Influence of temperature on survival and emergence of diapausing *Peristenus stenodemae* (Hymenoptera, Braconidae)

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Cocoons of *Peristenus stenodemae* Loan, a nymphal parasitoid of *Stenodema virens* (L.), were exposed to varying degrees of cold during diapause and tested for survival and emergence time. Survival of pupae was highest at temperatures above zero. Mortality increased with decreasing temperature reaching 100% at about –20°C. Three to four weeks were needed to reach 50% emergence after cold storage.

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1. Introduction

The mirid bug *Stenodema virens* (L.), distributed over Europe and also known from some Asian countries (Stichel 1956), is sometimes referred to as a pest of cereals (e.g. Mieržvejevskaja 1955, Strawiński 1956). It is the most common *Stenodema* species on cereals in central Poland (Bilewicz-Pawińska 1982) and is also common in Finland (Bilewicz-Pawińska & Varis 1985). In both countries the species is univoltine. Of the numerous food plants of this species, grasses, rye and winter wheat seem to be preferred (Jürisoo 1964, Bilewicz-Pawińska 1982).

Nymphs of *S. virens* are parasitized by *Peristenus stenodemae* Loan (Hymenoptera, Braconidae) (Loan & Bilewicz-Pawińska 1973), the extent of parasitism depending on host plant and year. The maximum parasitism found by Bilewicz-Pawińska (1982) was 35%. *P. stenodemae* is univoltine in Poland and hibernates as a pupa (cocoon) in soil.

The diapause of *P. stenodemae* under Polish field conditions lasts ten months, from July to May (Bilewicz-Pawińska 1982). In laboratory rearings *P. stenodemae* was found to react slowly to a rise in temperature during diapause (Bilewicz-Pawińska 1977, Bilewicz-Pawińska & Varis 1990). The optimum temperature for the termination of the diapause of this species has a greater range than that of four other *Peristenus* species studied (Bilewicz-Pawińska & Varis 1990).

Some parasite releases in the northeastern USA failed because of poor synchronization of the emergence of the parasitoids from overwintering cocoons and the occurrence of the nymphs of the host insects (Day 1987). Better knowledge of the diapausing conditions of parasitoids may make it possible to improve such releases. Because *Peristenus* species are common parasitoids of plant bugs (Heteroptera, Miridae) (Loan 1965, Loan & Bilewicz-Pawińska 1973), one of them was chosen for the object of this study. The aim was to determine the low-

temperature threshold for survival of *P. stenodemae*, and to examine the termination of diapause of the pupae and the influence of the length of low-temperature periods during storage on survival of *P. stenodemae*.

2. Materials and methods

The *P. stenodemae* pupae used in this study were bred from fifth instar nymphs of *S. virens* collected from rye fields in Poland, near Warsaw, in June–July 1988 and 1989. The total number of cocoons was 670: 170 cocoons in 1988 and 500 in 1989. The cocoons were put in ventilated plastic cages, 30–40 (1988) and 50 (1989) in each. All the cages were kept in a refrigerator in August and September of both years.

From the beginning of October in both years, the cages were exposed to different temperatures. Some of the cocoons (series F) were moved to constant temperature cabinets in Finland, the rest (series P) were kept in unstable temperature conditions in a refrigerator or freezer in Poland. Each temperature range continued for at least one month, and the cocoons were kept in complete darkness. In the constant-temperature cabinets, the RH was 60–100%, and the monthly humidity was constant. In the refrigerator and the freezer, the humidity was maintained between 53 and 68%, except when the temperature was –20°C, when it reached 80%.

The whole experimental period, including the emergence period of the adult braconids, lasted until June–July or, in series 5P and 9F, until September or October of the following year. Throughout this time, the cocoons were exposed to cool storage above freezing temperatures or were frozen for one to six months from January onwards (Table 1). After freezing, the cocoons were kept 1–4 months at temperatures above zero in a cold chamber (F) or in a refrigerator (P). For emergence, the cocoons were moved to room temperature (av. 18–22°C) in May (1989) or in June (1990) and, in series 5P and 9F in September (1990).

The value of the plus-temperature sum of cool storage and the minus-temperature sum of the freezing period in explaining mortalities was tested with logit-linear (binomial) modelling using the GLIM-statistical package (Payne 1987).

3. Results

After the cocoons were transferred to room temperature, the median time before emergence of the braconids was 20–29 days. No distinct differ-

Table 1. Effect of storage temperature (range, mean) on mortality (%) and emergence (days needed to reach median emergence after cold storage) of *Peristenus stenodemae* pupae in Finland (F) and in Poland (P) in 1988 and 1989.

Year and experiment	Cool storage period(s) Months	Temperature		Freezing period Months	Temperature		Mortality %	Emergence days
1988								
3F	8	+5 – +6	+5.1	–	–		17	29
1P	8	+4 – +9	+5.8	–	–		48	25
2P	7	–8 – +8	+4.0	1	–6 – –11	–8.0	66	20
3P	6	–8 – +8	+5.0	2	–6 – –11	–8.4	68	21
8F	5	+0 – +5	+3.0	3	–10		46	26
4P	5	–8 – +8	+3.1	3	–6 – –12	–8.6	74	26
1989								
9F	5	+5 – +11	+5.1	6	–10		50	24
5P	5	+3 – +11	+4.7	6	–6 – –12	–9.2	82	24
11F	5	±0 – +5	+3.0	3	–10 – –20	–13.3	100	–
6P	5	–8 – +8	+3.6	3	–6 – –21	–12.3	88	25

ences were noted between similarly treated series. In most series the emergence period lasted about two weeks (11–16 days), independent of cold treatment and season (Table 1).

Mortality of pupae increased with the decrease in temperature and with length of treatment, according to a binomial model, $\ln (p/q) = 2.2–0.06 \times$ months of cool storage $\times$ mean temperature, where p is the percentage of dead insects, and q that of living insects. The cool storage temperature-sum was highly significant in explaining mortality ($df = 1$, $P = 0.001$); the freezing temperature-sum was not significant. According to the model, 50% mortality will be reached at a degree sum of +37°C, which means about six months at 6°C or five months at 7 degrees; 70% mortality at the degree sum of 22°C, and so on. Mortality reached 100% at a freezing temperature of about –20°C. The mortality of pupae kept at constant monthly temperatures was significantly lower than that of pupae kept at fluctuating monthly temperatures ($df = 3$, $P = 0.001$).

4. Conclusions

The survival of diapausing pupae of *P. stenodemae* depends on storage temperature, and length of diapause may be prolonged several months longer than in nature:

1) The mortality of pupae increases with decrease in temperature and with length of cold period, is lowest at low temperatures above zero, and reaches 100% at about –20°C.
2) The survival of pupae is higher at constant temperatures than at fluctuating temperatures.
3) For emergence, a period of roughly equal length is needed independently of the cold treatment and the season.

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