Manipulating insect and tick behavior through biomimetic robots

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Keywords: animal-robot interaction; ethorobotics; behavioral asymmetries; arthropods; bionics

Abstract

Ethorobotics is a new and fascinating field of bio-robotics involving the use of robotic animal replicas to study animal behavior. By emitting controlled biomimetic stimuli, robotic artefacts enable selected interactions with interesting possibilities over classical ethology[1]. Despite growing interest in this field, studies on arthropods of agriculture and veterinary importance are still limited. Herein, four case studies dealing with arthropods of economic relevance are presented. In the first, a robotic apparatus with female and male interfaces was used to investigate whether sex, mating experience, and asymmetries of robotic cues affect the escalation of pushing behavior in the larger grain borer, *Prostephanus truncatus*[2]. The directions of robotic cues led to different outcomes in beetle pushing behavior, showing lateralized population-level specialization for each interaction context. Bio-robotic artefacts can also be useful to study predator-prey interactions under highly standardized experimental conditions. For instance, the second study analyzed the lateralized escape and surveillance responses of the migratory locust, *Locusta migratoria*, during biomimetic interactions with a robotic predator mimicking the Guinea fowl, *Numida meleagris*[3]. The jumping escape response was lateralized at the individual level, which could help avoid the predictability of the display itself. In contrast, predator surveillance was lateralized at the population level. This lateralized behavior could improve coordination in the swarm during certain group tasks such as predator monitoring. A further set of experiments confirmed the hypothesis that jumping direction and surveillance orientation of *L. migratoria* can be modulated when previously exposed to the approach of a robotic predator (i.e., the leopard gecko, *Eublepharis macularius*)[4]. The study of interactions between insects and robots represents a promising strategy to explore social learning (i.e., a highly complex process for acquiring information on the environment). In the third study, *Lucilia sericata* adults were induced to observe bio-robotic conspecific and predator demonstrators reproducing different flower foraging choices. The social information provided by the bio-robotic demonstrators significantly influenced the fly selection process and indicated the complex risk-benefit trade-off that flies undertake. *Lucilia sericata* adults avoided colored disks previously visited by a bio-robotic predator and preferred those previously visited by a bio-robotic conspecific[5]. The fourth case focused on the study of lateralized population-level searching in the castor bean tick, *Ixodes ricinus*, using a mechatronic device[6]. The device moved a tuft of fox fur as a host-mimicking combination of visual and olfactory host-derived cues extended over time and standardized for each replicate. Of note, the device can be further used to study the effects of repellents on tick detection under

highly reproducible conditions. From a practical perspective, robotic devices are critical for introducing automation and bioinspired engineering solutions to the procedures currently used for artificial feeding of bloodsucking arthropods to increase the effectiveness of blood-feeding systems by improving their host-like characteristics. Overall, ethorobotic studies on insects and mites deserve further research efforts to increase our knowledge of arthropod behavioral ecology and its applications in the field, especially concerning Integrated Pest/Vector Management optimization.

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