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# Interactions between calliphoridae dipters and *Helicodiceros muscivorus*

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**Abstract**. *This article reports on the experimental results of a research programme dealing with the reproductive strategies of* Helicodiceros muscivorus *(L. fil.) Engler (Araceae: Aroideae). In particular, the role played by the odorous mixture emanated by the vegetable species as olfactory information received by the insects, and the importance of that specific biological activity in governing the behavioural choices made by the pollinating insects is studied.*

**Riassunto.** *Questo articolo riporta i risultati sperimentali di un programma di ricerca sulle strategie riproduttive di* Helicodiceros muscivorus *(L. fil.) Engler (Araceae: Aroideae). In particolare, viene descritto il ruolo svolto dalla miscela odorosa emanata dalla specie vegetale quale informazione olfattoria recepita dagli insetti, e l'importanza di tale specifica attività biologica nel guidare le scelte comportamentali degli insetti impollinatori.*

The expression «floral fragrance» is not always synonymous with delicate perfume. Proof of this lies in the singular case of the Araceae, plants that emanate a particularly disgusting smell to attract insects and in this way put into practice a diabolical strategy for being pollinated and ensuring reproduction.

The repellent smell of the arum leaves no one indifferent. Indeed, all keep their distance, with the exception of some insect species, which find it quite attractive. Such a clear success with these animal organisms aroused the interest of a group of researchers at the University of Cagliari, who studied in depth the secrets of this mysterious phenomenon. In fact, for quite some time many of the experiments performed by this research group, coordinated by Professor Anna Maria Angioy, concern the study of the senses of olfaction and taste in different animal organisms, especially insects (http://esitosymp.org).

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Of the several species of Araceae, the choice fell on the emblematic case of *Helicodiceros muscivorus* (L. fil.) Engler (Araceae: Aroideae) known as *snakeroot* «erba serpentaria» [1] (fig. 1), a plant that grows on the small islands off the coasts of Sardinia, Corsica and the Balearic Isles [2, 3]. This was certainly not a difficult choice. Although its presence had been described several times, data on the biology of this vegetable species were scanty and often in the form of anecdotes. But knowledge on the subject of insect/plant interactions plays an important role in the international scientific scenario. Moreover, *Helicodiceros muscivorus* is a rare species and therefore to be safeguarded because of its importance in the field of biodiversity. Finally, a reason of fundamental importance in

*Photo:* SALVATORE SPANO

**Figure 1. *Helicodiceros muscivorus* (L. fil.) Engler: the spotted pigmentation of the floral spathe imitates the skin of a snake.**

undertaking this study was the realization that the plant grows on the Sardinian islands of Cavoli and Serpentara (fig. 2); therefore studying and understanding it meant making a contribution to knowledge concerning a rarity in Sardinia's biological heritage.

The odour emanated by *Helicodiceros muscivorus* recalls that of a decomposing animal carcass, which usually attracts numerous Calliphoridae dipters (fig. 3). The latter are nothing more than quite common flies, the females of which use decomposing meat as the substrate for depositing their eggs. Such observations led to the supposition that the plant was playing a flagrant chemical trick on the insects by simulating the carcass of an animal. From this came the hypothesis that the odour produced by the plant might

*Photo:* Salvatore Spano

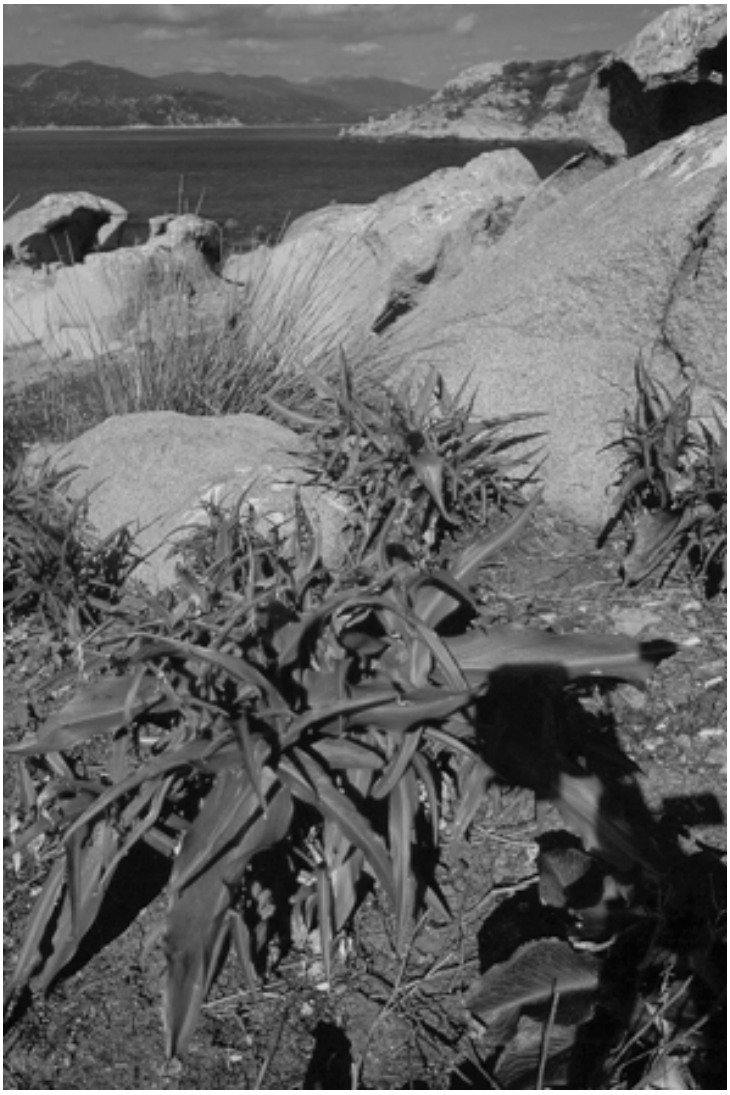

**Figure 2. Island of Serpentara: *Helicodiceros muscivorus* in the period of florescence.**

represent an exemplary case of perfect imitation of the odour produced by an animal substrate in putrefaction. Confirmation of this hypothesis signified demonstrating that the odour of arum was chemically identical to that of the carcass. Moreover, both the odours should evoke equivalent sensorial activity and therefore generate identical olfactory information in the insect.

To identify the biological activity of the single volatile substances present in the odorous mixture gathered from the plant and the carcass, a combination of a gas-chromatographic and a mass spectrometric chemical analysis was used. Simultaneously, an electro-antennographic (EAG) functional survey was performed on the insect's olfactory sensorial neurons [4].

*Photo:* SALVATORE SPANO

**Figure 3.** ***Calliphora vicina*** **on the spathe of** ***Helicodiceros muscivorus.***

*Photo:* Salvatore Spano

**Figure 4. Floral spathe of *Helicodiceros muscivorus* visited by Calliphoridae dipters.**

The results show that the plant volatile mixtures and the decomposing meat have in common three identical chemical compounds capable of powerfully exciting the olfactory nerves of insects' antennae. Even the patterns of the antennal electrophysiological responses, that is to say, the nervous olfactory information sent to the Central Nervous System, were of the same intensity and specificity. In deciphering the information, the insect brain thus interprets the message as corresponding to a delicious and attractive perfume. In fact, the same number of insects were attracted by the odour of the plant and by that of the animal carcass. Decidedly interesting was the fact that the exemplars were prevalently females of *Calliphora vicina* and *Lucilia caesar* (fig. 4).

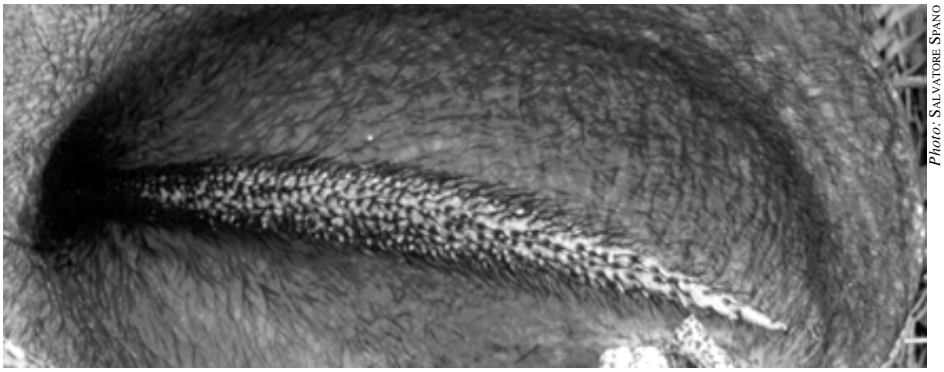

*Photo:* SALVATORE SPANO

**Figure 5. Apical part of the spadix of *Helicodiceros muscivorus* enveloped by floral spathe.**

As a confirmation that insect behaviour was effectively «guided» by the three chemical components and only by these, a blend of their synthetic analogues was placed on plants that had stopped emanating odours and therefore could no longer attract insects. Simulating in this way the production of odours in no longer active plants, it was seen that their power to attract was revived: the same number of insects flew to the chemically manipulated plants and to the plants emanating their natural odour, while they almost completely ignored plants that no longer emanated odour. The volatile substances identified in the odorous blend produced by the plant therefore represent molecules with a specific biological activity involving the insects' behavioural choices.

*Helicodiceros muscivorus* therefore activates perfect chemical mimicry with which it succeeds in capturing a large number of female insects, the problems of which only just begin with capture [5]. Under the impression that they have found a perfect place for depositing their eggs and thus ensuring their progeny, they are instead about to fall into a trap cleverly devised by the plant. The surface of the floral spathe is in fact a perfect imitation of the skin of an animal, both in its reddish-pink colour and its being covered with a thick growth of hairs. To further strengthen the illusion there is also the fact that the spadix (fig. 5), an axile structure enveloped by the spathe, produces heat when the plant is in bloom. For female flies, irresistibly attracted by the multisensorial information including chemical, visual, tactile and thermal signals, a tremendous ordeal begins. They go down into the interior of the concameration corresponding to the proximal part of the spathe, a sort of chamber trap containing the reproductive organs of the plant. The male and female flowers, situated in distal and proximal positions respectively on the spadix, are separated by a bare part of the latter and by a ring of elongated sterile flowers. When the flies reach this position they are imprisoned between the male and female flowers. In their long struggle to escape, they spread the pollen they were covered with when they previously visited another plant. After twenty-four hours, their mission has been completed: the female flowers have been fecundated, the inflorescence loses its enticing smell, the heat-producing activity ceases, the sterile flowers become dehydrated and the

floral chamber can gradually free the insects, by then exhausted. Some do not survive this torture and their remains can be found inside the trap, frequently accompanied by larvae born from the recently deposited eggs. As concerns the surviving flies, a final formality awaits them before regaining their freedom. On the way out of the floral chamber, they must touch the male flowers which in the meantime have reached maturity and are therefore abundantly covered with pollen. Thus, on abandoning the plant, the flies take on a load of precious pollen so as to be ready for their appointment with other *Helicodiceros* awaiting their visit.

Odours are surely an extraordinary and widespread means of seduction, and not only in the insect world, as many have experienced, even personally. In the case of the insects in question, odours represent a means of seduction far more effective than the sight of the flowers in orienting them and leading them to their favourite sites, even when they are at great distances.

The results of this research [5] represent a fundamental contribution to knowledge concerning insect/plant interactions. From the experimental results come important prospects for development in the practical and applicative fields, of great interest both owing to the potentialities expressed by the use of species of «useful insects» and in systems of integrated biological control of harmful species in the medical-veterinary and agrobusiness fields.

Together with this research, an intensive programme of educative and training activities at secondary school and university level have been carried out, together with information supplied to the general public. A synthesis is given in the website http://www.unica.it/~biologia/isolevillasimius/

## REFERENCES

[1] Bocchieri E., *The flora of Serpentara Island (Southern Sardinia): phytogeografic relevance and conservational requirenment*. Colloques phytosociologiques, XIX, vegetation et qualitè de l'enviroment cotier en Mediterraneè (Cagliari, 1989).

[2] Rosello J.A. & Saez L., Notes on some Balearic *Araceae*. *Acta Bot. Barc*., **44**, 169-174 (1997).

[3] Fridlender A., Distribution, ecology and conservation of *Helicodiceros muscivorus* (L. fil) Engler in Corsica. *Webbia*, **55**, 7-35, (2000)

[4] Arn H., Städler E., Rauscher S.*Z.,* The electroantennographic detector – a selective and sensitive tool in the gas chromatographic analysis of insect pheromones. *Naturforsch.,* **30**: 722 – 725. (1975).

[5] M.C. Stensmyr, I. Urru, I. Collu, M. Celander, B.S. Hansson, A.M. Angioy, Rotting smell of dead - horse arum florets. *Nature,* **420**, 625-626, (2002).