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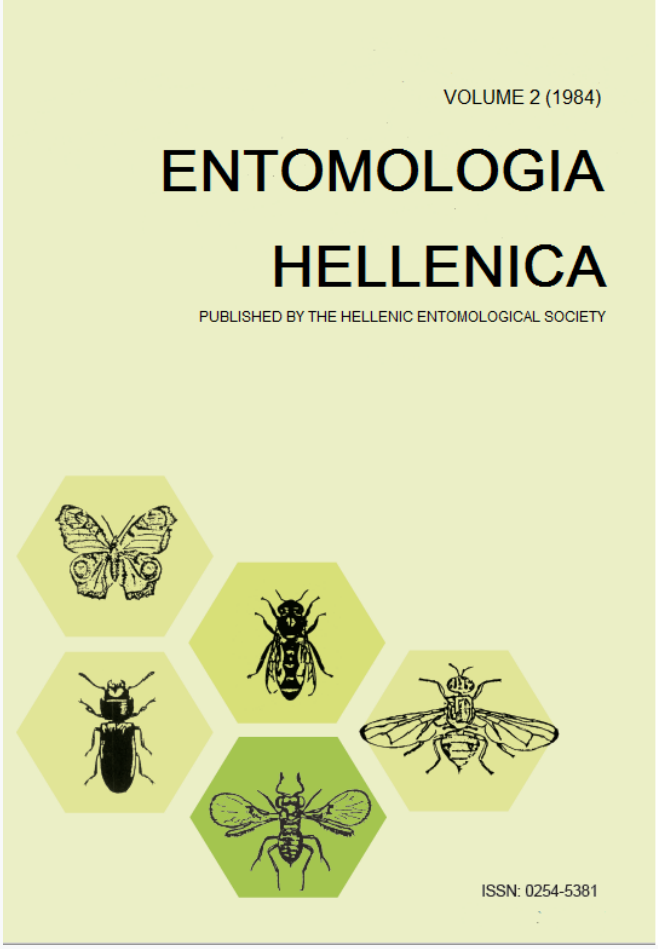

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Notes on Life History and Field Efficiency of *Cybocephalus fodori* Predator of *Quadraspidiotus perniciosus* in Northern Greece[1]

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ABSTRACT

Sampling results during 1978-1979 and 1981-1982 in two heavily-infested almond orchards in Northern Greece, showed a high mortality of the San José scale. A considerable part of this mortality was attributable to indigenous entomophagous insects, especially predators. Among them, *Cybocephalus fodori* Endrödy-Younga (Coleoptera: Nitidulidae) appeared to be the key species. Field observations showed that *C. fodori* hibernates as an adult, forming aggregations. *C. fodori* reared in outdoor cages showed full adult activity by end March. Given an abundant supply of prey, the insect develops two complete and a third partial generations per year. Under constant conditions (25±2° C, 65±5% R.H. and 16 hrs light per day), the development of its three larval instars was completed in about 19 days and the pupal stage lasted about 10 days. On average, 68 *Quadraspidiotus perniciosus* Comstock (Homoptera: Diaspididae) adult females were partly consumed per larva of *C. fodori*. Individually deposited eggs and young larvae were found under the covers of the San José scales.

Introduction

The genus *Cybocephalus* Erichson (Coleoptera: Nitidulidae), which includes some predator species, is widespread throughout the world in tropical and subtropical regions. In both Israel and Egypt nine species were recorded (Blumberg 1973, Alfieri 1976) and in oases in Tunisia, Algeria and Morocco seven species. Fewer species are recorded in northern temperate zones such as in Europe (four species), in California (two species), and in southern zones such as South Africa (two species) and Brazil (two species) (Kartman 1946, Grouvelle in Junk 1913). The majority of *Cybocephalus* species are predators on scale insects of the family Diaspididae, such as *Aonidiella aurantii* Maskell in California (Flanders 1934) and *Parlatoria blanchardi* Targioni-Tozzetti, in Morocco (Balachowsky 1926, Smirnoff 1954).

Populations of *Cybocephalus fodori* Endrödi-Younga were observed for the first time on almond trees infested with the San José scale *Quadraspidiotus perniciosus* Comstock, during biological control experiments conducted in 1978-1979 and 1980-1981 in Northern Greece. The *C. fodori* populations were relatively large and their presence was continuous as long as *Q. perniciosus* existed on the trees. Since this species could be an important biological control agent against San José scale, I decided to study its larval development and voracity, behavior, and phenology and to make an estimate of its contribution to the overall effectiveness of natural enemies against *Q. perniciosus*.

Materials and Methods

The insects were reared in the insectary and in out-

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door cages on squashes infested with *Q. perniciosus*, or observed and sampled in the field. Twenty five newly-emerged larvae were reared individually in 7 cm^3 vials, containing as food mature *Q. perniciosus* females which had not oviposited, under 25±2° C, 65±5% R.H. and 16 hrs photoperiod. To provide a sufficient food supply and to check voracity, the larvae were transferred every second day to a new vial containing 15 to 20 *Q. perniciosus* females collected from the squashes after their covers had been removed and their bodies detached from the surface of the squashes. Each time, the remaining scales in each used vial were counted to check voracity.

To study the phenology of *C. fodori*, insects were reared in cages placed outside the Benaki Laboratory, on squashes infested with *Q. perniciosus*. Successive generations were separated from each other by moving squashes bearing the offspring larval population of *C. fodori* to new cages. In addition, results from samplings on *C. fodori* population conducted in the field were taken into account.

The efficiency of *C. fodori* as a control agent against *Q. perniciosus* was estimated in two almond orchards highly infested with San José scale, in the localities "Patrida" (1978-1979) and "Trilophos" (1980-1981) in the region of Veria (Northern Greece). The "Patrida" orchard consisted of 200, 5-8 year old trees of the Texas, Retsou and Truito varieties. The "Trilophos" orchard had 65, 15-20 year old trees of the same varieties. During the experiments, and for about six months beforehand, no chemical treatments were applied. Samplings of the *Q. perniciosus* populations were made by cutting twigs 0.8-1.2 cm thick, 20-30 cm long, and up to one year old. One randomly chosen twig was cut from every other tree. Following laboratory examination, the number of scales, rates of parasitism, predation, and mortality from unknown causes were recorded. Samplings of predator populations were carried out: a) by means of adult captures on 5 Rebell® yellow colour sticky traps suspended in the "Patrida" orchard, and 4 in the "Trilophos" orchard, which were replaced every second week, and b) by periodical visual inspection of the trunks and main branches of 30 marked trees in the "Patrida" orchard and 9 marked trees in the "Trilophos" orchard.

Results and Discussion

a. Notes on biology and behavior

The eggs of *C. fodori* are oblong 0.4 × 0.2 mm, and pale white, with purple cross stripes. The eggs are deposited in the space under the scale and above the adult female host's body, the long axis of the egg almost parallel to the dorsal surface of the body. One egg is laid per scale. *C. fodori* eggs have not been found under empty scales of dead *Q. perniciosus*.

Larval exuviae are semitransparent of a shiny white colour. During molt, the old cuticle is split lengthwise from the head capsule along the mid-dorsal line. The anal end of the exuviae is of a light reddish colour; it remains attached to the substrate. Three larval instars and a pupal stage have been distinguished during preimaginal development of *C. fodori* according the number of ecdyses observed. As Table 1 shows, in the laboratory larval development was completed in 19.2 days and the pupal stage in 9.9 days. The second instar is the shortest in duration and the third instar, which includes a prepupal period of about 4 days, is the longest. The first instar larva of *C. fodori* consumes about 4 young female adults of *Q. perniciosus* per day; the second instar consumes about 5, and the third about 6. On an average, each *C. fodori* individual, during its total larval development, consumes 68.4 individuals of *Q. perniciosus*.

TABLE 1. Duration of development and voracity of the preimaginal instars of *C. fodori* under constant conditions (25±2 °C, 65±5% RH, 16 hrs light/day), n = 25.

	Duration in days		No. of partly consumed *Q. perniciosus*	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Larva 1st	5.20	0.8	21.0	2.6
Larva 2nd	3.8	1.3	20.1	4.3
Larva 3rd	10.2	1.5	37.6	7.1
Pupa	9.9	0.9		
Complete development	26.9	1.6	68.4	12.4

A kind of thigmotactism is noticed in the larvae of all instars. Thus, the populations of young larvae living under the scales are not visible. More advanced larvae, with a body size larger than the size of the host body are often found with their anterior segments under the covers of the scales and the rest of their bodies extending outside. Developed larvae can also be found resting under empty scales of dead *Q. perniciosus*.

C. fodori larvae reared in the laboratory pu-

pated at the bottom of the vials. No pupae of *C. fodori* were found on host plants in the field or on the squash in the rearing cages. It is likely that, in the field, pupation occurs in the soil as has been reported for other cybocephalid species (Flanders 1934, Kartman 1946, Smirnoff 1954). In the rearing cages, pupation occurs in cavities under the squash or under the filter paper at the bottom of the cage. In the field as well as in the rearing cages adults, when approached, immobilize and suddenly fall down as a defense mechanism.

b. Phenology

In cages outside the laboratory during 1982-1983 *C. fodori* completed 2 generations and a partial third one during the year. These generations overlap, since many adults live for as long as 10 months (Fig. 1). The insects hibernate as adults. From the end of October until February, aggregations of various sizes (usually from 5 up to about 25 individuals) were observed in protected sites such as openings in the bark on the trunk of the trees in the field, or on the muslin, or cavities of the squash in the rearing cages. The movement of *C. fodori* adults on the host-bearing plant surface was very limited during this period. Also, mating, oviposition and larvae were not observed. Therefore, the existence of a diapause which has already been found on other cybocephalid species (Blumberg 1976), or of a quiesence is possible. Ovipositions begin by the end of March. First generation adults of *C. fodori* emerged from early June to mid-July, second generation adults from early August onwards, and third generation ones from early October onwards.

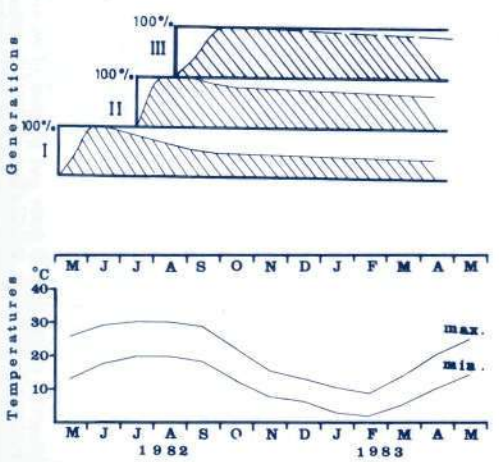

FIG. 1. Three generations of *C. fodori* adults reared in cages outside the Benaki Laboratory.

c. Field efficiency of *C. fodori* as a control agent against *Q. perniciosus*

In both localities "Patrida" and "Trilophos", a heavy *Q. perniciosus* infestation was controlled by *C. fodori, Chilocorus bipustutatus* and *Prospaltella perniciosi* within one year (Katsoyannos and Argyriou 1983). In both cases, predation was the most important control factor. In "Patrida", the rate of predation increased from 32% in mid July to 56% in mid August; during the same period, the rate of parasitism did not exceed 4.5%. In "Trilophos", the rate of predation increased from 19% in early August to 48% in early October compared with a maximum rate of parasitism of 14%. In both orchards, among the predators, *C. fodori* populations were the most important. Also, a correlation between the population size of *C. fodori* and the recorded rate of predation on *Q. perniciosus* was noticed (Fig. 2, Fig. 3). Therefore, it is suggested that a high proportion of the observed predation might be due to the action of *C. fodori*. The results of the laboratory experiments concerning its voracity combined with the field observations support this conclusion.

In all the samplings from both orchards, no parasitism on larvae or adults of *C. fodori* was found. This is a considerable advantage when it is compared with the other important predator *C. bipustulatus*, on which an important rate of parasitism occurs during its second and third generations (Katsoyannos in press). The mode of living of *C. fodori* larvae under the covers of the scales, provides some protection against chemical sprays for a considerable portion of the population, as has already been observed on other *Cybocephalus* species (Kehat et al. 1974). These two characteristics, in addition to its relatively high efficiency against *Q. perniciosus*, suggest that *C. fodori* is a good biological control agent, particularly suitable for use in Integrated Control programs in fruit orchards in Northern Greece.

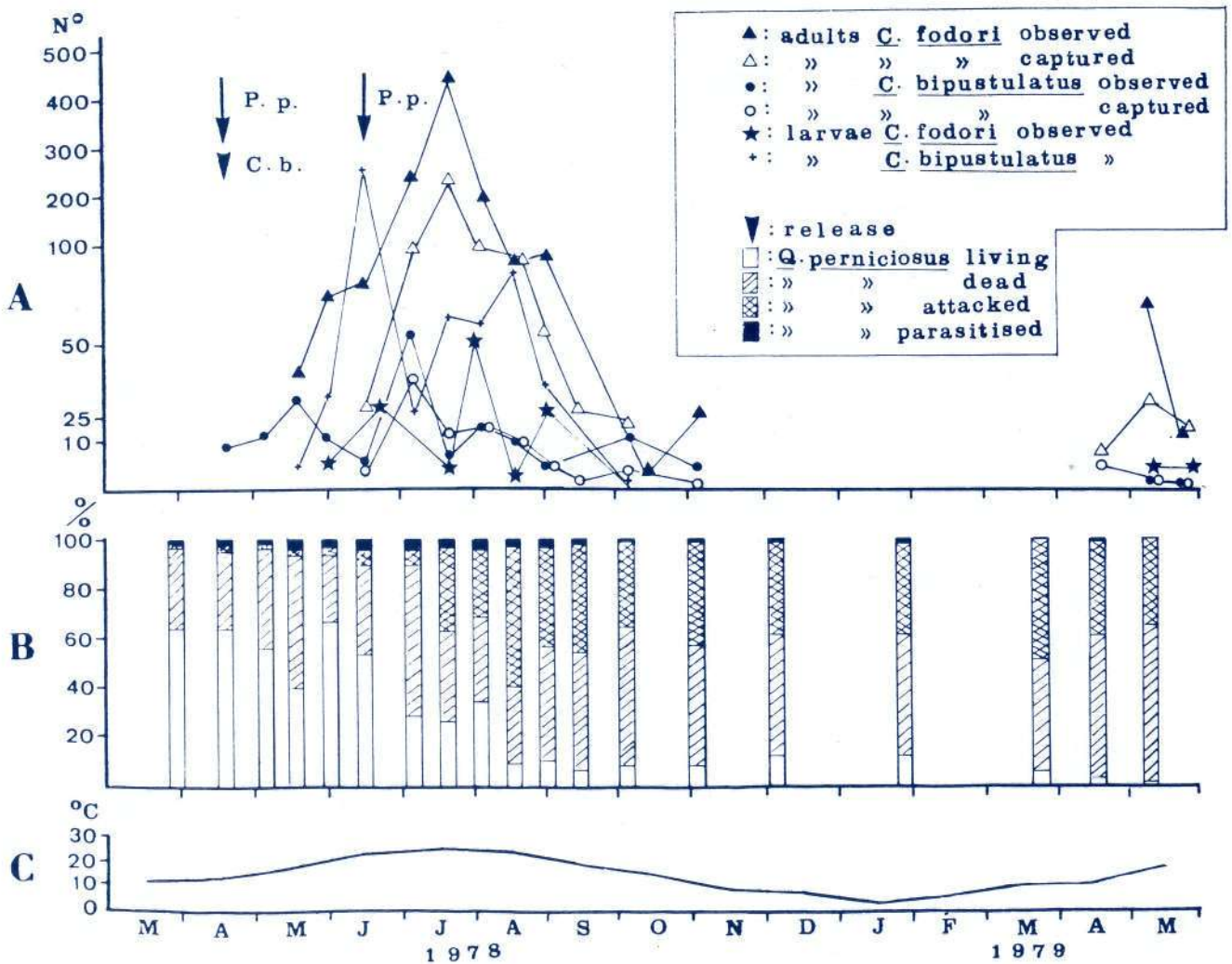

FIG. 2. A = Number of predators observed on 30 marked trees and number of parasites captured on 5 yellow sticky traps on almond trees at Patrida-Veria during 1978-79; B = Percentage of living, dead, attacked and parasitized *Q. perniciosus* on almond trees at Patrida-Veria during 1978-79; C = Average mean temperatures at Patrida-Veria during 1978-79; P.p. and C.b. = *P. perniciosi* release and *C. bipustulatus* release, respectively.

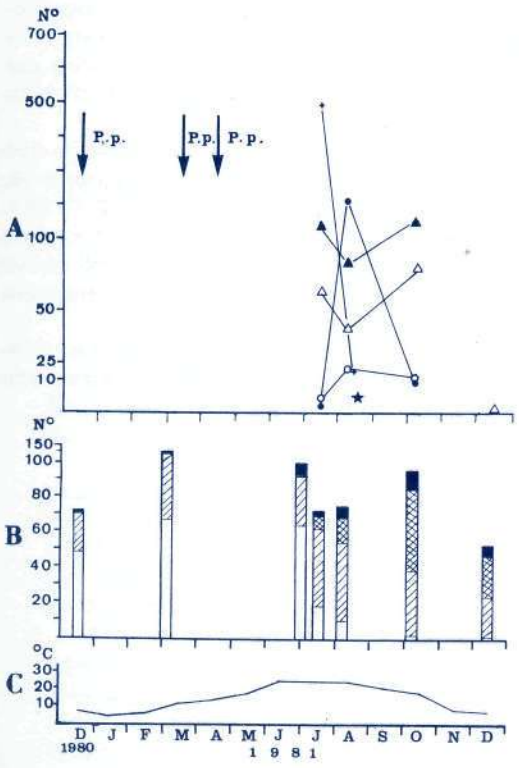

FIG. 3. A = Number of predators observed on 9 marked trees and number of parasites captured on 4 yellow sticky traps on almond trees at Trilophos-Veria during 1980-81; B = Density of living, dead, attacked and parasitized *Q. perniciosus* on 8-12 mm thick twigs from almond trees at Trilophos-Veria during 1980-81; C = Average mean temperatures at Trilophos-Veria during 1980-81 (for explanation of symbols refer to Fig. 2).

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KEY WORDS: *Cybocephalus fodori*, Predator, *Quadraspidiotus perniciosus*, Biological control, Almond fauna

Μερικά Χαρακτηριστικά του *Cybocephalus fodori*, Αρπακτικού του *Quadraspidiotus perniciosus* σε Αμυγδαλεώνες της Β. Ελλάδας

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ΠΕΡΙΛΗΨΗ

Στα αποτελέσματα δειγματοληψιών κατά τη διάρκεια 1978-1979 και 1981-1982, σε δύο

σοβαρά προσβεβλημένους αμυγδαλεώνες της Βορείου Ελλάδας, παρατηρήθηκε υψηλή θνησιμότητα του κοκκοειδούς *San José*. Εκτός από το ποσοστό θνησιμότητας που οφειλόταν σε κλιματικούς παράγοντες, η λοιπή θνησιμότητα ήταν αποτέλεσμα της δράσης των φυσικών εχθρών. Ένα μεγάλο μέρος της δράσης αυτής αποδίδεται σε ιθαγενή είδη και κυρίως σε αρπακτικά, μεταξύ των οποίων το *Cybocephalus fodori* παρατηρήθηκε να είναι το ιδιαίτερης σημασίας είδος.

Πλήρης δραστηριότητα των ακμαίων του *Cybocephalus fodori* σε εκτροφή του έξω από το εργαστήριο παρατηρήθηκε στα τέλη Μαρτίου. Παρεχομένου του ξενιστή σε αφθονία, το έντομο συμπλήρωσε τρεις γενιές το έτος. Κάτω από σταθερές συνθήκες (25± 2° C, 65± 5%RH και 16 ώρες φωτοπερίοδο) η εξέλιξη των τριών προνυμφικών του σταδίων διάρκεσε 19 μέρες περίπου και του νυμφικού στάδιου περίπου 10 ημέρες. Κατά μέσο όρο, 68 θήλεα *Quadraspidiotus perniciosus* φαγώθηκαν μερικά από κάθε άτομο *C. fodori* κατά τη διάρκεια της προνυμφικής του εξέλιξης.

Στον αγρό παρατηρήθηκε ότι το *C. fodori* διαχειμάζει ως ακμαίο σχηματίζοντας συγκεντρώσεις. Τα ωά, ένα ανά κοκκοειδές, και οι νεαρές προνύμφες, βρέθηκαν κάτω από ασπίδια του *Q. perniciosus*.