A Nutritional Disease of Oats Apparently Due to the Lack of Copper

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A deficiency of available copper in the soil is reported to have caused a nutritional disease of oats in Europe (*1*) and in Australia (*2*), but apparently this disease has not been reported in this country. However, a similar disease has appeared in oats planted on the Experiment Station Farm at Gainesville, Florida, and this report is concerned with the symptoms of the trouble and the remedy for it.

The oat variety, Florida 167, when grown on certain parts of the Experiment Station Farm, has exhibited for several years an apparent nutritional disease. Others varieties have been affected, although they have been grown to a lesser extent. The symptoms of this disease develop on this variety as follows: After being seeded at the usual planting time in November, the oats come up and at first appear normal. The only difference detected after about two months is that the affected oats are smaller than nonaffected plants. In later stages of growth, about three degrees of severity of the symptoms have been noted, namely, severe, moderate, and slight. In severe cases the leaves begin to show a characteristic marginal chlorosis early in February. As the disturbance progresses, the margin and tips of the leaves become brown or may look as if they have been scorched. Tillers begin developing about the middle of February. The emerging tips forming the bud of the tillers frequently are rolled up tightly, and the rolled-up part becomes light colored, then brown, and eventually may die. After that the entire plant may die or may struggle along, putting out new tillers which in turn develop similar characteristics. Such plants produce practically no heads and little foliage. If the condition is moderate, the plants will have some of the characteristics described above. New tillers develop late, which results in the plant material being immature at normal harvesting time. The oats produce heads, but instead of ripening to a normal yellow color, these heads tend to have a whitish-green color, and very little grain is produced. Slightly affected plants appear normal except for considerable blasting and light grain. Sometimes the upper leaves, which cover the head just as it emerges, are chlorotic and may even appear scorched. Symptoms of this nature on this variety have been observed on several farms in central Florida.

Affected plants seem to develop wiry roots that show root rot in various stages, but this is probably secondary in nature. There was no apparent difference in the amount of ***Helminthosporium*** leaf spot on affected and normal plants.

Field experiments, in which the Florida 167 variety was grown, were conducted in a badly affected area[1] in an effort to determine the cause of the abnormality. In one set of experiments a uniform liberal application of the major fertilizer elements, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur, was applied. In addition to the major elements, copper, zinc, manganese, boron, and molybdenum were applied to the soil in all possible combinations before seeding the oats. The copper was applied as copper chloride at the rate of 10 pounds/acre. The seed were treated with New Improved Ceresan. In another experiment an assortment of treatments were tried including fertilizer, rate of top dressing with nitrate of soda, seed treatment with New Improved Ceresan, and the minor elements in combination with these.

[1] The soil type is Arredondo loamy fine sand.

Oats which did not have copper developed severe symptoms of the disease and produced practically no grain. The foliage was small, and very few plants even produced heads. Oats grown on every copper treatment were either free or practically free of the described disease and produced relatively good yields. The only treatment of value was copper. Top dressing with extra nitrate of soda seemed to accentuate the trouble.

Copper chloride which was applied in 1944 to old fertility plots and copper sulfate which was applied in 1942 had a pronounced residual effect on the yield of oats and largely prevented the disease. The disease was prevalent in other parts of the old fertility experiment.

A more detailed report will be published elsewhere.

References

1. MELCHERS, W. J., and GERRITSEN, H. J. *Koper als onmisbaar element voor plant en dier.* Wageningen: N. V. Drukkerij, Vada-Gebr. Zomer en Keuning, 1944.
2. PIPER, C. S. *Aust. Coun. sci. industr. Res. Pamph.* *78*, 1938, 24–28; *J. agric. Sci.*, 1942, **32**, 143–178.

The Migration of Newly-hatched Loggerhead Turtles Toward the Sea[1]

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The initial adaptations of newly-hatched loggerhead turtles may be divided into three major behavioral sequences: (1) escape from the deep nest on the ocean beach; (2) direct migration to the sea immediately after escape; (3) orientation toward deep water once the ocean surf is reached.

The conditions of development of the loggerhead turtle preclude the possibilities of prenatal stimulation in determining the remarkable adjustments of the newly-hatched animal. The nest of these turtles, a hole in the sand about one foot in diameter and two feet deep, is installed in midsummer months by the adult female, which immediately afterward returns to the sea. Each nest contains from 50 to 200 eggs. After an incubation period of about 7 weeks the young turtles hatch, mill around in the nest for 3–5 days, emerge as a group, and make a rapid run for the ocean. Although the crawl from the nest to the water may cover a distance as great as 25 yards, no errors are shown in direction of crawl. Once in the water, the animals swim toward the open ocean. The escape from the nest, which occurs typically at night, is accomplished by slow activity in the nest, which raises the nest floor gradually to the beach surface by knocking sand from above.

The guiding physical stimuli which determine the nest-to-sea movements of the young loggerhead have been the subject of some previous investigations. Hooker (*2*) and Parker (*3*) have referred to positive geotropic reactions, visual hue discrimination and preference, and discrimination of visual "openness" (the uniformity of the ocean horizon) as possible means of explaining the oriented crawling.

In order to determine the critical stimuli for the directing of

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the migration in the young turtle, observations were made under natural conditions and in a privately arranged laboratory on the east coast of Florida.

The major results of these studies show that the newly-hatched loggerhead is activated and guided in its movements from the nest to the sea by photokinesis and phototropism, the critical stimulus for which is normally the light reflected from the ocean surf. The following observations will serve to indicate the validity of this conclusion.

TABLE 1

NUMBER OF TURTLES RESPONDING POSITIVELY TO SIMULTANEOUSLY PRESENTED LIGHT AND GRAVITATIONAL STIMULATION

Angle of incline	No. of animals tested	No. showing positive geotropic response	No. showing positive phototropic response	No. showing ambiguous response*
6°	16	1	8	7
10°	6	1	3	2
13°	11	2	8	1
Total.......	33	4	19	10

* This group includes inactive animals as well as 4 animals which moved in no particular direction around the release point on the inclined plane.

Neither sound nor smell of the water will direct the crawling movements when vision of the surf is prevented. Sixty newly-hatched animals placed in an open pit on the beach milled around but showed no oriented movements in the direction of the water. When vision of the surf was permitted by placing them on the open beach, they entered the water immediately. Four animals, released on the beach on a quiet, moonless night when the surf was absent, failed to find the water, but when released later, at the same point on the beach, after the moon had risen, they crawled quickly into the ocean.

A group of 5 animals placed on the beach at night were observed to follow a beam from a flashlight as it was moved around on the beach surface. Confusion of orientation was produced in a group of 50 turtles by releasing them on the beach on a moonlit night and by stimulating them simultaneously by a spot of light directed near them on the sand. About half of the animals followed the spot of light as it was moved about, and the other half crawled to the sea. Some individuals could be induced to reverse their direction of crawl, even after getting into the water, by moving the light from the edge of the ocean up onto the slope of the beach.

In the laboratory, the newly-hatched animals became very active when stimulated by ambient light, even of moderate intensity. Focal light stimuli in addition prompted the animals to approach and attack the light source. Turtles also showed an acceleration in approach time negatively related to distance from a focal stimulus. Circular crawling in the direction of the seeing eye was induced by temporarily blinding one eye and illuminating from above.

An approximate threshold of discrimination of light intensity was determined by observing the movements toward two light panels differing in brightness. They discriminated light ratios as low as 1:2 at an illumination level of 0.1 millilambert. This discrimination is smaller than the light differences typically occurring either at night or during the day between the surf and surrounding areas of beach and ocean.

Gravity as a stimulus was compared with light directly by releasing the animals on an inclined plane with a lighted window at the top. The results (Table 1) indicate that geotropism is relatively ineffectual. In a similar experiment, pairing light with sea water, the light approach again was dominant.

Further experiments were conducted to discover whether the turtles would crawl toward a "broken" visual pattern in preference to a "uniform" pattern, when opposed by a brightness difference favoring the broken pattern. Every one of a group observed approached the brighter but interrupted stimulus pattern in preference to the dimmer uniform field. This result pointed to an interpretation in favor of light rather than pattern as critical. As applied to the natural environment, this indicates that it is unlikely that the presence or absence of trees, shrubs, or sand dunes defines the seaward movements.

Inasmuch as the migratory nest-sea reactions normally occur at night under levels of illumination precluding the possibility of hue discrimination for the rod-cone eye, as is found in turtles, it was considered that hue discrimination could not determine the movement.

The previously reported embryonic study of development in the loggerhead (*4*) disclosed that the crawling and swimming movements evolve as specialized reactions within a matrix of more generalized body movements, and that these reactions, along with the migratory response pattern itself, may be elicited in animals prematurely released from the egg. The fundamental character of the oriented reactions was further established by the fact that the movements toward light stimuli are relatively unmodifiable through learning of a detour path in a Y-maze. The conclusion was clear from these observations that the light-induced movements were sufficient to account for the stereotyped character of the actual sea-approach behavior. Positive phototropism, conceived as a stage in maturation, is further suggested by the fact that the response becomes weak at about 6 days of age and a negative response to very bright light appears at about 3 weeks of age.

It may be concluded that the phototropic reactions to differences in light intensity and the kinetic effects of light, which may be observed under both laboratory and natural conditions, have significant relations with the environmental circumstances under which the nest-sea migration occurs. At night the white and sometimes phosphorescent surf constitutes the most intense light stimulus in the nest locale. This light is apparently the critical stimulus for both activating and guiding the ocean crawl. At dawn or dusk or, in fact, throughout the day, the brilliant surf also acts as a directing and motivating influence for the animals to reach the ocean. The observations showed that the positive responses to light are dominant and invariable during the first few days after hatching. In addition, it was observed that the female adult carefully selects nestsites which provide clear vision of the surf, and that other geographic features are not involved in the nest location.

The physical stimuli effective in leading the animal from the surf to the deeper areas of the ocean and the processes underlying these movements were not clearly defined.

These studies will be reported in full elsewhere (*1*).

References

1. DANIEL, R. S., and SMITH, K. U. *J. comp. physiol. Psychol.*, in press.
2. HOOKER, D. *Yearb. Carnegie Inst.*, 1907, #6, 111; 1908, #7, 124; *Science*, 1908, **27**, 490; *Pap. Tortugas Lab., Carnegie Inst.*, 1911, **3**, 69.
3. PARKER, G. H. *J. exp. Zool.*, 1922, **36**, 323.
4. SMITH, K. U., and DANIEL, R. S. *Science*, 1946, **104**, 154.