Integrated Protection of Stored Products
IOBC/wprs Bulletin Vol. 30 (2) 2007
37-41

The importance of food supplements for parasitoids of stored product pests: the case of *Venturia canescens* (Hymenoptera: Ichneumonidae).

Panagiotis A. Eliopoulos*
Technological Educational Institute of Kalamata, Department of Crop Production, 24 100, Antikalamos, Kalamata, Greece
**Corresponding author e-mail: p_eliopoulos@hotmail.com*

Abstract: Laboratory studies were conducted on the effect of honey-feeding on progeny production and longevity of adults of *Venturia canescens* Gravenhorst (Hymenoptera: Ichneumonidae) parasitizing larvae of the Mediterranean flour moth *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae). Experimental adults lived under various temperature regimes with access to hosts. Provision of adult parasitoids with honey resulted in a significant increase in production of total offspring at all temperatures. Highest mean fertility of honey-fed wasps was recorded at 20°C, followed in decreasing order by 25, 30 and 15°C. At all temperatures honey-fed wasps lived significantly longer (almost three times) than their starved conspecifics. The experimental findings are analyzed with the objective of improving the effectiveness of *V. canescens* as a biological control agent of stored product pests.

Key-words: *Venturia canescens*, *Ephestia kuehniella*, adult feeding, longevity, progeny production, life tables, stored products, biological control, parasitoid

Introduction

Parasitoids have often been used against agricultural and horticultural pests during the last decades. However, their application for the control of stored product pests remains very limited. One of the main reasons for this phenomenon is not only that the level and reliability of control may be insufficient but also the very low economic injury level of stored products (Schöller et al., 1997). Therefore, optimization of biological control methods is essential for their practical implementation. One of the most common methods to improve parasitoid effectiveness in storage facilities is to provide them with suitable food supplements. Importance of adult feeding for parasitoids of stored products pests has been demonstrated in many recent studies (Wäckers, 1996; Wäckers et al., 1998; Schmale et al., 2001), where it was clearly shown that adult feeding causes significant increase of egg production, number of offspring and longevity. This is even more apparent in species which do not feed on the haemolymph of their hosts (host-feeding), like the moth parasitoid *Venturia canescens*.

Venturia canescens is a thelytokous, koinobiont, solitary endoparasitoid of lepidopterous larvae. Its host range includes many moth species, mainly pyralids, whose larvae are pests of stored products (Salt, 1976). Several laboratory and field studies have examined its potential against Pyralids (Ahmad, 1936; Corbet and Rotheram, 1965; Harvey and Thompson, 1995; Harvey et al., 1996; Harvey and Vet, 1997; Schöller, 2000a; 2000b; Heinlein et al., 2002). However, it should be mentioned that there is no commercial application of *V. canescens* as bioconrol agent to date.

This study deals with the effect of adult feeding on progeny production and longevity, at four different temperatures. The findings are analyzed on the basis of improving the efficiency of *V. canescens* as biocontrol agent against stored products pests.

Materials and methods

Host and Parasitoid cultures

Larvae of the Mediterranean flour moth *E. kuehniella* were used as hosts. The host species was reared in incubators at 25°C with a L:D 16:8h photocycle and 65±5% R.H. Culturing was undertaken using clear plastic boxes (17 x 11 x 5cm) containing 200-250g of semolina with 250-300 host eggs. This allowed host larvae to develop with excess food throughout larval life. The original population of the parasitoid *V. canescens* had been collected in flourmills near Athens, Attiki Co.

Venturia canescens was also reared in plastic boxes (as for *E. kuehniella*). Approximately, two hundred 4^{th}-5^{th} instar larvae from host culture were placed in each box together with 10 adult wasps. This procedure was repeated every 4 days. Boxes were left until adult wasps hatched. To segregate parasitoids for experiments, parasitized hosts were removed from the culture and placed individually in Petri dishes at 20°C.

Effect on number of progeny

Full grown moth larvae (5^{th} instar) were placed in groups of 100 into a large modified Petri dish (diameter 12cm). Air circulation was achieved through a hole (diameter 4cm) in the lid, covered with nylon mesh. The dishes were left undisturbed for 24h before being presented to parasitoids, in order to permit release of mandibular secretions (e.g. silk) which contain kairomones that elicit probing behavior by *V. canescens* (Corbet, 1971).

The following day, newly emerged adults were collected and placed individually in a dish and either were given no access to food or were provided with honey *ad libitum* smeared on the inside of the dish. Each parental wasp was transferred daily to another Petri dish identical with the previous one. Larvae in the previous dish were transferred at 25°C to large glass jars containing an excess of food medium to complete development and emerging adult parasitoids or moths were counted. The procedure was carried on until the parental wasp died.

To study the effect of honey-feeding on the number of progeny produced, the offspring of 10 honey-fed and 10 starved adults, were counted at four constant temperatures (15°, 20°, 25° and 30°C).

Effect on longevity

Adult longevity of cohorts of 35 honey-fed or starved individuals exposed to a range of constant temperatures (15°, 20°, 25° and 30°C) was measured. A constant supply of honey and hosts (50 mature L5 larvae of *E. kuehniella*) was achieved by transferring daily each experimental adult to a Petri dish identical with the initial one. Parasitoid longevity was determined by checking daily (or every 8 hours in the case of cohorts kept at 30°C).

Statistical analysis

Data were subjected to analysis of variance at $\alpha = 0.05$. Means were separated using the Tukey – Kramer HSD Test (Sokal and Rohlf, 1995) and all statistical analyses were performed using the statistical package JMP v.4.0.2 (SAS, 1989).

Results

Feeding on honey resulted in a remarkable increase in offspring at 15°C (75.8%), 20°C (352.9%), 25°C (258.8%) and 30°C (112.3%). The differences in number of progeny among fed and starved wasps were significant at all temperatures (Table 1) (15°C: F=18.71; df =1, 18; P=0.0004, 20°C: F=149.02; df =1, 18; P<0.0001, 25°C: F=167.64; df =1, 18; P<0.0001, 30°C: F=55.02; df =1, 18; P<0.0001).

Table 1. Mean number of progeny produced by female *V. canescens* at various constant temperatures, supplied daily with 100 full grown larvae of *E. kuehniella* (65 ± 5% R.H., 16:8 L:D)

Temperature (°C)	n	Honey-fed		Starved	
		mean ± S.E.[α]	range value	mean ± S.E.[α]	range value
15	10	35.7±3.62 aA	22-58	20.3±0.82 bA[F]	16-25
20	10	108.6±6.89 aB	78-136	24.0±0.73 bB	19-26
25	10	82.9±4.58 aC	67-108	23.1±0.54 bB	19-25
30	10	51.8±3.51 aD	36-71	24.4±1.14 bB	20-30

n : number of parental females.
[α] : means in a column followed by the same capital letter are not significantly different; means in a row followed by the same small letter are not significantly different (Tukey-Kramer HSD Test, α: 0.05)
[F] : differences proved to be significant but were minor and biologically meaningless

Honey-fed adults lived significantly longer than their starved counterparts at all experimental conditions (15°C: F=293.62; df =1, 68, 18; P<0.0001, 20°C: F=78.14; df =1, 68; P<0.0001, 25°C: F=134.61; df =1, 68; P<0.0001, 30°C: F=76.93; df =1, 68; P<0.0001). Food supply resulted in almost three times increase of longevity at all temperatures (Table 2).

Table 2. Longevity of honey-fed and starved adults of *V. canescens* in days (mean ± S.E.) lived at various constant temperatures (65 ± 5% R.H., photoperiod: 16L:8D).

Temperature (°C)	n	Honey-fed		Starved	
		mean ± S.E.[α]	range value	mean ± S.E.[α]	range value
15	35	42.80 ± 1.54a[F]A	21-55	14.00 ± 0.67bA	9-21
20	35	15.60 ± 1.10aB	5-30	5.26 ± 0.39bB	2-9
25	35	7.37 ± 0.38aC	5-13	2.19 ± 0.23bC	1-6
30	35	4.19 ± 0.31a[F]C	0.5-8	1.29 ± 0.11bC	0.3-2.3

n : number of experimental adults
[α] : means in a column followed by the same capital letter are not significantly different; means in a row followed by the same small letter are not significantly different (Tukey-Kramer HSD Test, α: 0.05)
[F] : differences proved to be significant but were minor and biologically meaningless

Discussion

Wasps with access to honey produced significantly more progeny than starved ones. Similar conclusions have been made not only for *V. canescens* (Harvey et al. 2001) but for many other synovigenic parasitoids (Wäckers, 1996; Wäckers et al., 1998; Schmale et al., 2001). Beling (1932) was the first to suspect the importance of adult feeding on *V. canescens* when she observed newly-emerged wasps leaving and then returning later on to the host habitat with nectar droplets in their mouthparts.

During the present study honey supply resulted in significantly increased longevity of *V. canescens* adults in all cases. Similar observations have been made in earlier studies (Beling, 1932; Ahmad, 1936; Matsumoto, 1974). Starved adults lived 3.5 days at 23°C while fed adults

lived as long as 40 days (Ahmad, 1936). Furthermore, Beling (1932), recorded significant effects of food type on longevity, with adults fed on sugar solution living up to 57 days and honey-fed wasps living up to 72 days.

Adult feeding (on sugar or hosts) can have strong effects on parasitoid fitness parameters such as longevity, lifetime fecundity, survival, searching efficiency, overall activity and other related parameters (Godfray, 1994; Jervis et al., 1996; Jervis and Kidd, 1999). This has been verified not only for *V. canescens* (Ahmad 1936; Harvey et al., 2001; Eliopoulos, 2003), but also for many other parasitoids of stored product pests, such as *Uscana lariophaga* Steffan (Trichogrammatidae)(van Huis et al., 1990), *Anisopteromalus calandrae* Howard (Wäckers, 1996; Wäckers et al., 1998; Schmale et al., 2001), *Dinarmus basalis* Rondani (Schmale et al., 2001) (Pteromalidae), *Heterospilus prosopidis* Viereck (Wäckers et al., 1998; Schmale et al., 2001) and *Habrobracon hebetor* Say (Braconidae) (Nickle and Hagstrum, 1981).

These conclusions, in combination with the fact that a lack of suitable food has been regarded as an important factor for poor performance of many biocontrol agents (Wolcott, 1942) may justify the use of food supplements in suitable release sites to augment the efficacy of released parasitoids and other natural enemies (Schöller et al., 1997; Schöller, 1998; Wäckers et al., 1998). However, not only laboratory but mainly field studies are needed to investigate methods for food supply. Such food supplements promise substantial improvement in biological control efficacy in storage ecosystems.

References

Ahmad, T. 1936: The influence of ecological factors on the Mediterranean flour moth, *Ephestia kühniella* and its parasite *Nemeritis canescens*. – J. Anim. Ecol. 5: 67-93.

Beling, I. 1932: Zur Biologie von *Nemeritis canescens* Grav. (Hymen. Ophion.). I. Züchtungserfahrungen und ökologische Beobachtungen. [On the biology of *N. canescens*. I. Breeding experiences and ecological observations.] – Z. angew. Ent. 19: 223-249.

Corbet, S.A. & Rotheram, S. 1965: The life history of the ichneumonid *Nemeritis* (*Devorgilla*) *canescens* (Gravenhorst) as a parasite of the Mediterranean flour moth, *Ephestia* (*Anagasta*) *kuehniella* Zeller, under laboratory conditions. – Proc. R. ent. Soc. Lond. (A) 40: 67-72.

Corbet, S.A. 1971: Mandibular gland secretion of larvae of the flour moth, *Anagasta kuehniella*, contains an epideictic pheromone and elicits oviposition movements in a hymenopteran parasite. – Nature 232: 481-484.

Eliopoulos, P.A. 2003: Study of the parasitoid *Venturia canescens* (Hymenoptera: Ichneumonidae) as a biocontrol agent against lepidopterous pests of stored products. – Ph.D. Thesis, Agricultural University of Athens: 181 pp. (In Greek, English abstr.)

Godfray, H.C.J. 1994: Parasitoids – Behavioral and Evolutionary Ecology. – Princeton Univ. Press, Princeton, NJ

Harvey, J.A. & Thompson, D.J. 1995: Developmental interactions between the solitary endoparasitoid *Venturia canescens* (Hymenoptera: Ichneumonidae), and two of its hosts, *Plodia interpunctella* and *Corcyra cephalonica* (Lepidoptera: Pyralidae). – Eur. J. Entomol. 92: 427-435.

Harvey, J. A. & Vet, L. E. M. 1997: *Venturia canescens* parasitizing *Galleria mellonella* and *Anagasta kuehniella*: differing suitability of two hosts with highly variable growth potential. – Ent. exp. and appl. 84: 93-100.

Harvey, J.A., Thompson, D.J. & Heyes, T.I. 1996: Reciprocal influences and costs of parasitism on the development of *Corcyra cephalonica* and its endoparasitoid *Venturia canescens*. – Ent. exp. and appl. 81: 39-45.

Harvey, J.A., Harvey, I.F. Thompson, D.J. 2001: Lifetime reproductive success in the solitary endoparasitoid, *Venturia canescens*. – J. Insect Behavior 14: 573-593.

Heinlein, G., Schöller, M., Prozell, S. & Reichmuth, C. 2002: Oviposition of *Venturia canescens* (Gravenhorst) (Hymenoptera: Ichneumonidae) parasitizing the Indian meal moth *Plodia interpunctella* (Hübner)(Lepidoptera: Pyralidae). – IOBC/WPRS Bull. 25(3): 109-114.

van Huis, A., Kaashoek, N.K. & Maes, H.M. 1990: Biological control of Bruchids (Col.: Bruchidae) in stored pulses by using egg parasitoids of the genus *Uscana* (Hym.: Trichogrammatidae): a review. – In: Fleurat-Lassard, F. & Ducom, P. (eds): Proceedings of 5th International Working Conference on Stored Product Protection, Bordeaux, France: 99-108.

Jervis, M.A. & Kidd, N.A.C. 1999: Parasitoid adult nutritional ecology: implications for biological control. – In: Hawkins, B.A. & H.V. Cornell (eds). Theoretical approaches to biological control, Cambridge University Press, Cambridge.

Jervis, J.A., Hawkins, B.A. & Kidd, N.A.C. 1996: The usefulness of destructive host feeding parasitoids in classical biological control: theory and observation conflict. – Ecol. Entomol. 21: 41-46.

Matsumoto, B.M. 1974: On the adult longevity of the entomophagous parasite, *Venturia canescens* (Hymenoptera: Ichneumonidae). – Entomophaga 19: 325-329.

Nickle, D.A. & Hagstrum, D.W. 1981: Provisioning with preparalyzed hosts to improve parasite effectiveness: A pest management strategy for stored commodities. – Environ. Entomology 10: 560-564.

Salt, G. 1976: The hosts of *Nemeritis canescens*, a problem in the host specificity of insect parasitoids. – Ecol. Entomol. 1: 63-67.

SAS Institute 1989: JMP, A guide to statistical and data analysis, v.4.02. – SAS Institute Inc., Cary, N.C.

Schmale, I., Wäckers, F.L., Cardona, C. & Dorn, S. 2001: Control potential of three hymenopteran parasitoid species against the bean weevil in stored beans: the effect of adult parasitoid nutrition on longevity and progeny production. – Biological Control 21: 134-139.

Schöller, M. 1998: Integration of biological and non-biological methods to control arthropods infesting stored products. – IOBC/wprs Bulletin 21(3): 13-26.

Schöller, M., 2000a: Biologische Bekämpfung der Speichermotte *Ephestia elutella* (Hübner) in gelagertem Getreide. – Agrarökologie 35, Bern.: 143 pp.

Schöller, M. 2000b: Forager in the rye: Biological control of *Ephestia elutella* in bulk grain. – IOBC/wprs Bulletin 23(10): 149-160.

Schöller, M., Prozell, S., Al-Kirshi, A.G. & Reichmuth, Ch. 1997: Towards biological control as a major component of integrated pest management in stored product protection. – J. stored Prod. Res. 33: 81-97.

Sokal, R.R. & Rohlf, F.J. 1995: Biometry (3rd ed.). – Freedman, New York, USA.

Wäckers, F. 1996: Can food provision increase the efficacy of biological control in storage systems? – Proc. 20th Int. Congress of Entomology, Florence, Italy, 25-31 August 1996: 551.

Wäckers, F.L., Schmale, K., Cardona, C.M. & Dorn, S. 1998: The effect of food supplements on the longevity of the bean weavil parasitoids *Anisopteromalus calandrae* and *Heterospilus prosopidis*. – IOBC/wprs Bulletin 21(3): 75-82.

Wolcott, G.N. 1942: The requirements of parasitoids for more than hosts. – Science 96: 317-318.