STUDIES ON THE FUNCTION OF THE ABDOMINAL ROTATION RESPONSE IN PUPAE OF TENEBRIOL MOLITOR

by

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(With 9 Figures)
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INTRODUCTION

Tenebrio molitor is commonly found in mills, farmhouses, and other places where grain products have been stored. The insect tends to occupy dark, moist, illventilated areas in these habitats. The larval stage (the yellow mealworm) pupates in the late spring, remaining a pupa from 8 to 20 days (temperature dependent), and then emerging as an adult grain beetle in the summer (HINKIN, 1964; DAVIDSON & PEIRS, 1966). Although some behavioral work has been carried out on the larval and adult stages (e.g. GROSSLIGHT & HARRISON, 1961; PERTTUNEN & PALOHEIMO, 1963; ALLOWAY, 1969, 1970; and AUGUST, 1971), HOLLIS (1963) reported what appears to be the only behavioral study of the pupa. Briefly, HOLLIS (1963) carefully described the abdominal rotation response (a relatively vigorous circular movement of the abdominal segments), demonstrated that it could be reliably elicited by electrical and tactile stimulation, and reported habituation to repeated electrical stimulation.

The impetus for beginning the present line of research was to develop an understanding of the function(s) this most curious response served for the species. Since relatively little is known about the response, the present series of experiments was designed with the more limited preliminary goal of collecting relevant information about the response system in order to facilitate the formation of productive functional hypotheses. The methodological strategy employed consisted of deriving a list of many "possible" functions

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(based on the Hollis experiment, general biological background information on *Tenebrio molitor*, and some informal observations in our laboratory), and then attempting to gather evidence of specific characteristics (or parameters) of the abdominal response system which would reflect on the plausibility of these functional interpretations.

The present experimental approach represents a formalization of the "research strategy" informally utilized by ethologists (often in the field), to derive and quickly test hypotheses concerning the survival value of a particular behavior or structure. Tinbergen (1963), in his comprehensive review of methodological issues relevant to the problem of function, discusses the field observations that led to Blest's (1957) classic study of predator reactions to "eyespots" of butterflies:

"A peacock butterfly (*Vanessa io*) has cryptically colored ventral wing surfaces. When at rest, these surfaces are exposed to view. When disturbed in cool weather, for instance by a human observer prodding it with a sharp twig (italics ours), the peacock butterfly flaps its wings, thereby exposing the brightly colored 'eyespots' on the dorsal surfaces and its fore- and hind wings. While doing this the insect orients itself accurately in such a way that the surface of the wing is continuously turned towards the observer" (Tinbergen, 1963, p. 528).

The importance of this preliminary phase of work on the problem of function, while perhaps not immediately obvious, can be understood if one considers that the failure of touch stimuli to elicit the response would have strongly indicated that the predator defense hypothesis needed some re-thinking, and most certainly Blest's (1957) research on predator reactions to "flashed" eyespots would have taken a very different turn.

In the case of abdominal rotation in *Tenebrio molitor*, based on what little information could be assembled, several possible interpretations were suggested: (1) The response may be an antipredator-parasite defensive response; (2) it may serve to remove small objects which have fallen on the pupa; (3) it may serve to shift the animal's body orientation; (4) it may be used for locomotion to escape from some unfavorable environmental condition; (5) it may aid the animal in emerging from the pupal skin; (6) within the context of the large-scale physiological reorganization in progress during metamorphosis, it may serve a self-stimulation/exercise function; and finally (7) the primary functions of the response may occur within either the larva or adult stage, and the response system in the pupa may either be a carryover (from the larva), or the early development of an adult response mechanism with little actual utility in the pupal stage itself. The present series of experiments was designed to investigate several of these possibilities.