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SHORT NOTES

Prey selection patterns in *Notonecta maculata* Fabricius, 1794 (Insecta, Hemiptera)

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Notonecta maculata Fabricius, 1794 is an aquatic species of Hemiptera widely found in the Western Palearctic region (5), where it can be considered a key player as a secondary consumer (1) principally of still water systems. Thus, it is specially interesting to increase our knowledge of the trophic ecology of this species, which is considered an opportunist (4) feeding mainly in natural pools, on terrestrial arthropods that fall on the water surface (6). The role of this aquatic bug in the predation of animals trapped on water surfaces has been analysed in few studies (2).

The aim of the present experimental study was to detect the possible prey selection patterns of *N. maculata* at the water surface in relation to type, state (alive or dead) and size of prey. The response of the species to different vibration frequencies was also studied.

The study was conducted in an artificial pond in Alfacar (S Spain) in early spring. The *N. maculata* population in the study pond was very high; in excess of one thousand exemplars. All the experiments were carried out between 16:00 and 18:00 sun time (water temperature 18-21ºC). Potential prey were thrown into different areas of the pond, the existence or not of a response was detected, and response time was measured. Three prey types : bee (*Apis mellifera*), ant (*Messor* sp.) and grasshopper (*Oedipoda* sp.) were selected. For each prey type, 15 alive and 15 dead individuals (killed by freezing to avoid the use of odourous substances) were randomly thrown into the water. Previously, all the individuals were measured (precision ± 0.01 cm). As control, blades of grass, measured previously and thrown the same number of times (n = 15), were employed. It was considered as an affirmative response when, in the first ten minutes, *N. maculata* actively contacted the prey, and response time was the time elapsed from the contact of the prey with water to the contact between prey and *N. maculata*. To study the response time to different vibration frequencies, a mechanical vibrator model SF-9324 Pasco Scientific was employed (contacting with the water surface), using three frequencies (l, 5 and 10 Hz). Also, the response time was quantified in each experiment (15 times for every frequency and in different pond places).

For the three prey species, there was a higher response percentage for live individuals (100% for the three species) *vs*. dead ones (60%, 80% and 73.3% in ant, bee and grasshopper respectively), statistically significant for ant (χ^2= 7.5; df= 1; p= 0.006) and grasshopper (χ^2= 4.6; df= 1; p= 0.032) but not for bee (χ^2= 3.33; df= 1; p= 0.068). In the control, the response percentage was even less (40%; χ^2= 12.86; df= 1; p= 0.003). These results support the idea than *N. maculata* behaves, at the water surface, more as a predator than as a necrophage, particularly as an ambush predator (7). Moreover, these results indicate that the prey mobility, and not only the water perturbation derived from the contact after the fall, is related to the detection by *N. maculata,* as (3) noted for *N. glauca.* The lower response percentage to the control than to the dead prey indicates that *N. maculata* has the capacity to distinguish shape, colour or smell of the prey. In the present study, the opportunism of *N. maculata* was supported because it did not show any kind of selectivity between the three live preys offered, despite the clear differences in size, shape and movement type presented by each one.

The mean response time was always shorter with live prey : ant (29.2 s; SD = 44.1; N = 15), bee (40.5 s; SD = 42.7; N = 15) and grasshopper (67.9 s; SD = 90.3; N = 15) compared with dead ones: ant (120.0 s, SD = 136.0; N = 9), bee (104.2 s, SD = 108.4; N = 12) and grasshopper (110.4 s; SD = 125.9; N = 11). By means of a Man-Withney U-test analysis, we proved that the response time was significantly lower to live prey than dead prey (ant : Z= 2.48; p= 0.013; n1= 12; n2= 17; bee : Z= 1.96; p= 0.05; n1= 20; n2= 18; grasshopper : Z= 2.06; p= 0.04; n1= 17; n2= 15). These results, together with the previous ones, show that *N. maculata* not only respond more to the live prey but they do so more quickly. Moreover, these data show in relation to the time response an ant-bee-grasshopper gradation when the prey is live and bee-grasshopper-ant when dead. These results, in the case of live prey, seem to show a fast first selection for smaller prey (ant), perhaps because the bigger ones may present a risk or high energetic cost (grasshopper). In relation to the dead prey, *N. maculata* may have responded more to the heavier ones because they represent greater food quantity. Although a grasshopper is of greater length than a bee (approximately x 1.5 in the species used here), the total volume of the bee is relatively similar to that of the grasshopper, consistent with the similarity in selection of dead individuals of these two species by *N. maculata*. The analysis results show that there is no statistically significant correlation between individual prey size (within the same kind of prey) and response time (Table 1), perhaps because the differences in size within one prey kind were not large.

TABLE 1

Pearson correlation coefficient between prey size and response time

Prey	Live			Dead		
	r	p	n	r	p	n
Ant	0.60	>0.05	15	-0.18	>0.05	9
Bee	0.34	>0.05	15	0.42	>0.05	12
Grasshopper	0.33	>0.05	15	-0.41	>0.05	11

The results of the vibration experiments show a minor response percentage to low frequencies (53.3% of response to frequency 1, in comparison with 100% to frequencies 5 and 10) and, moreover, a minor response time to high frequencies ($\bar{x}$= 81.10 s, SD = 44.43, n = 8 for frequency 1; X = 28.3 s, SD = 35.66, n = 15 for frequency 5; $\bar{x}$ = 11.92 s, SD = 13.78, n = 15 for frequency 10). Man-Withney U-test analysis proved that the response time is significantly higher to frequency 1 than to the remaining frequencies (between 1 and 5 : Z= 2.84; p= 0.0045; n1= 8; n2= 15; between frequencies 1 and 10 : Z= 3.61; p= 0.0003; n1= 8; n2= 15). The differences between the mean response times for frequencies 5 and 10 Hz are not significant, but a tendency is observed (Z= 1.89; p= 0.059; n1= 15; n2= 15). These data show that the vibration frequency produced by a possible prey play an important role in the detection by *N. maculata*, as has been pointed out for this and other Hemiptera species (3).

Our results seem to show : absence of differential selectivity for the three prey species studied; higher response percentage and lower response time to live prey ahead of dead ones (only not statistically significant for response to bees); no clear size selection within the same prey species (probably because of small differences) and a higher response percentage and lower response time to vibrations with higher frequencies (representing a possible prey).

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