CO-ORDINATED RESPONSE TO STIMULI IN CORAL POLYPS

WITH the assistance of an award from the Commissioners for the 1851 Exhibition and of a grant from the Royal Society, Dr. G. A. Horridge left the cold waters of the North Sea for a period of two months to visit Ghardaqa on the Red Sea, in order to study the response to contact stimuli of corals living in that warm sea. A report of this work has recently been published*. The term coral includes so many subclasses, orders and families that no conclusions regarding response can be formulated which will apply to all of them. Most corals expand only in darkness and do not keep well under artificial conditions, so that Dr. Horridge worked chiefly at night, with a dim light, and used fresh material for each experiment. Electrical stimulation was based on the discharge of a condenser as described by Pantin, and the number of polyps which began to retract was recorded visually. The progressive spread of excitation across the colony in response to successive shocks at short regular intervals was observed. To take two examples: in a gorgonid (*Acabaria pulchra*) a stimulated tentacle reacted, and the retractions gradually spread to neighbouring tentacles, until all the tentacles of one polyp had contracted symmetrically, but unlike other corals there was little co-ordination between the polyps of the colony. In *Tubipora*, on the other hand, there is a highly correlated conducting system, although this is subject to the intensity and repetition of the stimulus. In more than a dozen species studied, however, it was found that the individual polyps possess a conducting system which co-ordinates their retraction through the mesenteric muscles. At first the reaction is slow, requiring a second shock to activate it fully, and causing a jerky wave of polyp retraction, differing from the slower and more continuous feeding response.

A working model was constructed to illustrate the effect of conducting and non-conducting units in inter-neural facilitation in a two-dimensional net, using a perforated board with movable pegs. The non-conducting unit is assumed to be so "at the instant when an impulse arrives", but the connexion "becomes conducting for later impulses which may arrive within a specified time". Experiments with the model, however, do not coincide with those on the living colony in certain species, the spread of excitation in which is less than that in the model. To account for this variability a second model was used. The nerve net is now considered as a population of cells, and an impulse excites only a proportion of the cells in a group. In some species, and in others after low stimulation, there was no interaction between units; in other species the wave of excitation spreads when more than a critical number of units is stimulated.

The inter-neural facilitation theory of Pantin assumes an all-or-nothing response, in which a series of separate units forms, for the time being, a continuous pathway. This theory is inadequate for the corals, and requires modification along the lines suggested by Dr. Horridge. Yet all theories await histological research on the nerve net of corals.

N. B. EALES

* Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 675, Vol. 240 (9 May, 1957): The Co-ordination of the Protective Retraction of Coral Polyps. By G. A. Horridge. Pp. 495–529. (London: Royal Society, 1957.) 12s.

THE EUROPEAN BADGER

SOME interesting observations on tame and wild badgers (*Meles meles meles* (L.)) have been made by John Sankey, of the Juniper Hall Field Centre at Dorking (*South-Eastern Naturalist and Antiquary*, 60, 20; 1955).

The tame badgers were kept in captivity primarily to obtain information on their breeding cycle and habits. This has not yet been possible, but other information, otherwise difficult or impossible to get by watching the animals in their natural habitats, is recorded in the paper.

All the animals were obtained within six to about eight weeks from birth. At about two months the cubs emerge from the sett for the first time, and older badgers have usually been so conditioned to their natural life that it is impossible to tame them. Young animals taken before or at this critical point of development will readily take to a human, and, by frequent handling and attention, become very tame. Their reactions to certain situations are often remarkable and amusing. Badgers vary in their temperament, the females probably being more equable.

The badgers thrived on a variety of foods, and the diet could be varied within wide limits.

From observations on eight females and seven males the average weight of a badger about eight weeks old was found to be 4½–5 lb. The difference in weight between the sexes does not appear to be significant at this stage, and any deviations from the normal might be due to other heredity or nutritional causes.

From specimens reared, but not born, in captivity the weights of the adult male and female differ more. The male is, on an average, a little more than four pounds heavier than the female. These badgers appeared to be fully grown, but not necessarily sexually mature, about the autumn of their first season. Little increase in weight occurred from then onwards.

Badgers lose some of the smaller white hairs during the first summer, and the longer, thicker hairs are gradually replaced. A noticeable moult occurred from the beginning of June and lasted for several weeks. This appears to be the badger's annual moult. Scratching is intense during this period, and the hair may be shed in quantity.

Several of the captive animals died when young, mostly before eight weeks. Since their former life is unknown, that is, at the time when they were dug out or where caught in some other way, little can be deduced about their resistance to disease, though two cubs succumbed to a pneumonic infection which they had contracted previously.

There is little information about whether badgers do bathe in pools, ponds and rivers. Observers agree that badgers drink water, and this was confirmed by the captive badgers. Bathing is recorded in the case of three males and three females, but only during summer. One female began to go into water at about five months, and all the others bathed during their first summer. When the weather is warm, a bath is taken regularly. It seems very probable that wild badgers go into water regularly in the summer months. Badgers keep their faces very clean. The action is similar to that of a cat; the paw is licked and wiped over the face.

All the badgers reared beyond eight weeks have retained the natural habit of "setting scent" in captivity. Scent may be frequently set on the same object, such as a man's shoe. Unfamiliar objects interest the badger ; but the fact that scent is set on familiar things, on which it was set perhaps only a few moments before, is difficult to explain.

The scent appears to serve the purpose of marking out territory and to enable the creature to locate its whereabouts. There appears to be no difference in this habit between male and female even when kept together. Nor is there any modification in the setting of scent in the presence of dogs and tame foxes. Fear causes the sudden release of musk in tame badgers. The fluid is milky-yellow and of moderately thick consistency.

Only four sounds have been noted in the case of tame badgers. First, there was a persistent rhythmical whimpering in young specimens which was nearly always followed by death ; this was apparently a note of discomfort or pain. Secondly, there was a low continuous guttural purr produced when food was smelt, or when the animals wanted attention ; this was probably a conditioned feeding request. Thirdly, a deep-throated muffled growl, which was clearly a note of warning, and sometimes followed by attempted attack. Fourthly, there were puppy-like yelps used only during play, and more especially in juveniles up to about six months.

The badgers were reared and kept on an artificial diet. Small quantities of vitamins and salt were added to the food from time to time. The food taken confirms the badger's omnivorous nature. Meat is undoubtedly preferred, and sweet things are greatly liked. One female badger drank small quantities of mild ale, and a male on several occasions lapped sweet wine. A number of natural foods were tested —among them being earthworms, insects (some showing aposematic colours) and molluscs. Most of these (including some insects with aposematic colours) were eaten, with the exception of the Roman snail (*Helix pomatia* L.).

In his observations on wild badgers Sankey showed that badgers can become conditioned to the presence of man ; little attention need be paid to whether the badgers smell the observers.

Badgers pick up food anywhere, but usually have fairly well-defined feeding grounds ; there is a definite pattern of tracks from the colonies to the feeding grounds. Dung pits are concentrated near the setts or the feeding grounds, and are seldom seen elsewhere. Yew berries appear to be eaten fairly liberally in the autumn but are often regurgitated.

The loud "blood-curdling" noise described by Neal has been recorded, and supports Neal's opinion that this call has no sexual significance ; it does not preclude the possibility that on occasion it can be used to attract from a distance an animal of the opposite sex. The observations also suggest that the sound has nothing to do with the dismissal of the cubs.

The article also contains an account of an old badger-baiting pit.

AN ELEMENTARY THEORY OF INTERSPECIFIC COMPETITION

By M. H. WILLIAMSON

Department of Zoology, University Museum, Oxford

THE proposition known as Gause's hypothesis is often stated so as to imply that two species cannot remain in competition indefinitely. In the mathematical theory of competition cases occur in which two competing species can coexist. The word 'niche' has been used in discussions on this subject, but not in such a way that it can be applied unambiguously to field data. It would therefore seem worthwhile to restate and develop the mathematical theory so that its relation to particular situations in the field is more readily apparent. Before this can be done, it is necessary to discuss what is meant by the word competition. There are almost as many definitions of competition as there are authors who have written on the subject, and it would be pointless to mention all the variants that have been proposed. Instead, an argument will be developed which leads to a definition that can be treated mathematically, and comments on other definitions will be given during the argument.

The usual meaning of a word must be considered when defining it for scientific use. No doubt Andrewartha and Birch[1] had some such idea in mind when they said that "The literal meaning of 'compete' is 'together seek' ". This is not the literal meaning of compete but a literal translation of the Latin *competere*, which means to coincide. The Concise Oxford Dictionary gives 'strive with another' as a possible meaning of compete, and this suggests that there are three properties that must be included in a definition for use in ecology. These are : (1) that competition is mutual or reciprocal ; (2) that it is harmful ; (3) that the action of A on B is of the same type as the action of B on A.

Properties 1 and 2 are equivalent to the definition given by Odum[2], when he says that the effect of population growth and survival of species A on species B is negative and the effect of B on A is also negative when they are in competition. Elton and Miller[3], by saying "*Interspecific competition*, in the more limited and correct use of the notion, refers to the situations in which one species affects the population of another by a process of *interference*, i.e., by reducing the reproductive efficiency or increasing the mortality of its competitor. Or both species may be acting in such a way on each other", deliberately exclude property 1 ; but it is difficult to distinguish between some cases that they would call competition and, say, predation. The bearing of (3) on ecology can perhaps be clarified by an imaginary example. Suppose that a population of predators, say, dogs, are feeding on a population of prey, say, rabbits. Suppose also that many of the dogs are poisoned by eating the rabbits. Then the effect of the dogs on the rabbit population and the effect of the rabbits on the dog population would both be negative, and so by Odum's definition the species are in competition, although the situation is not one which most people would consider to be competition at all.

At this point it is necessary to define the term 'controlling factor'. By this is meant a factor which acts more severely against the individuals of a popula-