Development, larval voracity, and greenhouse releases of *Stethorus punctillum* (Coleoptera: Coccinellidae)

DA Raworth[1]

Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre,
PO Box 1000–6947, Highway No. 7, Agassiz, British Columbia, Canada V0M 1A0

The Canadian Entomologist **133**: 721 – 724 (2001)

Stethorus punctillum Weise (Coleoptera: Coccinellidae) is a Palearctic species first found in North America in the 1940s (Putman 1955). Commercial mass-rearing methods were developed in the late 1990s (Agriculture and Agri-Food Canada, London, Ontario, and Applied Bio-nomics Ltd, Saanich, British Columbia). The beetle is now released in North America to control two-spotted spider mites, *Tetranychus urticae* Koch (Acari: Tetranychidae). Knowledge of the life-history traits of *S. punctillum* is necessary for effective use of the predator in greenhouses. Putman (1955) provides useful information, but his results cannot be readily interpreted with respect to larval voracity, lower developmental temperature threshold, and developmental time in degree-days (°d), traits that affect efficacy. In this note I report new results relating to these life-history traits and to beetle releases in greenhouse vegetable crops.

Development

Adult beetles were obtained every year from fields of commercial strawberry [*Fragaria* × *ananassa* Duchesne (Rosaceae)] and raspberry [*Rubus idaeus* L. (Rosaceae)], and reared at 21–23°C and 15L:9D photoperiod on 'Totem' strawberry infested with *T. urticae*. During August 1989, June–July 1991, and May 1992, the developmental time and lower developmental temperature threshold for *S. punctillum* were determined by observing daily the developmental stage of individuals in a cohort at 15.9 ± 0.5°C (n = 28), 17.1 ± 0.5°C (n = 18), 19.4 ± 0.5°C (n = 40), and 21.8 ± 0.5°C (n = 18) at 15L:9D photoperiod, and at two ramped regimes, 21–28°C [mean 24.3°C (n = 40)] and 22–30°C [mean 26.2°C (n = 40)]. Eggs were either laid during a 24-h oviposition period on 2.5-cm diameter strawberry leaf disks at 21°C or obtained from colonies of the beetle. In the latter case the developmental status of the egg could not be determined. Single eggs were isolated on excised leaf sections and placed on a 2.5-cm diameter mite-infested leaf disk in a plastic seal-tight petri dish (3.5 cm diameter × 0.8 cm deep). Leaf disks were replaced as needed to maintain an excess food supply. A subset of adults was sexed using external morphology (Hodek 1973). Thermal constants were determined by regression analysis (Campbell et al. 1974; SAS Institute Inc 1990).

Survival to adult was 36% (65 beetles). Mortality at the egg stage, instars I, II, III–IV, and pupal stage was 24, 24, 8, 4, and 4%, respectively, and was due to unknown causes. Putman (1955) noted that pathogens caused 20% larval mortality in some years; our insects were not examined for pathogens. Survival to adult did not differ between temperatures (χ^2 = 10.1, df = 5). It is assumed that mortality in the early stages of development did not bias the following results. Temperature thresholds for development from egg hatch to adult, 10.7 ± 0.95°C (mean ± SE) for females (r^2 = 0.89, $P < 0.001$, n = 22) and 12.7 ± 0.45°C for males (r^2 = 0.98, $P < 0.001$, n = 12), were not different ($P > 0.05$). The data were pooled and beetles for which sex was not determined were

[1] E-mail: raworthd@em.agr.ca.

included (Fig. 1). Duration from egg hatch to adult was 217.1 ± 0.1°d above 11.6°C. The proportion of 217.1°d spent in the egg, larval, and pupal stages was 0.28, 0.51, 0.21, respectively.

Larval voracity

Voracity was determined during May–June 1990 for cohorts of larvae at 14.0 ± 0.5°C (n = 15), 17.9 ± 0.5°C (n = 14), and 21.8 ± 0.5°C (n = 15) (15L:9D photoperiod). Larvae were reared singly in glass vials (1.5 cm diameter × 5 cm tall) with Fluon® (Asahi Glass Fluropolymers United States Inc, Chadds Ford, Pennsylvania) coating the upper inner 2-cm of the vial to prevent escape. The bottom of the vial was fitted with a disk of emery cloth to facilitate movement. Excess *T. urticae* eggs (10–130 eggs depending on larval instar) were provided two to four times daily on chips of aluminium foil. Mite eggs were moved from leaves to the foil, using a brush moistened with distilled water. Only undamaged, spherical eggs were used in the experiment. Number of eggs eaten and larval instar were noted at every feeding. Sex of the resulting adults was determined.

Ten beetles survived to adult and all were female. Most mortality occurred in the egg (38%) and first-instar (27%) stages at each temperature. The mean ± SE number of eggs eaten by instars I–IV was 36.6 ± 2.6, 67.6 ± 3.2, 197.4 ± 11.2, and 712.4 ± 18.5, respectively, and the proportion of time spent in each instar was 0.32, 0.18, 0.18, and 0.32, respectively. There was no relationship between total eggs eaten and temperature ($P > 0.05$).

Establishment and movement in greenhouses

Stethorus punctillum was released in February and March 1997 into commercial greenhouse crops of tomato, *Lycopersicon esculentum* Miller (Solanaceae), cucumber, *Cucumis sativus* L. (Cucurbitaceae), and pepper, *Capsicum annuum* L. (Solanaceae), to determine if early-season releases would establish on these crops and to determine the extent of their movement. No prior releases had been made. The beetles were mass-reared in London, Ontario, and shipped in groups of 100 to Agassiz, British Columbia. On arrival, 5–10 beetles from each group of 100 were set aside for sex determination and fecundity and survival trials. Beetles in these trials were provided with *T. urticae* on leaf disks in seal-tight dishes. Eggs produced were counted, removed, and checked daily for eclosion. The beetles were released at four sites by placing an open container on the ground near mite-infested plants for 24 h: 399 beetles, 21 February on tomato 'Trust' (1 ha, plants 3 m tall, 24-h temperature 18–19°C); 400 beetles on pepper 'Eagle', 13 February (2.2 ha, plants 1 m tall, 24-h temperature 20–23°C); 170 beetles on pepper '444', 20 March (0.8 ha, plants 1.5 m tall, 24-h temperature 20–23°C); and 438 beetles on cucumber 'Flamingo', 7 March (0.15 ha, plants 2.5 m tall, 24-h temperature 21–23°C). All plants in the original mite infestation and plants in other infestations flagged by greenhouse staff were thoroughly examined for the presence of *S. punctillum* every 1–2 weeks for 1 month (mean ± SD plants/sample, 76 ± 41). Distance moved was determined from scale maps of infestation locations.

Stethorus punctillum had moved 125 m in pepper ('Eagle') 18 d after release and 36 m in cucumber 21 d after release. Larvae and pupae were observed on pepper (84 and 102, respectively) and cucumber (8 and 6, respectively), indicating establishment on those crops. No *S. punctillum* were recovered on tomato despite ongoing mite infestations and twice-weekly surveys by pest managers as well as our own sampling. A 50-d fecundity trial of a subsample of 15 female beetles indicated that the beetles released on tomato were viable: mean ± SE eggs/beetle, 52.5 ± 15.1; mean ± SE larvae/beetle,

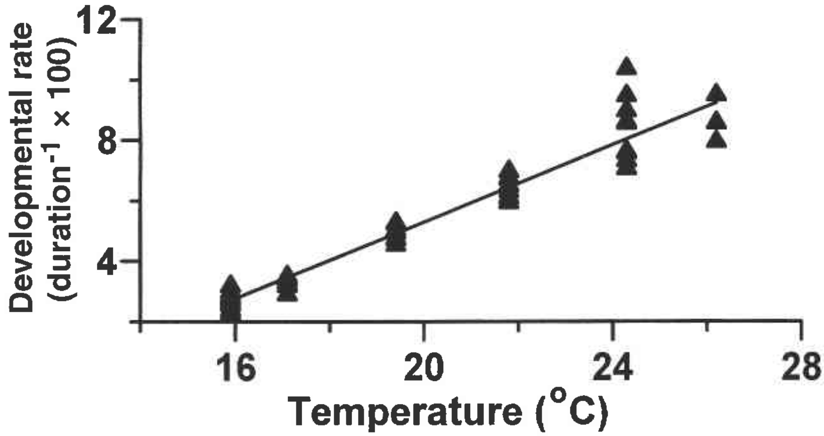

FIGURE 1. Development rate of *Stethorus punctillum* from egg hatch to adult *versus* temperature: $y = -7.351 + 0.633x$ ($r^2 = 0.94$, $P < 0.001$, $n = 65$), temperature threshold 11.6 ± 0.30°C.

39.3 ± 12.7; mean ± SE adult survival, 23.4 ± 3.9 d; and sex ratio 1.2:1 females:males. Beetle activity is affected by light, temperature, and prey availability (Putman 1955). These factors may also affect dispersal rates.

Application to releases in greenhouses

The cost of *S. punctillum* often necessitates inoculative releases. Population increase will be affected by developmental rate, which is dependent on temperature. Development from egg to adult at 21 and 25°C is 23 and 16 d, respectively. The large larval demand for food (1014 *T. urticae* eggs) suggests that release of beetles in mite infestations will facilitate establishment.

The work showed that mass-reared *S. punctillum* released as early as February will move throughout the greenhouse and establish on pepper and cucumber. Lack of establishment on tomato may be related to plant trichomes (Putman 1955). Additional studies are required to establish greenhouse release rates and determine the impact on *T. urticae* populations on different host plants (Rott and Ponsonby 2000).

The author thanks J Whistlecraft for mass-reared *S. punctillum*, and M Robertson, R Edmonds, S Lum Min, E Walsh, and S Clements for technical assistance. The work was funded in part by the BC Raspberry Growers' Association, the BC Greenhouse Vegetable Research Council, the Agriculture and Agri-Food Canada – Matching Investment Initiative program, and the Program of Energy Research and Development. Pacific Agri-Food Research Centre contribution No. 646.

Campbell A, Frazer BC, Gilbert N, Gutierrez AP, Mackauer M. 1974. Temperature requirements of some aphids and their parasites. *Journal of Applied Ecology* **11**: 431–8

Hodek I. 1973. *Biology of Coccinellidae*. Prague: Academia

Putman WL. 1955. Bionomics of *Stethorus punctillum* Weise (Coleoptera: Coccinellidae) in Ontario. *The Canadian Entomologist* **87**: 9–33

Rott AS and Ponsonby DJ. 2000. The effects of temperature, relative humidity and host plant on the behaviour of *Stethorus punctillum* as a predator of the two-spotted spider mite, *Tetranychus urticae*. *BioControl* **45**: 155–64

SAS Institute Inc. 1990. *SAS/STAT user's guide, version 6, 4th edition, volumes 1 and 2*. Cary, North Carolina: SAS Institute Inc

(Received 30 March 2001; accepted 23 July 2001)