immediate causes which include differences in feeding (polyphagy in the greenhouse whitefly and oligophagy in the cabbage whitefly) or ultimate factors which are evolutionary pressures due to habitat stability.

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Attraction of Two Species of *Polistes* Wasps to Prey Wounded by Them¹

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During the course of field studies on the predation of lepidopterous larvae by *Polistes jadwigae* DALLA TORRE (YAMASAKI et al., 1978), it was observed that once one individual of the wasp inflicted wounds on a 5th instar larva of the citrus swallowtail, *Papilio xuthus* LINNÉ, the others foraging in the experimental area came to the wounded prey. *P. chinensis antennalis* PÉREZ which often visited the area for foraging also showed similar behavior. These findings suggest that the prey wounded by the hunting adults of the two species of *Polistes* are attractive to other *Polistes*

adults possibly because of the odor emitted by body fluid of the prey. As these predators have a wide range of prey, such a fact may be found in prey other than the citrus swallowtail. This paper describes results of two field experiments to determine whether the wounded larvae of the citrus swallowtail and other two prey species are attractive to the prey-searching adults of the two species of *Polistes*.

Two experiments, i. e. Experiments I and II, were conducted in an area (8×12 m) in the campus of the Faculty of Agriculture, Kyushu University, Fukuoka, in July and August of 1978. The area was overgrown with short weeds and surrounded by a soybean field, a citrus grove and open spaces overgrown with weeds and shrubs. During the period of the experiments, adults of *P. jadwigae* and *P. c. antennalis* from natural colonies were observed searching for prey in the area.

The purpose of Experiment I was to determine whether the wounded larvae of the citrus

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Fig. 1. Scene of an experiment on the attraction of *P. jadvigae* to the wounded larvae of citrus swallowtail (Experiment I).

swallowtail on its host plants are attractive to prey-searching adults of *P. jadvigae*. Two sets of four potted trees of *Citrus tamurana* (ca. 70 cm in height) were arranged at intervals of 5 m in the middle of the experimental area. Distance of trees within each set was 1.5 m. A 5th instar citrus swallowtail larva reared on *C. unshiu* was placed on each tree. Larvae placed on the trees of one set were wounded seriously just before placing, and those on the trees of the other were kept unwounded and alive. When prey-searching wasps entered the experimental area from the outside, their behavior and flying courses in the area were recorded by two observers who sat at 4.7 m distance from each set (Fig. 1). Wasps that visited the prey were caught with a net and removed to avoid effects of prey-location learning. The sets were replaced with each other at intervals of half an hour, and at the same time the wounded prey on the trees were renewed. The experiment was carried out between 10:00 and 15:00 every day for the period, July 31–Aug. 2, but total time of observation was twelve hr because of intermittent bad weather.

The purpose of Experiment II was to determine whether the wounded larvae of three prey species including the citrus swallowtail are attractive to prey-searching adults of *P. jadvigae* and *P. c. antennalis*. A wooden desk (55×80×23 cm) covered with a white paper was set up in the middle of the experimental area. Two petri dishes (10×2 cm) each containing equal number

of the prey larvae torn into two or three pieces were placed on the desk at intervals of 40 cm. One dish was opened while the other was closed, and these were exposed to the wasps visiting the experimental area. Observations on their behavior were made by two observers who sat at 4 m from the desk. Wasps that visited the dishes were caught with a net and removed to avoid effects of prey-location learning. The two dishes were replaced with each other at intervals of half an hour, and at the same time the prey in the dishes were renewed. The experiment was carried out between 10:00 and 16:00 on Aug. 5 and Aug. 7, using laboratory-reared or field-collected prey. The species of the prey and the number of prey put in a dish during a half an hr were as follows: ten 5th instar larvae of the citrus swallowtail; four 4th instar larvae of the oriental armyworm, *Mythimna separata* WALKER, collected on *Zea mays*; twenty 4th instar larvae of the giant bagworm, *Clania variegata* SNELLEN, which were taken out of the bags collected on *Quercus serrata*. Total time of observation was one hr for the citrus swallowtail and for the giant bagworm, but half an hr for the oriental armyworm.

Numbers of *P. jadvigae* visiting the trees and the prey in Experiment I are shown in Table 1. Wasps visited trees bearing the wounded prey more often than those bearing the unwounded prey. A one-tailed binomial test indicated that difference in numbers of the visiting wasps between the two types of trees was significant at

Table 1. NUMBERS OF *P. jadvigae* THAT VISITED TREES BEARING WOUNDED OR UNWOUNDED LARVAE OF CITRUS SWALLOWTAIL AND THESE PREY THEMSELVES

Prey condition	No. of wasps	
	Tree	Prey
Wounded	13 ^a	11 ^c
Unwounded	3 ^b	0 ^d

^{a,b} Significantly different at 5% level.

^{c,d} Significantly different at 1% level.

Table 2. NUMBERS OF *P. jadvigae* AND *P. c. antennalis* THAT VISITED OPEN OR CLOSED PETRI DISHES CONTAINING THE TORN LARVAE OF SOME SPECIES OF LEPIDOPTERA.

Species of Lepidoptera	No. of <i>P. jadvigae</i>		No. of <i>P. c. antennalis</i>	
	Open	Closed	Open	Closed
Citrus swallowtail	1	0	12 ^a	0 ^b
Oriental armyworm	1	0	7 ^a	0 ^b
Giant bagworm	2	0	7 ^a	0 ^b

^{a,b} Significantly different at 1% level.

the 5% level. Records of the flying course in the experimental area were made of eleven out of thirteen wasps visiting the trees with the wounded prey. Nine out of the eleven wasps came from the lee sides to the trees, and eight of the nine wasps succeeded in finding the prey. A one-tailed binomial test showed that difference in numbers of wasps visiting the prey between the two types of prey was significant at the 1% level, also.

Numbers of *P. jadvigae* and *P. c. antennalis* visiting the two types of dishes in Experiment II are given in Table 2. Neither *P. jadvigae* nor *P. c. antennalis* visited the closed dish regardless of prey species. In the case of *P. jadvigae*, the open

dish was visited by all of the wasps entering the experimental area irrespective of prey species, but the number of the entering wasps was too small to detect a significant difference in their response to the two types of dishes. All of them came from the lee sides to the dish. *P. c. antennalis* frequently visited not only the open dish containing citrus swallowtail larvae but also that containing either oriental armyworm larvae or giant bagworm larvae. According to the one-tailed binomial test, difference in numbers of visiting wasps between the two types of dishes was significant at the 1% level for all three of the prey species.

The result of Experiment I shows that *P. jadvigae* is attracted to the wounded larvae of the citrus swallowtail. In this experiment, most of the wasps visiting trees with wounded prey came from the lee sides and succeeded in finding the prey. In addition, both species of *Polistes* visited only the open dish containing the torn larvae in Experiment II, and there was a significant difference in numbers of *P. c. antennalis* visiting the two types of dishes. From Experiment II, it is clear that *P. c. antennalis* responds to torn larvae of the oriental armyworm and the giant bagworm. Although the number of wasps observed was small, *P. jadvigae* is considered to react in the same way. It should be emphasized that all of the wasps entering the experimental area visited only the open dish and that they came to it from the lee sides. Thus, it is concluded that both species are attracted to the wounded lepidopterous larvae in different systematic positions probably in response to the odor of the prey's body fluid.

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