darkness, all fireflies having ceased to flash except three that now rapidly rose into the cherry trees. After a time, which I failed to measure, the fireflies reappeared in their normal number, resuming their regular rate of flashing and their usual mode of flying in very irregular courses and at various heights.

The fireflies were determined by H. C. Fall through K. F. Chamberlain, assistant state entomologist, as belonging to the *Photinus scintillans-marginellus* group. As no "glow worms" were observed in the grass, it is probable that the females were of the luminous kind and flying. Only males were captured, however.

As Lutz in his "Field Book of Insects," points out, the lightning, in *Photinus* at least, is principally for sexual attraction. He adds: "Another view is that the light is a warning signal to nocturnal birds, bats, or other insectivorous animals. The family Lampyridae to which the lightning bugs belong is known to be refused by birds in general." It is therefore readily understood that the fireflies when frightened by the air vibrations, if not the noise of the firecrackers, raised their warning signals at double speed. This is especially obvious when it is remembered[1] that the flashing is the result of a stimulus conveyed by special nerves whereby oxygen is brought to the network of tracheae in the adipose tissue, thus producing a slow combustion, and being of the nature of a reflex motion.[2]

The sudden lighting up and nearly as abrupt darkening of the garden could be considered as rude major synchronous flashing induced by vibrations of the air. This is somewhat in line with the observations of Hess,[3] who found that he could initiate synchronous flashing by means of a pocket flashlight and even cause the insects to adopt a somewhat higher frequency of flashing. Also in this case the more rapid flashing was of the nature of a warning signal, and it is worth noting that the fireflies excited by the cannon crackers showed a double frequency of flashing. Flashing, therefore, on occasion serves undoubtedly as a warning signal besides its usual sexual function.

A perusal of literature indicates that various theories have been advanced to explain the concerted action or photosynchrony. Most recent authors[4] believe that the synchronous flashing is led by a pacemaker. This theory of "sympathy" is supported by observations like those of Alexander who saw the flashes passing like waves over a long row of trees near Bangkok and noted slight differences in time of flashing but not in frequency. Others have tried to explain the synchronous flashing by the influence of concerted movement. Thus von Osten-Sacken (see Brehm's Tierleben) observed the synchronous flashing of the American species *Photinus pyralis* L. to be connected with rhythmic up-and-down movements of the swarms of fireflies, and Allard[5] notes that as the creatures arise very slowly, each flash is attended by a sudden upward flight-impulse which may even carry them almost straight up several feet. On the other hand, the frightened and more rapidly flashing fireflies which the writer saw in his garden kept strictly near the ground and Morrison observed the synchronism near Bangkok on still as well as on quite windy days. It seems, therefore, that the photosynchrony is somewhat dependent on the movements of the beetles, but independent from the stimulating influence of breezes, as one might suspect. The major influence in the synchronism is then apparently the reflex action of the fireflies on seeing the light of the luminous pacemaker. This mass action may, however, have been originally induced by a strong external stimulus, such as the air vibrations proceeding from the cannon crackers, and the writer had, indeed, the impression that there followed upon the general luminosity of the fireflies a period of longer intervals of more general flashing and of prevailing darkness.

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[1] See Vernon L. Kellogg, "American Insects," p. 269, 1908.

[2] The sudden luminosity of the fireflies upon being frightened reminds the writer of a similar effect he saw on a night when the Atlantic Ocean was brilliantly phosphorescent and the bathtub filled with sea water would become a fiery phosphorescent mass every time the water was agitated. Also in this case, the *Noctilucas*, even though lowly protozoans, responded by suddenly flashing up upon being disturbed, in this case the layer of protoplasm below the cuticle being active.

[3] W. N. Hess, *Biological Bulletin*, 38: 39–77, 1920.

[4] As, for instance, T. F. Morrison, SCIENCE, 69: 400–401, 1920, and G. Alexander, SCIENCE, 82: 400, 1935.

SECONDARY BINOCULAR VISION IN BIRDS

IT has been pointed out by Dunlap and Mowrer that "due to the relatively restricted magnitude of possible eye movement in most avian species, the field of vision is usually changed by means of quick jerky movements of the entire head instead of by means of the so-called 'saccadic' eye movements so conspicuous, for example, in human beings and other Primates." They called attention to the possibility of the nictitating membrane, or "third eyelid," having a function in birds somewhat comparable to that of a shutter in a motion picture camera.

The head movements of birds, in so far as they are concerned with vision, are of three types: (1) Movements that effect a change in the visual field; (2) movements tending to maintain a given visual field during bodily displacement; and (3) movements tending to hold the image of a moving object motionless on the retina.

[5] H. A. Allard, SCIENCE, 52: 539, 1920.

Movements for the purpose of changing the visual field are of three main types, horizontal, vertical and "peering." For the sake of simplicity I shall confine myself to the first two.

Horizontal movements, well illustrated by doves, pigeons and fowl when walking, and by coot and gallinules while swimming on a still pond, consist of an apparent movement of the head backward and forward. It was suggested by Mikesh and demonstrated by Dunlap and Mowrer that the only real motion is forward; that although the head appears to be drawn back after each forward thrust it is really maintained in the same relation to the visual field, while the body moves forward. There is therefore an alternation of short maintenance of and sudden change in the visual field.

Vertical head movement is seen in many shore birds, which, while standing still, bob their heads up and down with a greater or lesser pause at the uppermost and lowermost positions.

Undoubtedly a number of different causative factors enter into this head movement on the part of birds—indeed, several have been suggested. But whatever the causative factors may be there is one resultant of the head movement of much importance that appears to have been overlooked.

The vision of most birds is monocular, the visual fields of the two eyes being quite independent of each other. Monocular vision with two eyes, each having a short focus wide angle lens, has the advantage of giving a sharp and distinct retinal image of everything within two large visual fields. But it has the disadvantage of recording two independent single images each in a single focal plane, resulting in more or less inability to judge accurately the distance of any given object from the fixed point of the single eye bearing upon the object.

This disadvantage is overcome by the horizontal head movements of such birds as the doves, pigeons, coots and gallinules and by the vertical head movements of the shore birds. Such head movements provide a base line from which distances may be measured, and the blotting out of the image between the extremes of this base line, assuming a retinal lag, results in a stereoscopic effect.

Thus the birds, under the apparent physical handicap of monocular vision, in reality, as a resultant of the movements of the head, possess all the advantages of binocular vision, in addition to the advantages inherent in double monocular vision.

Although it is believed that the attainment of the advantages of binocular vision is an important factor in the head movements of birds, it is not assumed that it is the only factor, or that it explains its origin.

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AN INFECTIOUS DISEASE CAUSING WIDESPREAD NECROSIS IN THE LIVER OF THE MEXICAN AXOLOTL

AN inbred colony varying from 400 to 800 white and black axolotls (*Amblystoma mexicanum*), raised from four pairs of breeders brought from Europe, has been maintained at the Morris Biological Farm of the Wistar Institute since 1931. About a year ago a disease appeared which has since spread through the entire colony and has destroyed most of the animals.

The disease develops so insidiously that it is usually not recognized until well advanced. Commonly, though not in all cases, the earlier external signs are similar to those of approaching metamorphosis and consist in partial reduction of the gills and the tail-fin and in wasting of the arms and legs, which gradually lose their well-rounded, fleshy appearance. The white axolotls often become faintly flushed because of congestion of cutaneous capillaries; occasionally blood blisters form in the fin. In the black variety these vascular phenomena are masked by the cutaneous pigment cells.

The axolotls lose their appetite and finally refuse food altogether. However, the resulting emaciation may not be obvious, because in many animals considerable quantities of fluid accumulate in the coelomic cavity, leading to a bloated appearance. This, indeed, is the most striking sign of the disease, though it is not always present. If withdrawn with an aspirating needle, fluid reaccumulates within a few days. It is slightly turbid and contains many wandering cells and fine granules from broken-down chromatophores. Micro-organisms have not been demonstrated by various aerobic and anaerobic culture methods, nor by direct smears, though the granules mentioned may readily be mistaken for bacteria.

At autopsy the most conspicuous lesions are found in the liver, which is usually enlarged, often to over twice its normal size, and coated with a film of fibrinous exudate. Frequently the surface is very irregular, due to the presence of projecting coarse nodules, which are white, solitary or multiple, and vary from a few millimeters to over a centimeter in diameter; they contrast sharply with the more normal gray liver (especially in the black variety). The nodules vary much in consistency, depending on the stage of the disease; some are quite firm, while others are soft, with obviously necrotic centers. Usually they are well circumscribed and surrounded by a zone of congestion. Histologically the nodules are found to consist of necrotic liver cells, which in the ventral parts have fused into a structureless mass; at the periphery the area is usually invaded by wandering cells, which, together with fibroblasts, may form a zone of considerable extent. The liver cells beyond these localized lesions exhibit various stages of degeneration.