EFFECT OF VARIABLE PHOTOPERIOD ON DEVELOPMENT AND SURVIVAL OF *CIRROSPILUS* SP. NR. *LYNCUS* (HYMENOPTERA: EULOPHIDAE), AN ECTOPARASITOID OF *PHYLLOCNISTIS CITRELLA* (LEPIDOPTERA: GRACILLARIIDAE)

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The eulophids *Cirrospilus* sp. near *lyncus* and *Pnigalio pectinicornis* L. are the most abundant parasitoids of the citrus leafminer, *Phyllocnistis citrella* Stainton, in Spain (Urbaneja et al. 2000). These were opportunistically recruited onto this pest after its introduction in 1993. *C.* sp. near *lyncus* is a late larval solitary idiobiont ectoparasitoid which can also behave as a hyperparasitoid. Its impact on *P. citrella* relies on both parasitism and host feeding (Urbaneja et al. 1998a). *C.* sp. near *lyncus* populations in citrus orchards increase from mid-July until the end of October, but remain almost undetectable during the rest of the year (Urbaneja et al. 1999). A previous study demonstrated that *C.* sp. near *lyncus* was very well adapted to temperatures prevailing on the western part of the Mediterranean Basin. That is the range between 7.1°C, mean of minimum temperatures of the coldest month (January), and 29.0°C, mean of maximum temperatures of the hottest one (August) (Urbaneja et al. 1999). To further study the influence of environmental conditions on the biology of this wasp, the effects of photoperiod on development and survival were investigated.

Environmental chambers were used to check the effects of three different photoperiods: 16:8, 12:12 and 8:16 (L:D). Temperature fluctuated from 10°C to 30°C in eight 3h-steps of 5°C (mean temperature 20°C). Highest temperature always coincided with the mid-point of the photophase. This sequence mimics the regime of field temperatures both in spring and autumn. Therefore results obtained under both 16:8 and 8:16 (L:D) photoperiods are presumed to reflect field conditions at those seasons. Insects were reared at the Institut Valencià d'Investigacions Agràries as described by Urbaneja et al. (1998b). Eggs of *C.* sp. near *lyncus* were obtained by offering detached citrus leaves containing *P. citrella* third instar larvae (LIII) to isolated mated females (12 LIII per female). Exposure took place in Petri dishes (140 mm diameter) where leaves were placed on a layer of agar (2% weight) under a temperature of 25 ± 1°C during 4 hours. After exposure, leaves were checked under a stereoscopic binocular microscope and those containing parasitized hosts (recognized by the presence of *C.* sp. near *lyncus* eggs on them) were randomly transferred to the corresponding experimental photoperiod on a layer of

TABLE 1. MEAN DEVELOPMENT TIMES (DAYS) OF MALE AND FEMALE *C.* SP. NEAR *LYNCUS* UNDER THREE DIFFERENT PHOTOPERIODS (MEAN ± SE).

		16:8 (L:D)	12:12 (L:D)	8:16 (L:D)
Male	Egg	2.16 ± 0.18	2.28 ± 0.22	2.26 ± 0.15
	Larva	5.39 ± 0.32	5.72 ± 0.28	5.74 ± 0.21
	Pupa	8.84 ± 0.31	8.47 ± 0.41	8.50 ± 0.24
	Total	16.39 ± 0.33 (n = 14)	16.47 ± 0.24 (n = 16)	16.50 ± 0.19 (n = 17)
Female	Egg	2.25 ± 0.22	2.11 ± 0.12	2.67 ± 0.25
	Larva	5.71 ± 0.38	6.07 ± 0.22	5.88 ± 0.30
	Pupa	9.14 ± 0.28	9.09 ± 0.25	9.29 ± 0.35
	Total	17.11 ± 0.39 (n = 19)	17.27 ± 0.36 (n = 22)	17.83 ± 0.28 (n = 12)

TABLE 2. STAGE SPECIFIC SURVIVAL (%) OF *C.* SP. NEAR *LYNCUS* UNDER THREE DIFFERENT PHOTOPERIODS. INITIAL NUMBER OF REPLICATES WAS 60, BUT CALCULATIONS ARE BASED ON THE NUMBER OF NON-DECAYING LEAVES (=REPLICATES) AT THE END OF EACH PERIOD.

Photoperiod	Egg-larva	Larva-pupa	Pupa-adult	Total
16:8 (L:D)	93.3	85.7	91.7	73.3
12:12 (L:D)	93.0	97.5	97.4	88.4
8:16 (L:D)	92.5	89.2	87.9	72.5

agar (2% weight) in a Petri dish (55 mm diameter). Sixty replicates (= leaves) were used for each photoperiod. Leaves decaying during the study period were excluded from the analyses. Parasitoid development was checked daily until adult emergence. Development times and stage-specific mortality were recorded and eventually emerging adults were sexed. These results were subjected to a two-way analysis of variance (STSC 1987).

Development times for the three experimental photoperiods are presented in Table 1. There were no differences among photoperiods (F = 2.951; df = 2, 98; P = 0.0572). Although there were differences between sexes (F = 48.059; df = 1, 98; P < 0.0001), no interaction between sex and photoperiod factors occurred (F = 1.820; df = 2, 98; P = 0.1677). Furthermore, there was good agreement between development times obtained in the present study and that reported previously (Urbaneja et al. 1999) under a constant temperature of 20°C and a photoperiod of 16:8 (L:D): 17.20 ± 0.30 d. Survival of the different stages are shown in Table 2. Larvae were the most sensitive stage, whereas both eggs and pupae were more resistant. Similar results had already been found under different constant temperatures (Urbaneja et al. 1999). However, no effect of photoperiod on survival was found. Agreement between results obtained in this study and those obtained under a constant temperature regime (Urbaneja et al. 1999) indicates usefulness of the latter for prediction of field performance based on a thermal constant.

Photoperiod is one of the signals insects use to perceive environmental changes and adjust their life cycle accordingly (Tauber et al. 1986). Abrams et al. (1996) indicated shorter development times should be expected in insects developing late in the season relative to either an upcoming winter or an approaching optimal date for adult emergence. Although *C.* sp. near *lyncus* is presumed to be native to a temperate area, such as the Mediterranean Basin (Schauff et al. 1998), where photoperiod changes considerably along the year, no effects of this factor alone could be detected. However, influence of the combined effect of photoperiod and with temperature cannot be excluded. Based on these results and on those previously presented by Urbaneja et al. (1999), *C.* sp. near *lyncus* should be able to breed continuously under typical Mediterranean conditions. The absence of this wasp in citrus orchards from autumn until early summer may be related to the extraordinary scarcity of *P. citrella* during winter months. We hypothesize that *C.* sp. near *lyncus* is forced to abandon citrus orchards and does not return until *P. citrella* populations have already peaked up. For this reason, conservation tactics aimed at favoring the permanence of *C.* sp. near *lyncus* could increase the impact of parasitism early in the season. *C.* sp. near *lyncus* was first noticed in Spain as a parasitoid of *P. citrella*, and its original host range remains unknown. Therefore, as a first step to implement conservation strategies, its host range should be determined.

SUMMARY

No differences could be observed neither in development times nor on survival of *C.* sp. near *lyncus* exposed to three different photoperiods: 16:8; 12:12 and 8:16 (L:D).Therefore, conservation tactics aimed at favoring the winter permanence of this species in citrus orchards could increase the impact of this opportunistic parasitoid on its host *P. citrella*.

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