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SHORT COMMUNICATION

Influence of host plant and prey availability on developmental time and surviorship of *Nesidiocoris tenius* (Het.: Miridae)

ALBERTO URBANEJA[1,*], GERVASIO TAPIA[1,†], & PHILIP STANSLY[2]

[1]*Departamento de Investigación y Desarrollo. Koppert Biological Systems S.L., Finca Labradorcico del Medio, Aguilas, Murcia, Spain, and* [2]*University of Florida, IFAS, Immokalee, FL, USA*

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Abstract
Nesidiocoris tenuis is a zoophytophagous mirid with biological control potential. However, the relative importance of predation and herbivory for survival and development has not been clear. The bugs survived longer on tomato than on eggplant and especially sweet pepper, but could not complete development in the absence of supplemental food. Tomato also proved to be a more favorable substrate than pepper when eggs of *Ephestia kuehniella* were added as a food supplement. These results demonstrated that animal prey is a required dietary component for *N. tenuis,* and also that survival time on a strict plant diet is host plant dependent.

Keywords: Nesidiocoris tenuis*, Miridae,* Ephestia kuehniella*, sweet pepper, eggplant, tomato, zoophytophagy, biological control*

Mirids have been traditionally considered as phytophagous and include several agricultural pests. However, many are now known to be zoophytophagous and there is an increasing recognition of their importance as predators and their use in biological control (Albajes & Alomar 1999; Alomar 2002; Lucas & Alomar 2002). Examples include *Macrolophus caliginosus* (Wagner) and *Dicyphus hesperus* (Knight) that are generally available and widely used in protected crops in North America and Europe, respectively (Barnadas et al. 1998; Sánchez et al. 2003a). Other mirids have been

Correspondence: Phil Stansly, University of Florida/IFAS, 2686 State Road 29N, Immokalee, FL 34142, USA. Tel: 1 239 658 3427. Fax: 1 239 658 3469. E-mail: pstansly@ufl.edu
* Present address: Instituto Valenciano de Investigaciones Agrarias (IVIA). Dep. Protección Vegetal y Biotecnología. Apartado Oficial, 46113 Carretera de Moncada-Náquera, Km. 4.5 Moncada Valencia, Spain.
† Present address: Centro de Investigación y Formación Agraria 'La Mojonera-La Cañada, Junta de Andalucía, Autovía del Mediterráneo, Sal. 420, Apdo. de Correos 91, 04700 El Ejido, Almería, Spain.

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integrated into conservation biological control programs in horticultural crops in Europe and elsewhere, including *D. tamanii* Wagner, *Nesidiocoris tenuis* (Reuter) and *M. pygmaeus* Rambur (Castañé et al. 1996; Lucas & Alomar 2002; Perdikis & Lykouressis 2002; Calvo & Urbaneja 2003).

N. tenuis is perhaps the species in this latter group most often encountered in protected horticultural crops, especially tomato under biological control in South-eastern Spain and the Canary Islands (Goula 1985; Carnero et al. 2000; Van der Blom 2002; Sánchez et al. 2003b). *N. tenuis* can make significant contributions to the control of greenhouse pests such as whiteflies, leafminers, lepidopterans and spider mites (Arzone et al. 1990; Marcos & Rejesus 1992; Solsoloy et al. 1994; Torreno 1994; Vacante & Garzia 1994; Trottin-Caudal & Millot 1997; Jorda et al. 1998 Carnero et al. 2000; Vacante & Benuzzi 2002; Calvo & Urbaneja 2003). However, by feeding on tomato it can also cause fruit blemishes and flower abortion (Malausa & Ehanno 1988; CABI 1993; Vacante & Garzia 1994; Calvo & Urbaneja 2003), although injury to other crops has not been reported.

Information on the relative importance of predation and herbivory could be of use in maximizing benefits and minimizing plant injury. Vacante & Garzia (1994) showed pest suppression by *N. tenuis* was of greater benefit than the damage caused to tomatoes. The biological control potential of this species has stimulated experimental releases to control the whitefly *Bemisia tabaci* Genn. (Hom.: Aleyrodidae) on tomato and eggplant with positive results (J. Calvo, Koppert Biological Systems S.L., personal communication). However, there is little information available on the role of plant feeding versus predation in the biology of this insect. Here we report on experiments to evaluate development and survivorship of *N. tenuis* on three vegetable plant hosts, with and with out prey.

Tomato, *Lycopersicum esculentum* Mill. var. Saskia, sweet pepper *Capsicum annuum* L. var. Spiro and eggplant *Solanum melongena* L. var. bandera (Seminis Vegetable Seeds Ibérica S.A., Almeria, Spain) were seeded simultaneously in tray cells and later transplanted into individual 1-L pots to obtain homogenous and pesticide-free plants. The pots were placed in 2×4-m screened cages (20×10 threads/cm) within an air-conditioned greenhouse located at the Koppert Biological Sciences facility in Águilas (Murcia, Spain). Plants were used when the fourth node leaves were fully expanded.

N. tenuis used in the studies came from colonies originally collected from multiple locations in the province of Murcia and maintained at the same Koppert B.S. facilities. Adults ($n = 25$) of *N. tenuis* were introduced with three plants of each host species into separate 50×50-cm wood frame screened cages for 2 days. Five days after removal of adults, aerial parts of the plants were checked for oviposition scars and cut into small sections each containing one egg of *N. tenuis.* Plant parts were placed individually in Petri dishes (5.2 cm diameter) on a fine layer (2 mm) of agar (2%, w/v) and examined daily until nymphs appeared. First nymphal instars were then placed individually into covered clear plastic cages (3.5 cm diameter at the bottom, 4.9 cm at the top, and 2.7 cm high) and held in a large growth chamber ($25 \pm 1^{\circ}$C, 75 ± 5%, 16:8 L:D photoperiod). A section of stem and leaf of each host plant and water in an Eppendorf tube fitted with a cotton wick was provided. Eggs of *Ephestia kuehniella Zeller* (Lep.: Pyralidae) were added in the 'with prey' treatments and both leaves and prey renewed daily. At least 40 nymphs were used for each plant-prey combination. Nymphs were examined daily until death or final molt to adult. Nymphal development times (days, nymphal instar survivorship (%) and sex ratio were calculated.

Data on total nymphal development times was subjected to two-way analysis of variance to evaluate the effect of factors sex and crop, using Tukey's test for mean separation in the event of a significant F ($P < 0.05$) (SPSS 1999). Nymphal development times between plants were compared with a one-way analysis of variance. Sex ratio of adults was compared to a null hypothesis of 1:1 using a Chi-square test.

None of the nymphs tested was able to complete development on the plant without supplemental food (Table I). However, tomato proved to be the most suitable plant food, allowing up to one-third of the nymphs to survive through to third instar. Eggplant was intermediate, with one-third surviving through the second instar but none further. Sweet pepper was the least suitable plant host, allowing only 10% to survive through the first instar.

N. tenuis was able to complete development on all three host plants when supplemented with *E. kuehniella* eggs with degrees of success that were consistent with the above results (Table I). Lowest survivorship was observed on pepper (64.3%) compared to 73.7 and 72.7% on eggplant and tomato, respectively. Nymphal developmental time was longer on sweet pepper (14.2 $\pm$ 0.2 days) than either eggplant (12.5 $\pm$ 0.3 days) or tomato (12.8 $\pm$ 0.2 days) ($F = 12.446$; df = 2, 126; $P < 0.001$, Table II). No differences among sexes ($F = 0.003$; df = 1, 126; $P = 0.964$) nor interactions between sex and crop factors were observed ($F = 0.387$; df = 1, 126; $P = 0.814$).

Sex ratio (♀:♂) was 1:1.29 and 1:1.5 and different from 1:1 on supplemented eggplant ($\chi^2 = 0.28$; $n = 32$) and tomato ($\chi^2 = 2.41$; $n = 70$), respectively. In contrast sex ratio was 1:1 on sweet pepper ($\chi^2 = 0{,}033$; $n = 30$).

Our results demonstrated the inability of *N. tenuis* to complete development to adulthood on a strictly phytophagous diet. In contrast, *Macrolophus pygmaeus* Rambur was able to develop on tomato, eggplants, cucumber, sweet pepper and green beans without supplemental prey prey and with survivorship of about 50% (Perdikis & Lykouressis 2002). Survivorship increased to more than 80% with the addition of prey. *Dicyphus tamaninii* nymphs completed development on green and ripe tomato fruits, but not on tomato leaves (Lucas & Alomar 2002). Thus, *N. tenuis* appeared to be less phytophagus on the tested plants than other cited mirid predators, based on their ability to develop in the absence of insect prey.

Table I. Survivorship (%) of first (n) and subsequent nymphal instars of *N. tenuis* in sweet pepper, eggplant and tomato at 25°C and 16:8 L:D photoperiod with and without the addition of *E. kuehniella* eggs.

	Sweet Pepper		Eggplant		Tomato	
	Without *E. kuehniella* ($n = 46$)	With *E. kuehniella* ($n = 42$)	Without *E. kuehniella* ($n = 45$)	With *E. kuehniella* ($n = 48$)	Without *E. kuehniella* ($n = 60$)	With *E. kuehniella* ($n = 95$)
N_1	10.9	92.9	37.5	90.9	78.3	91.6
N_2	0.0	89.7	33.3	90.0	38.3	83.9
N_3	–	85.7	0.0	94.4	33.3	98.6
N_4	–	100.0	–	94.1	0.0	98.6
N_5	–	90.0	–	100.0	–	98.6
Total	0.0	64.3	0.0	72.7	0.0	73.7

Table II. Development time of male and female nymphal instars of *N. tenuis*, (days; mean ± SE), in sweet pepper, eggplant and tomato at 25°C and 16:8 L:D photoperiod with and without addition of *E. kuehniella* eggs.

	Sweet Pepper			Eggplant			Tomato		
	With *E. kuehniella*		Without *E. kuehniella*	With *E. kuehniella*		Without *E. kuehniella*	With *E. kuehniella*		Without *E. kuehniella*
	Male ($n = 15$)	Female ($n = 15$)	($n = 14$)	Male ($n = 18$)	Female ($n = 42$)	($n = 28$)	Male	Female	
N_1	2.1 ± 0.2a	2.2 ± 0.1a	2.7 ± 0.2	2.3 ± 0.3a	2.4 ± 0.3a	4.5 ± 0.1	2.6 ± 0.1a	2.6 ± 0.1a	4.1 ± 0.2
N_2	5.4 ± 0.4a	5.2 ± 0.2a	–	3.9 ± 0.1a	309 ± 0.1a	2.5 ± 0.1	4.5 ± 0.2a	4.6 ± 0.3a	4.9 ± 0.5
N_3	2.9 ± 0.3a	2.9 ± 0.1a	–	3.8 ± 0.3a	3.5 ± 0.2a	–	2.5 ± 0.2a	2.5 ± 0.2a	5.6 ± 0.9
N_4	3.5 ± 0.4a	3.1 ± 0.1a	–	2.5 ± 0.2a	2.3 ± 0.2a	–	2.5 ± 0.1a	2.5 ± 0.1a	–
N_5	1.8 ± 0.1a	1.8 ± 0.1a	–	2.5 ± 0.1a	2.3 ± 0.3a	–	2.5 ± 0.1a	2.8 ± 0.3a	–
Total	14.0 ± 0.2a	14.3 ± 0.2a	–	12.6 ± 0.3a	12.4 ± 0.4a	–	12.8 ± 0.2a	12.7 ± 0.3a	–

Means followed by the same letter between columns and for the same crop are not statistically different (Anova, $P < 0.05$).

Undoubtedly, the availability of prey would be necessary for successful establishment of *N. tenuis* in any of the three crops tested. Nevertheless, our results showed that absence of prey could be tolerated longer on tomato than on pepper and even eggplant. However, with this added flexibility in tomato comes the added risk of plant injury, requiring careful monitoring of the crop when *N. tenuis* is present. Damage in tomato has been reported when numbers of *N. tenuis* are high relative to their prey (Trottin-Caudal & Millot 1997; Calvo & Urbaneja 2003), although economic thresholds are usually not reached (Vacante & Garzia 1994). Some tomato growers have reportedly learned to reduce populations of *N. tenuis* below damaging levels by applying the insect growth regulator lufenuron in bands (Antonio Monserrat, CIDA, Murcia, Spain, personal communication). Plant injury should not be an issue in crops such as eggplant and sweet pepper in which no damage has been reported.

We also showed that survivorship of *N. tenuis* could be increased with the addition of eggs of *E. kuehniella* as a food supplement. The presence of *E. kuehniella* eggs might also reduce damage to tomato by *N. tenuis,* although this was not the case in a study of the zoophytophagous mirid *Dicyphus tamaninii* (Lucas & Alomar 2002). In any case, it should be possible to colonize or allow colonization with *N. tenuis* early in the crop before damage is likely to occur and before pests become established, thus preventing buildup of large and difficult to control pest populations. Further research will determine whether *N. tenuis* can be used as an augmentative biological control agent to supplement its present role in conservation biological control and IPM in horticultural crops of southeastern Spain.

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References

Albajes R, Alomar O. 1999. Current and potential use of polyphagous predators. In: Albajes R, Lodovica-Gullino M, Van Lenteren JC, Elad Y, editors. Integrated pest and disease management in greenhouse crops. Dordrech: Kluwer. pp 265–275.

Alomar O. 2002. Facultative predation as a biological control. In: Pimentel D, editor. Encylopedia of Pest Management. New York: Marcel Dekker, Inc. pp 1–3.

Arzone A, Alma A, Tavella L. 1990. Roulo dei Miridi (Rhynchota Heteroptera) in the control of *Trialeurodes vaporariorum* Westw. (Rhynchota Aleyrodidae). Boll Zool Agraria Bachicoltura 22:43–51.

Barnadas I, Gabarra R, Albajes R. 1998. Prospects for biological control of *Bemisia tabaci* with two predatory mirid bugs. Entomol Exp Appl 86:215–219.

CABI. 1993. Distribution map of pests nos. 61, (1st revision), 278 (2nd revision), 279, 290, 466, 476 (all 1st revision), 535, 536 and 537. pp 2–4.

Calvo J, Urbaneja A. 2003. *Nesidiocoris tenuis* Reu. (Het.: Miridae) en tomate: ¿Amigo o Enemigo? Almería Verde 4:21–23.

Carñéro A, Díaz S, Amador S, Hernández M, Hernández E. 2000. Impact of *Nesidiocoris tenuis* (Heteroptera, Miridae) on whitefly populations in protected tomato crops. Bulletin OILB WPRS SROP 23(1):259.

Castane C, Alomar O, Riudavets J. 1996. Management of western flower thrips on cucumber with *Dicyphus tamaninii* (Heteroptera: Miridae). Biol Control 7:114–120.

Goula M. 1985. *Cyrtopeltis* (*Nesidiocoris*) *tenuis* Reuter (Heteroptera: Miridae), nueva cita para la Peninsula Ibérica. Bol Soc Port Ent (supl 1) III:93–102.

Jordá C, Arias M, Tello J, Lacasa A, Del Moral J. 1998. La sanidad del cultivo del tomate. Valencia. Espana Phytoma.

Goula M. 1994. Notas miridológicas, 3. Bol Asoc Esp Ent 17(2):357.

Lucas E, Alomar O. 2002. Impact of *Macrolophus caliginosus* presence on damage production by *Dicyphus tamaninii* (Heteroptera: Miridae) on tomato fruits. J Econ Entomol 95:1123–1129.

Malausa JC, Ehanno B. 1988. First observations in France of *Cyrtopeltis* (*Nesidiocoris*) *tenuis* Reuter, 1895 (Het. Miridae). Nouv Rev Entomol 5:180.

Marcos TF, Rejesus RS. 1992. Population dynamics of *Helicoverpa* spp. in tobacco growing areas of Llocos Norte and La Union. Philippine Entomol 8:1227–1246.

Perdikis D, Lykouressis P. 2002. Thermal requirement for development of the polyphagous predator *Macrolophus pigmaeus* (Hemiptera: Miridae). Environ Entomol 31:661–667.

Sánchez JA, Gillespie DR, McGregor RR. (2003a). The effects of mullein plants (*Verbascum thapsus)* on the population dynamics of *Dicyphus Hesperus* (Heteroptera: Miridae) in tomoto greenhouses. Biol Control In press.

Sánchez JA, Martínez JI, Lacasa A. 2003b. Distribution and abundance of mirids in horticultural crops in the region of Murcia (Spain). In: 3rd International *Bemisia* Workshop. Barcelona 17–20 March, 2003. Barcelona, Spain.

Solsoloy AD, Domingo EO, Bilgera BU, Solsoloy TS, Bugawan HS, Barluado ZD. 1994. Occurrence, mortality factors and within-plant distribution of bollworm, *Helicoverpa armigera* (Hübn.) on cotton. Philippine Sci 123:9–20.

SPSS. 1999. SPSS Manual del usuario, versión 10.0 para Windows 98. SPSS, Chicago, IL.

Torreno H. 1994. Predation behavior and efficiency of the bug *Cyrtopeltis tenuis* (Hemiptera: Miridae), against the cutworm, *Spodoptera litura* (F.). Philippine Entomol 9:426–434.

Trottin-Caudal Y, Millot P. 1997. Etude de deux mirides en culture de tomate: *Macrolophus caliginosus* Wagner et *Nesidiocoris* (*Cyrtopeltis*) *tenuis* Reuter. Infos Paris 131:40–44.

Vacante V, Garzia GT. 1994. Indagini sul ruolo ecologico di *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae) nelle serre fredde di pomodoro del Ragusano. Informatore Fitopatol 44:45–48.

Vacante V, Benuzzi M. 2002. Pomodoro, la difesa biologica e integrata. Colture Protette 31:27–33.

Van Der Blom J. 2002. La introducción artificial de la fauna auxiliar en cultivos agricolas. Bol San Veg Plagas 28:109–120.