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HOST SCALE EFFECTS ON THE PARASITIC MITE *HEMISARCOPTES COCCOPHAGUS* MEYER AND THEIR IMPLICATIONS FOR THE BIOLOGICAL CONTROL OF DIASPIDID PESTS

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ABSTRACT
Hemisarcoptes coccophagus Meyer (Astigmata: Hemisarcoptidae) is a mite parasitizing armored scale insects (Homoptera: Diaspididae), with a variable potential as a biological control agent. We demonstrate that different scale stages, species and host plants have a pronounced effect on the parasitization patterns of the mites, implying that these factors should be considered in biological control programs.

KEY WORDS: Acari, *Hemisarcoptes,* Diaspididae, host effect, biological control.

INTRODUCTION

Hemisarcoptes coccophagus Meyer (Astigmata: Hemisarcoptidae) is a parasitic mite attacking armored scale insects (Homoptera: Diaspididae). All feeding stages of this mite parasitize diaspidid hosts, causing scale death or reduction in fecundity.

There are several indications that *H. coccophagus* may successfully control some armored scale pests (Kaufmann, 1977; Hill et al., 1993; Gerson et al., 1990). However, in Israel, where this mite occurs in diverse natural and agricultural habitats, it fails to prevent diaspidid outbreaks. Although the mite is usually regarded as a generalist natural enemy, the inconsistent performance of *H. coccophagus* in the field suggested that its regulating ability may be host-specific, varying amongst different habitats. Here we summarize the results of a field study which demonstrate that different scale stages, species and host plants have a pronounced effect on the parasitization patterns of the mite and may thus affect its controlling efficacy.

METHODS

Four species of armored scale insects were sampled in Israel during an entire year. *Parlatoria pergandii* Comstock and *P. cinerea* Hadden were obtained from orange and grapefruit orchards in the Negev region from May 1991 to July 1992. As Gerson (1967) found no differences in parasite and predator activity on these two species, they will be referred together as "chaff scale." Latania scale *[Hemiberlesia lataniae* (Signoret)] and oleander scale (*Aspidiotus nerii*

Bouché), occurring on acacia (*Acacia cyanophylla*) trees in the coastal plain of Israel, were sampled from September 1991 to September 1992. Latania scale is a uniparental species which occurred on the bark, branches, and mature leaves; oleander scale infested only young and mature leaves. We report only results obtained from mature acacia leaves which were inhabited by both species.

Citrus samples were taken every second month from lignified branches or trunks, collected in chips of ca. 10 cm^2 from at least 5 trees/orchard. A total area of 50 cm^2 (more at low scale density), carrying ca. 300 scale females/sample, was used as the basic unit examined (immature scale males were only negligibly attacked). Samples from acacia trees were obtained every 3 weeks: three leaves (six at low scale density) were collected and their whole surface was examined.

Host scale suitability was evaluated by the following criteria: mean intensity of feeding mite stages (mean number of mites divided by the number of attacked scales, see Margolis et al., 1982), fecundity (number of eggs found per scale divided by the number of mite females ovipositing thereon), and survival as well as generation time of *H. coccophagus* while developing on different hosts. Host preference was estimated by comparisons of mite prevalences (proportion of hosts parasitized) on various hosts. To assess the aggregation pattern of the mite we used both the Negative Binomial distribution (Southwood, 1978) and Taylor's Power Law (Taylor, 1984). The numerical response of the mite was estimated by plotting its density vs. the density of the corresponding host. Densities of both mites and scales were calculated as mean numbers per 1 cm^2.

RESULTS

Life History of the Mite

Long-distance dispersal of *H. coccophagus* among host colonies was brought about by a phoretic association between its heteromorphic deutonymph (hypopus) and the scale predator *Chilocorus bipustulatus* (L.) (Coleoptera: Coccinelidae). Within scale colonies all active mite stages were seen searching for hosts. Upon finding a host, the parasite developed to adulthood (if at a young stage) and reproduced there. We observed that feeding by ovipositing females and their progeny eventually caused scale death. As the host died, mites wandered off in search of other scales. The time required to develop from egg to adult (1–2 weeks, depending on the host, Izraylevich and Gerson, 1993a) was shorter than the total ovipositional period (3–4 weeks, laboratory observations). Consequently, members of the early cohort of a female's progeny obtained enough nutrients from her host to reach maturity during the span of the mother's oviposition. Progeny of the later cohort, however, often found themselves on a moribund or dead scale and had to disperse to find a new host. The available host resource is thus partitioned between reproducing mother(s) and her (their) early progeny. We observed that at least some of the early progeny mated prior to dispersion and that both sexes mated several times. Strong mating competition was seen as several males crowded around and on single females and interfered with each other in their copulation attempts at high mite densities.

Effect of Host Scale Species

Mite mean intensity on all stages of latania scale was significantly higher than on corresponding stages of oleander scale (Fig. 1). Fecundity of *H. coccophagus* on the former

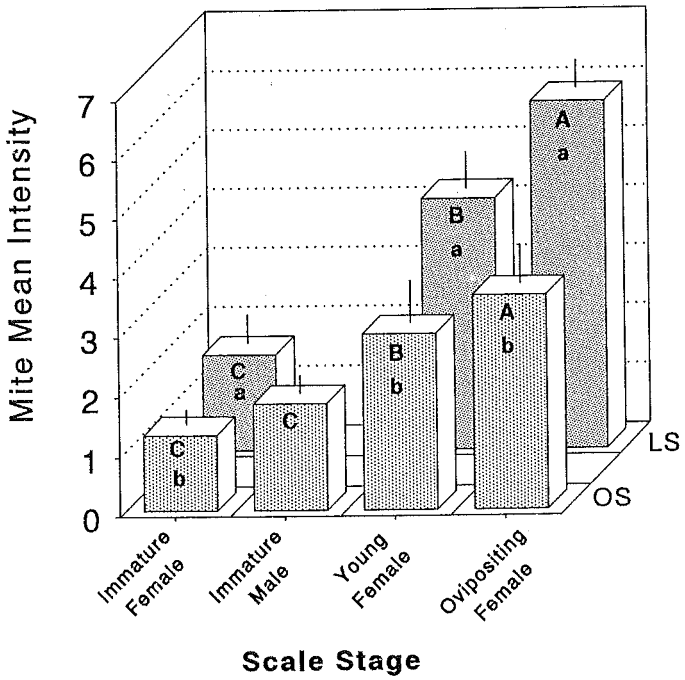

Fig. 1. Mean intensity (±SE) of *Hemisarcoptes coccophagus* Meyer parasitizing different stages of latania scale (LS) and oleander scale (OS) on mature acacia leaves, when mite populations were largest. Different letters denote significant differences at the 0.05% level in nonparametric *F* test (Tukey). Capital letters correspond to comparisons between stages within each scale species; small letters apply to comparisons between species within each stage.

diaspidid was also higher than on the latter (Fig. 2). Moreover, in the laboratory the full reproductive output of the mite on ovipositing females of latania scale was at least 20 times higher than on the same stage of oleander scale (Izraylevich and Gerson, 1993a). While developing on oleander scale, mites suffered higher mortality and their generation time was twice as long as on latania scale (Izraylevich and Gerson, 1993a). On the other hand, mite prevalence on both scale species was similar throughout the sampling period (Izraylevich and Gerson, 1993b), indicating that latania scale was not preferentially selected by host-searching mites (Izraylevich et al., 1995).

Spatial distribution of the mite in the field was clumped, with the degree of aggregation being similar on both host species (Izraylevich and Gerson, in press). Mite density increased concurrently with increasing scale density, indicating the existence of a numerical response. Numerical response differed among host species: it was faster on latania scale than on oleander scale (Izraylevich et al., in press).

Effect of Host Scale Stage

On both oleander and latania scales, the mean intensity of *H. coccophagus* was highest on ovipositing females, intermediate on young females and lowest on immature stages (Fig. 1).

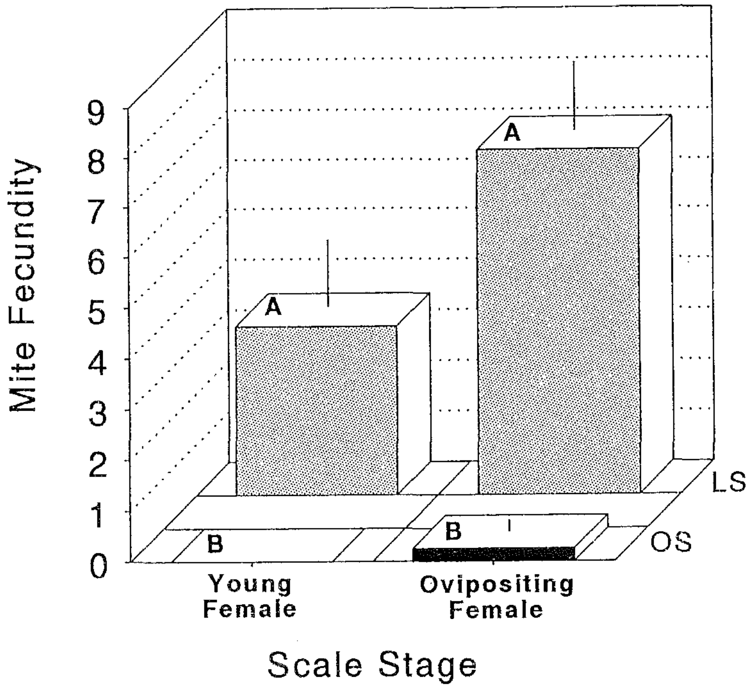

Fig. 2. Fecundity (mean ± SD) of *Hemisarcoptes coccophagus* Meyer parasitizing young and ovipositing females of latania scale (LS) and oleander scale (OS) on mature acacia leaves. Different letters denote significant differences at the 0.05% level in a nonparametric F test (Tukey).

Mite fecundity was also highest on ovipositing females (Fig. 2), and no eggs were found on immature scales. Mite prevalence on ovipositing females of both scale species was consistently higher than on young ones (Izraylevich and Gerson, 1993b), indicating that the former stage was preferentially selected by the mite. On young scale females mites were more aggregated than on ovipositing females (Izraylevich and Gerson, in press). Numerical response slopes were higher on ovipositing scale females than on young females, meaning that *H. coccophagus* responds faster to changes in the density of the former stage (Izraylevich et al., in press).

In contrast to latania and oleander scales, mite mean intensity, fecundity, degree of aggregation and rapidity of numerical response were similar on ovipositing and young chaff scale females (Izraylevich and Gerson, 1993a, b; Izraylevich et al., in press).

Effect of Host Plant

An analysis of host plant effect on scale suitability for the mite was conducted on chaff scale infesting two citrus species, grapefruit and orange. Scale females were larger and mite intensity was higher on grapefruit than on orange trees (Fig. 3). Fecundity of the parasite was also higher on the former plant (Izraylevich and Gerson, 1993a).

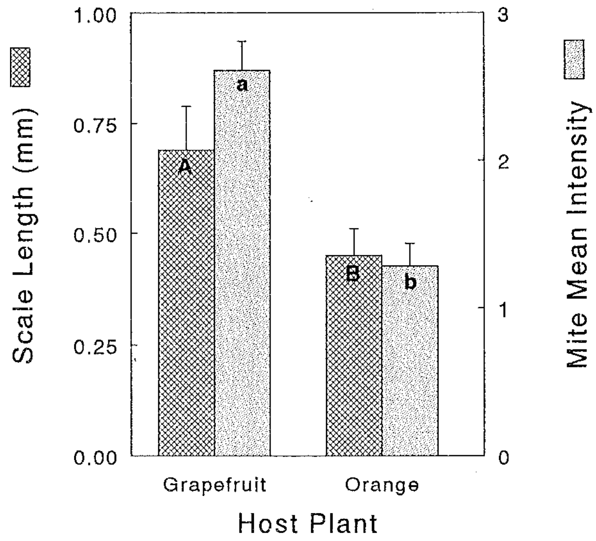

Fig. 3. Comparison of chaff scale length (mean ± SE) and mean intensity (±SE) of *Hemisarcoptes coccophagus* on different citrus species. Capital letters denote significant differences (0.05% level) between scale lengths (t test), while small letters denote significant differences (0.05% level) between the mean intensities of the mite (a nonparametric *F* test, Tukey).

DISCUSSION

Comparison of parasitization patterns on latania scale vs. oleander scale indicates that the former is the more suitable host for mite development and reproduction. Such species-specific reactions suggest that the success of biological control programs with *H. coccophagus* may depend on the target host.

Ovipositing females of latania and oleander scales were more suitable hosts than adult young females, and the rapidity of the numerical responses of the mite differed accordingly. In contrast, the suitability of chaff scale age phases was similar, and, consequently, the slopes of the numerical responses were also similar among its young and ovipositing females. Furthermore, young females of another diaspidid, the California red scale, *Aonidiella aurantii* (Maskell), are more suitable hosts than ovipositing females (G. Jiang, R.F. Luck and M.A. Houck, personal communication), a situation which differs from the present case. Mites attacking scales on acacia were more aggregated on young host females than on ovipositing ones (i.e. a larger fraction of young females escaped parasitism). This means that if a diaspidid population consists mainly of ovipositing females, a smaller number of mites will be needed to achieve a required parasitisation rate. Thus we argue that when a target pest has overlapping generations (i.e. all stages are simultaneously available for the mite), the chance of *H. coccophagus* to establish and control that pest in the field may depend on the specific age structure of the particular diaspidid population and on the abundance of suitable stage(s). Information on the relative suitability of scale stages and the timing of their appearance in the field is thus crucial for planning biological control programs with this mite.

Our data also indicate that host plants may influence the suitability of particular diaspidid species for the mite, through their effect on scale size. Thus the controlling potential of *H. coccophagus*, applied against a given diaspidid pest species with a known population age structure, could still vary on different plant species.

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