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HEIDARI, M.
Environment Department, Wye College, University of London, Wye, Ashford, Kent TN25 5AH, U.K.

INFLUENCE OF HOST-PLANT PHYSICAL DEFENCES ON THE SEARCHING BEHAVIOUR AND EFFICACY OF TWO COCCINELLID PREDATORS OF THE OBSCURE MEALYBUG, *PSEUDOCOCCUS VIBURNI* (SIGNORET).

ABSTRACT

INFLUENCE OF HOST-PLANT PHYSICAL DEFENCES ON THE SEARCHING BEHAVIOUR AND EFFICACY OF TWO COCCINELLID PREDATORS OF THE OBSCURE MEALYBUG, *PSEUDOCOCCUS VIBURNI* (SIGNORET).

Laboratory and glasshouse trials were conducted to investigate the influence of host-plant physical structure on the predation of the obscure mealybug, *Pseudococcus viburni* (Signoret) (Coccoidea: Pseudococcidae) by two coccinellid predators: *Cryptolaemus montrouzieri* (Mulsant) and *Nephus reunioni* Fürsch. Glasshouse trials showed that good control was achieved by *C. montrouzieri* irrespective of the hairiness of the plant species, but that *N. reunioni* was more effective on smooth leaves, such as those of *Citrus*, coffee and *Passiflora,* than on hairy plants, such as *Streptocarpus* and tomato, on which the density of the trichomes and their sticky exudations significantly reduced the walking speed and other searching parameters. It is concluded that the size of the predator and the type of trichomes have a marked influence on the level of mealybug control and that this could influence the choice of predators.

Key words: tomato crop, *Citrus limon*, *Coffea arabica*, *Lycopersicon esculentum*, *Passiflora caerulea*, *Solanum tuberosum*, *Streptocarpus* sp., damage, searching behaviour.

INTRODUCTION

The obscure mealybug, *Pseudococcus viburni* (Signoret), is widespread in tropical and subtropical regions and is a serious pest of protected cultivation. It is an occasional pest of tea, citrus, fruit trees, grapevines and many other ornamentals, including glasshouse crops. It causes severe damage to the leaves, stems, fruits and roots of the attacked plants (Miller & Kosztarab, 1979; Heidari, 1986; Heidari & Copland 1993).

In Europe, *P. viburni* is one of the most important pests under glass where it has recently been recorded on tomato crops (Copland *et al.*, 1992). According to Williams (1985), Australia is the probable native home of *P. viburni* and the search for the natural enemies in Australia may prove useful, as biological control is now important under glass, provided that ants are absent (Heidari, 1986; Kosztarab, 1996). At present, only the encyrtids *Anagyrus agraensis* Saraswat and *Pseudaphycus maculipennis* Mercet are considered possible parasitoids against *P. viburni*, although there have been contradictory reports as to their effectiveness.

However, the two coccinellid predators: *Cryptolaemus montrouzieri* (Mulsant) and *Nephus reunioni* Fürsch have shown some promise (Panis, 1979; Heidari, 1986; Clausen, 1987; Heidari & Copland, 1993).

Among several factors affecting the efficiency of biocontrol agents of insect pests, host-plant physical defences have been found to play an important role in the degree of control achieved. This study examined the effect of leaf hairiness on the effectiveness and searching behaviour of the two coccinellid predators, *C. montrouzieri* and *N. reunioni*. It also evaluated the ability of these predators to locate and destroy mealybug colonies on mixed plantings, as might exist in the field or under glass.

MATERIALS AND METHODS

Searching behaviour:

Six host plants (*Citrus limon*, *Coffea arabica*, *Lycopersicon esculentum*, *Passiflora caerulea*, *Solanum tuberosum* and *Streptocarpus* sp.) were chosen with a range of different physical morphology and secondary chemical attributes. To study the effect of different host plants, the computer programme Micromeasure (Varley *et al.,* 1994) was used, and this provided direct measurements for the distances walked, speed of walking, number of turns and other searching parameters from a video source.

Population regulation:

Seven large cages, each containing one plant each of *C. limon*, *C. arabica*, *P. caerulea*, *S. tuberosum* and *Streptocarpus* sp., were set up in the glasshouse (temp. range 20-25°C; photoperiod 16L:8D). The plants in six of these cages were heavily infested with *P. viburni* while the seventh cage contained uninfested plants as a control. The mealybug population on each infested plant was carefully counted and aged (T1) and then the six infested cages were divided into three treatments, each having added either (i) no predator, (ii) adult *C. montrouzieri* or (iii) adult *N. reunioni*, the latter two species in proportion to the number and age of the mealybugs (this proportion was based on previous observations on the consumption of the two ladybirds, so that the ratios of beetles to mealybugs was approximately 1:5.2mg (*Cryptolaemus*) and 1:0.6mg (*Nephus*) (Heidari, 1989)). After six weeks, the mealybug populations were again counted (T2) on each plant. The change in the mealybug populations after six weeks was calculated as follows:

(1 - (T2P x T1C / T1P x T2C) x 100

where T2P was the mealybug population after 6 weeks on the plants onto

which one or other of the predator species had been released; T1C was the mealybug population on the untreated control prior to the release of predators at the start of the experiment; T1P was the mealybug population on the non-control plants prior to the release of the predators at the start of the experiment, and T2C was the mealybug population on untreated control at the end of six weeks.

Table 1. The density and size of trichomes on the six species of host plant used in these experiments.

Plant species	Trichome type	Trichome density per 23mm²		Trichome size (µm)	
		Upper	Lower	Upper	Lower
Citrus	mostly glabrous	0	3	0	5-10
Coffea	glabrous	0	0	0	0
Passiflora	long, simple	0	6	0	20-39
Lycopersicon	several types: glandular; multicellular	96	160	50-400	50-900
Solanum	several types: glandular; multicellular	60	108	37-700	100-300
Streptocarpus	Long, dense, erect, bent tip.	51	236	100-800	50-400

Table 2. Comparison of four searching behaviour parameters (means ± s.d.) of adult *Nephus reunioni* on six plant species during an observation period of 300 secs.

Plant species	Time walking secs	Walking speed cm/min	Number of turns >90°	Time spent preening secs
Smooth-leaved hosts				
Citrus sp.	103.0 ± 16.1^{a}	68.8 ± 4.5^{a}	8.8 ± 1.1^{a}	10.6 ± 3.0^{c}
Coffea sp.	61.7 ± 11.7^{bc}	57.9 ± 4.2^{b}	5.9 ± 1.3^{ab}	7.6 ± 2.3^{c}
Passiflora sp	34.4 ± 10.2^{c}	61.1 ± 6.3^{ab}	4.3 ± 1.8^{b}	10.5 ± 3.7^{c}
Hairy-leaved hosts				
Lycopersicon sp.	61.8 ± 13.0^{bc}	20.9 ± 2.5^{cd}	6.8 ± 1.0^{ab}	69.8 ± 12.2^{a}
Solanum sp.	80.5 ± 13.1^{ab}	28.0 ± 2.3^{c}	6.5 ± 1.0^{ab}	37.8 ± 10.2^{b}
Streptocarpus sp.	90.6 ± 20.8^{ab}	15.1 ± 1.3^{d}	3.8 ± 0.9^{b}	13.4 ± 5.0^{c}

Note: numbers in columns followed by the same letter do not differ significantly at the 5% level.

PLANT HEALTH EVALUATION:

The health status of each plant was accessed and scored at the end of the experiment using a scoring system ranging from 0-10, based on the cosmetic appearance of the host plants, where zero referred to completely dead plants and 10 to completely healthy plants, similar to the non-infested treatments.

RESULTS

The size and density of the trichomes on the leaves of the six species used in the first experiment are shown in Table 1. The time allocated by each coccinellid to each searching activity varied greatly with leaf topography and surface quality. *N. reunioni* showed good searching activity (Table 2) on the smooth and less sticky leaves of *Citrus* and *Passiflora*, whereas its speed was greatly reduced and the amount of time spent preening was much greater on the leaves of tomato and potato which have glandular trichomes.

The proportion of mealybugs destroyed by the two coccinellids is shown in Table 3. It is clear that the searching behaviour of *C. montrouzieri* was unaffected by the leaf surface but that of *N. reunioni*, which, although it had been fairly effective on the smooth-leaved plants was still less effective than the larger *Cryptolaemus*. This is also clearly shown by the plant health assessment data, which are presented in Table 4. The mean score for the mealybug infested with *Nephus* was similar to that in the absence of any predators, whereas there was very little damage to the plants protected by *Cryptolaemus*

DISCUSSION AND CONCLUSION

The results strongly suggest that the hairiness of the leaves of the host-plants played an important role in the ability of the two coccinellid species to control *P. viburni*. The density and type of trichomes clearly affected the searching ability of *N. reunioni*, which is much smaller than *Cryptolaemus*. It appears, therefore, that *Cryptolaemus* is able to search and control this mealybug on most hosts plants whereas *Nephus* was relatively ineffective even on the smooth-leaved hosts if introduced when there was a heavy mealybug population already present. It is concluded that, of these two coccinellids, *C. montrouzieri* would be the more reliable biocontrol agent against mealybug species, particularly in mixed plantings. However, for classical biocontrol, *C. montrouzieri* may be less suitable because, with the disappearance of the prey, it could die out and resurgence of the pest might then require several seasonal releases; for inundative releases, though, it could be an ideal predator. On the other hand, *N. reunioni* might be efficient at lower population levels and could be introduced as a secondary and complementary predator for many mealybug species.

Table 3. Percentage of mealybug population destroyed by *C. montrouzieri* and *N. reunioni* compared with unpredated control populations (all five plants in same cage replicated twice).

Host plant species	*C. montrouzieri*	*Nephus reunioni*
Smooth-leaved hosts		
Citrus limon	100.0[a]	97.9[a]
Coffea arabica	100.0[a]	78.1[ab]
Passiflora caerulea	100.0[a]	63.4[b]
Hairy-leaved hosts		
Solanum tuberosum	100.0[a]	41.1[bc]
Streptocarpus sp.	99.9[a]	25.8[c]

Note: means in columns followed by the same letter do not differ significantly at the 5% level after arcsin transformation.

Table 4. Plant health (scored from 0 for dead plants to 10 for totally undamaged plants) after introduction of *C. montrouzieri* or *N. reunioni.*

Plant host species	Infested control	*C. montrouzieri*	*Nephus reunioni*
Smooth-leaved hosts			
Citrus limon	6.5	8.8	5.5
Coffea arabica	6.3	9.8	5.3
Passiflora caerulea	5.3	8.8	4.5
Hairy-leaved hosts			
Solanum tuberosum	2.8	8.5	1.8
Streptocarpus sp.	3.0	9.3	3.5
Mean (lsd 0.1% = 2.26)	4.3[B]	9.0[A]	4.1[B]

Note: means followed by the same letter do not differ significantly at the 5% level after arcsin transformation.

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