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GENERAL REVIEWS AND SUMMARIES

RECENT LITERATURE ON TROPISMS AND
INSTINCTIVE ACTIVITIES

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Allee (1, 2) asserts that the rheotactic reaction alone is not sufficient to account for the position isopods assume in streams, and that the thigmotaxis is also of importance. The molting period and breeding season are important in the ecology of stream isopods since they decrease the clinging ability. Other experiments show that the survival time in potassium cyanide is, for *Asellus communis*, inversely proportional to the rate of metabolism. Since isopods which are strongly positive to current have a much shorter survival time than those which are indifferent, it appears that high positiveness to current is an expression of a relatively high rate of metabolism.

Allen's (3) investigations show that in fresh water mussels the surfaces of the gills, the end of the upper part of the mantle, and the labial palps serve to carry food to the mouth. The food supply is not regulated but the amount of digestive juices secreted, and hence of digestion accomplished, depends upon the need for food. Digestion seems to be mostly accomplished in the stomach as few living organisms were found to have entered the intestine. A discussion of the possible use of the crystalline style is given.

Armbruster (4) in a very interesting paper on humble-bees describes the architecture and building materials of the nests, relation of sexes, color varieties, and orientation. He believes that bees usually find the way back to the hive by "optical signals"

but that they are also, after they have traveled a route many times, able to find it "blind" as an expert player is able to pick out the keys on a piano.

Babcock (5, 6) has made observations on the hibernating habits of the jumping mouse. Torpidity is periodic at the beginning of the season, lasting for only short intervals. The length of the period of hibernation is probably not entirely determined by temperature. In another paper this author states that the shrew, *Blarina brevicauda*, consumes very large quantities of food, sometimes several times its own weight in the course of a day. Since its food consists mainly of insects, other small animals, especially mice, and a little vegetation, it is of great economic importance.

Banta (7) writes an interesting description of the mating behavior of the wood frog, *Rana sylvatica*. Usually a female is clasped by but one male. Occasionally she may be pursued by a number, and a battle ensues in which she is often the one to suffer. It is possible that in sex recognition color and the peculiar behavior of the female play a part, but finally a chemical sense seems to be involved, although the one experiment designed to test this was unsuccessful.

Beck (8) discusses the importance of electrical phenomena in the central nervous system of the frog and presents experimental work.

Bittner, Johnson, and Torrey (9) have reëxamined the reaction methods of the earthworm to light. They maintain that there are neither random movements nor "trials," but that orientation is direct.

Using very sensitive apparatus Bose (10) has studied the rate of transmission of excitation in the sensitive plant. The latent period grows shorter as the stimulus is increased until the minimum is reached, the shortest being 0.06 second. Variation in temperature influences the rate of transmission (12.5 mm. per second at 31 degrees C.; 6.6 mm. at 23 degrees C.). From various experiments with electricity and temperature Dr. Bose concludes: "These results prove conclusively that the transmission of excitation in the plant is a process fundamentally similar to that which takes place in the animal."

Brunacci (11) finds that the frog, *Rana esculenta*, is greatly affected internally by changes in the concentration of its liquid environment. 10 per cent. solution of NaCl is maximal. Beyond this great metabolic changes occur in the water content of the tissues.

Buttel-Reepen (12) gives a lengthy review of the continental work on the relations of bees to flowers and discusses some observations of his own. He believes that odor is less important than color in attracting bees to blossoms. He also asserts that, though humble-bees often break through the corolla to rob flowers of their nectar, honey-bees seldom do so.

Cameron and Brownlee (13) have investigated the ability of frogs and their tissues to survive low temperatures. They give a complete review of recent literature and present experimental work. "Frogs freeze at a temperature of -0.44 degree C. to -0.02 degree C. in a manner very similar to that of solutions isotonic with their body-fluid." Heart tissue will survive a temperature of -2.9 degrees C. Frogs probably die at low temperatures on account of a specific effect on the brain or spinal cord.

Cowles (14) found that the starfish, *Echinaster spinosus*, when put into a black box illuminated from above would nearly always move toward a white card placed on one side of the wall. He believed this reaction was caused by the reflection from the card which caused the side of the starfish nearest to it to receive more light.

Crozier (15) finds that *Holothuria capitata* is photokinetic, its whole surface being sensitive. Although this sea-cucumber does not respond to an increase in intensity of light, it withdraws when shaded. It moves only with the anterior end in advance and is negatively phototropic. The green fluorescent integumentary pigment probably acts as a sensitizer.

Experiments were performed by Miss Dale (16) to determine the limits of hydrogen ion concentration fatal to *Paramoecium*. The action of the hydrogen and hydroxyl ions and of the polyvalent kations and anions may perhaps be ascribed to the power possessed by these of conferring electric charges on colloidal materials with which they come in contact.

Dice (17), in an excellent paper on the movements of *Daphnia* discusses the effects of temperature, light, gravity, mechanical stimulation, chemical content of water, age, and other factors. He concludes that, "the diurnal movements of *Daphnia pulex* are caused chiefly by changes in light intensity. The limits of the diurnal movements are determined by the factors effective in producing the seasonal movements. . . . Much of the behavior of *Daphnia* is determined by orientation to various stimuli, but some regulatory behavior is obtained by means of random movements.

. . . Change in geotaxis by changes in light intensity and in temperature has been observed in other plankton organisms, and is probably of widespread importance in determining the vertical movements of plankton."

Dupont (18) states that the mechanical irritation of the semi-circular canals in cartilaginous fishes causes reflex movements of the eyeball.

Hahn (19) describes the hibernating habits of the bear, woodchuck, bat, and ground squirrel. He had a pet ground squirrel which, although kept in the laboratory, slept for varying lengths of time whenever the room temperature was allowed to fall near the freezing point.

Hamilton (20) has studied the sexual behavior of monkeys confined in large cages or allowed to run free out doors. "At least two, and possibly three different kinds of hunger, or needs of individual satisfaction, normally impel the macaque toward the manifestation of sexual behavior, viz., hunger for sexual satisfaction, hunger for escape from danger and, possibly, hunger for access to an enemy." Homosexual relations are of common occurrence, even when members of the opposite sex are present.

Kanda (21) discusses mechanical, pressure, resistance and statocyst theories of geotropism with reference to *Paramœcium* and *Spirostomum*, concluding that the statocyst theory is probably correct, though not yet proved. He also shows (22) that the negative geotropism of the larva of *Arenicola cristata* is reversible by calcium and magnesium salts, but not by sodium and potassium salts. This is probably due to the Mg^{++} and Ca^{++} ions. The positive reaction to light is negated by NaCl, KCl, MgCl, and by seawater after exposure to $CaCl_2$ solution. Acids, alkalis and narcotics, so far as tried, did not reverse the geotropism of this larva.

Lashley (23) notes two instances of the persistence of the sucking instinct of cats into adult life.

Levick's (24) account of the nesting habits of Adelie penguins gives many points of interest. The males fight for mates but the victor does not always get the female sought. "As a rule it is the strongest and cleverest fighter of the group; but, curiously, this is not always so, as sometimes the bird who has undoubtedly proved himself the victor suddenly walks off, and by general consent his vanquished opponent is left in possession of the field." The recognized suitor must next be accepted by the female, and is often kept courting for some time. Once a pair is mated, how-

ever, no bachelor male can break up the match. The cock fetches stones for the nest, which the hen builds. "The adult birds are very fond of playing games." In order to have time for such recreation and to feed, they take turns with the incubation and the care of the young. A number of pairs may cooperate in the latter duty.

According to Lillie (25) the irritability of living organisms is due to changes in the permeability of the plasma membrane. These changes depend upon slight variations in external conditions, especially electrical phenomena. Variations in the speed of response and sensitivity depend primarily on the specific peculiarities of the plasma membranes of different tissues.

McIndoo (26, 27) has made a careful study of the olfactory sense in insects. He makes an extended review of the literature on the subject and concludes "that the organs called the olfactory pores by the author are the true olfactory apparatus in Hymenoptera and possibly in all insects and that the antennæ play no part in receiving odor stimuli . . . it will be realized that the antennæ can no longer be regarded even as a possible seat of the sense of smell in insects."

Polimanti and Mares (28) have been disputing about the condition of animals during winter sleep. The former accuses the latter of saying that during hibernation mammals are in a hypnotic state, the usual heat-regulating mechanism not functioning, and they show atavism in that they "return" temporarily to a condition like that in cold-blooded animals. This Mares does not deny but takes exception to Polimanti's assertion that he stated that bile- and gall-secretion were at a standstill during hibernation.

Mast (29) in discussing *Euglena's* method of orientation to light maintains that its responses are brought about by changes in light intensity, contrary to the assertions of Bancroft and Torrey. He also gives a very good discussion of the "trial and error" and "tropism" theories and advocates the abandonment of the latter term because it has been given so many meanings by different authors.

Patten (30) has attempted to standardize the reactions of blow fly larvæ to light by subjecting them to the simultaneous action of opposed horizontal beams of light of known intensity. When the two lights were of equal intensity the larvæ followed an almost straight course perpendicular to the line connecting the two lights. When the lightes were unequal they showed a deflection toward

the weaker light, the deflection being proportional to the intensity differences. An arrangement of bilaterally sensitive areas is suggested. The phototactic response is said to depend to a large extent on the stimulating effect of constant light and to follow the Bunsen-Roscoe Law.

Pearl (31) reports observations on the brooding instinct of Barred Plymouth Rock chickens. This instinct normally constitutes one element in the cyclical reproductive activities of hens. Though it usually recurs with greater or less regularity following periods of laying, it may appear in pullets which have laid only one egg and that some little time before. Broodiness appears rather suddenly and usually disappears slowly. Its manifestation is apparently closely connected with the functional activity of the ovary.

Phipps's (32) experiments with three species of amphipods seem to indicate that they respond negatively to changes in light intensity but are more strongly influenced by the direction of rays. When treated with depressing agents such as KCN, chlorotone, CO_2 , and when in a starved condition, many reverse their reaction probably on account of changes in their metabolic processes.

Powers (33) concludes that crayfishes are able to discriminate increases in CO_2 , and acetic or hydrochloric acids in a gradient, different species reacting to these substances in varying degrees. In general the reaction to hydrochloric acid is the most decided, that to acetic acid next, and that to CO_2 the least marked.

According to Roule (34) one of the biological conditions of the migration of salmon up streams is the seeking on the part of the fish of water which is richer in oxygen.

In his little book on the flea Russel (35) describes the sense organs, feeding and mating habits in considerable detail.

Shelford (36) compares the responses of motile and sessile organisms. In the former the most striking responses are changes in position, in sessile animals changes in structure and form are more prominent. In feeding motile animals are more restricted than at other times, while in sessile animals this is not the case, and the dispersal of spores, seeds, and other reproductive bodies serves to spread the species. On this account motile organisms are a better index as to whether conditions are favorable, but sessile organisms are more important as causes of succession, since they effect the surrounding medium more with waste products, skeletons, etc.

The animals of pond and rapids communities differ in their general reactions, according to Shelford (37), but within each community there is an agreement. Pond animals react best to a current of low intensity while those of the rapids prefer a stronger current. Animals of the same community but found at different levels exhibit specific peculiarities, as in their reaction to mud, sand and stone bottoms. Animals living beneath stones show a preference for weak light, those on stones, medium light, and those among stones, strong light.

Shelford (38) has studied the behavior of several terrestrial amphibians and arthropods to air of high evaporating power. Certain of these animals quickly acquired the ability to go to the parts of the experimental cage where the evaporation was least. Some showed increased sensibility with successive trials, and the writer believes this is probably "due to some disturbance in neutrality brought about by concentration" of body fluids. He also states, "there is no reason to assume that associative memory is essentially different or stands apart from the type of modification here described." "It is, therefore, a fairly safe assumption that the capacity to avoid disadvantageous, and the capacity for advantageous, modification are innate also."

Shelford and Allee (39) report the results of experiments to test the behavior of fish in water containing various substances. "Most of the fishes studied reacted negatively to various concentrations of carbon dioxide; to little oxygen; to boiled water with the removed oxygen restored; and to boiled water with acetic acid or carbon dioxide added. The behavior of the fishes when giving a negative reaction usually possessed prominent features. They tried the modified water a number of times and then began to turn back in lower and lower concentrations of the gradient or to spend shorter and shorter time in the modified water with each visit. The response was rhythmical rather than cumulative," but fishes soon learned to avoid the end of the tank where conditions were unfavorable, and when they did enter the modified water remained for shorter periods of time. "The fishes undoubtedly sense the solutes upon entering them." The writers believe that increased sensibility is due to increased tissue acidity. Advantageous reactions are apparently confined to stimuli encountered in everyday life and there is therefore correlation between the conditions of existence and types of irritability. The increased sensibility after repeated stimulation is not believed to be due to associative memory.

Simroth (40) describes his observations on marine gastropods. Colors depend upon pigment, uric acid, and calcium deposits. They frequently serve for warning or protection. Gastropods have many methods of locomotion—through changes of blood, pulsation, swelling, waving lateral parapodia, or gills, etc. Some throw off the gills and dermal processes when molested.

The habits of herring gulls are described and illustrated by Strong (41). These birds nest in large flocks in uninhabited places, particularly islands. They are omnivorous feeders, and hence good scavengers. The breeding season is from the first of May to August. The parents take turns guarding the nest and are ready to fight anything that comes near. Young birds are fed with partially digested food disgorged by the parents. The gulls make a variety of sounds including the alarm cry, the challenge, and the "mewing" for the young. They are easily frightened by sounds, and are sensitive to changes in temperature. They react positively to currents of air. Gulls probably rest during the night except in the breeding season or when food is especially abundant. Their behavior shows some modifiability.

Szymanski (42) has studied the average time of rest and activity of several animals for twenty-four-hour periods. Cockroaches rested during the day and were active from seven to ten hours at night. Goldfish were active mostly during the day. A salamander remained perfectly inactive from November to January. A canary had about the same periods of quiet and activity as man. A white mouse showed sixteen active and rest periods during a day; a gray mouse, nineteen of each.

Vestal (43) in his excellent paper on terrestrial associations points out that ecologically "the characters of plants may be classed as structural, physiological, biographical and numerical. Animals have in addition, behavior or psychological characters."

Wheeler (44) calls attention to a number of points in the behavior of cockroaches, bees, ants, etc., which make them good vehicles for carrying human diseases.

Miss White (45) has studied the reactions of brook trout from the time of hatching until the yolk sac is absorbed. Soon after leaving the eggs the young fish are positively rheotropic and negatively phototropic; light being a more potent stimulus than current. An excess of carbon dioxide in the water causes a rapid swimming without reference to light. Shadows cause no response until the fifth week after hatching and feeding commences at about two months. Sight is the most important sense in learning to feed.

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