caterpillars (Eliasson & Shaw 2003). The rate of parasitism in Sweden was 32.1% (of 476 larvae surviving diapause in 1994/1995). Selzer (1918) described a parasitism rate of Ichneumonidae in Germany of over 50% for some years and very low in other years. Moreover, we observed predation by a crab-spider, *Misumena vatia* (Clerck, 1757) (Germany), a Chrysopidae larva (Germany), and several predatory bugs, e.g. *Picromerus bidens* (Linnaeus, 1758) (Germany and Czechia) and *Troilus luridus* (Fabricius, 1775) (Germany). Numerous empty nymph skins found in Germany indicated that predatory bugs might complete their development near *E. maturna* nests. Vrabec & Jindra (1998) described that

*P. bidens* can decimate entire nests in Czechia. In some cases, gnawed leaves with known egg batches showed that herbivores like maybugs (*Melolontha* sp., Scarabaeidae) had consumed these leaves along with the egg batches. Additionally, egg mortality may be caused by faulty maturity, missed fertilization, or egg parasitoids though there are no direct observations.

The silk web may act as a shelter against predators or parasitoids (cf. Fitzgerald 1993). Although predatory bugs were never observed inside a nest as noticed for *Eriogaster* (Lasiocampidae) tents (Ruf & Fiedler 2005), some were observed to wait outside the web until a caterpillar left the nest. *Cotesia* females tried to sting caterpillars inside the nest through the silk or leaf boundary of the nest.

There are not only biotic mortality factors, but also some abiotic ones. Larval survival was negatively correlated with indices of solar energy (hours of sunshine per day, solar energy per day) for the 20 nests studied (Freese et al. 2006), i.e. increasing duration of sunshine led to smaller nests. The often cited preferential use of sunny sites (e.g. Ebert & Rennwald 1991; Eliasson 2001; Helsdingen et al. 1996; Wahlberg 1998, 2000, 2001; Weidemann 1985) therefore should be reviewed. Strong gusts of wind tore off small nests from branches in Germany in 2002. Furthermore, young ash leaves died off because of a late frost at the end of May 2004 in Germany. Therefore, *E. maturna* females had to lay eggs on the newly emerging leaves. But unfolding and growing leaves caused egg mortality by breaking egg batches and causing some eggs to fall off. Flooding may cause mortality for older larvae gregariously hidden in old leaves in the leaf litter (e.g. Pretscher 2000). But the coppiced forests of the study sites were not exposed to flooding, although humidity may play a role.

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