Reports

Territorial Behavior in Uganda Kob

Abstract. Territorial behavior of the Uganda kob, *Adenota kob thomasi* (P. L. Sclater), is largely the defense of small, fixed territories within a central area of concentrated territorial activity. This area is surrounded by a zone of more widely spaced territories. Females enter the territorial ground throughout the year for the purpose of breeding.

The well-defined pattern of year-around territorial behavior of the Uganda kob was discovered (*1*) in March 1957. Although other African antelopes exhibit territoriality, the behavioral pattern of the Uganda kob appears to be unknown among any of the other species. Initial interpretations were verified in several widely separated herds over the following 15 months, and from June through August 1959 an intensive study on marked animals was conducted to ascertain details of this behavior in the Semliki Game Reserve, 20 miles north of Fort Portal, Uganda.

About 10,000 Uganda kob occur in approximately 100 square miles of habitat included by the reserve and vicinity (*2*). The entire population utilized only 13 known territorial breeding grounds, suggesting that certain physiographic requirements limited the number of breeding grounds. Each ground was situated on a ridge, knoll, or slightly raised area characterized by short grass, good visibility, and proximity to a permanent stream. A territorial ground of average size consisted of a central area of intensive activity, about 200 yards in diameter, containing 12 to 15 more or less circular territories varying from 20 to 60 yards in diameter. Some had common boundaries; others were separated by neutral areas. The territories were fixed in position and could be recognized by a central area of closely cropped grasses on heavily trampled ground and boundaries clearly demarcated with longer, less grazed grasses. In the surrounding peripheral area, a zone 100 to 200 yards wide, about twice as many territories were found as in the central area. Territorial breeding grounds remained in the same locations from July 1957 to September 1959. Apparently the grounds are seldom shifted to new locations. Territorial behavior occurred throughout the year, with slight peaks of intensified activity during the two rainy seasons (April to May; October).

Fifty territorial males were captured by the use of paralyzing drugs and marked for identification (*3*) at three territorial grounds separated from each other by distances of 2 to 2½ miles. Only about a third of the tagged individuals were seen again on territories, but almost invariably an individual returned to the same territory it had occupied previously. Some males remained on territory less than a day, others for several days or a few weeks. The longest record was 2½ months. During occupancy of a territory the male left once or twice in daylight to obtain water and forage. Observations on about 50 additional territorial males marked naturally by scars, abscesses, broken horns, and other characteristics showed that individuals not subjected to the experience of capture returned to territories in about the same frequency as marked individuals. A high rate of exchange of individual males within individual territories seems to be a natural feature of the behavior pattern.

Exchange of males on a given territory involved serious fighting between the occupant and a challenging male, the latter running in rapidly, through the peripheral area, into the central area of activity to what appeared to be a predetermined territory, perhaps one that he had occupied previously. This pattern and other aspects of territoriality of Uganda kob have been documented in a 30-minute motion picture film, in sound and color (*4*). Fights for possession of a territory were the longest and most serious of the fights observed. Two deaths positively attributable to fighting were recorded. Successful fights in which the challenging male defeated the occupant of a territory and took possession were observed about a dozen times; more frequently unsuccessful challenges were observed, some of which involved hard fighting. Often males ran into the central area only to be chased out by territorial males, each making short runs or threatening gestures in relay until the invader ran out of the prized area.

Defense of boundaries between occupied territories was accomplished mostly by ritualized display rather than intensive fighting. For example, to maintain the integrity of territories, males frequently walked toward one another with lowered ears and met at the boundary without fighting. Feigning and dodging with lowered heads with slight, if any, clashing of horns was also characteristic of ritualized defense of boundaries. Often brief fights were precipitated by females entering the territorial ground to breed. In attempting to attract the female by driving her toward the territory with prancing display, a male sometimes ran into neutral ground or unoccupied territories. If he approached an occupied territory too closely, vigorous fighting in defense of the boundary ensued. However, without disturbance from outside, serious fights were infrequent, territorial boundaries being maintained through mutual respect and ritualized display. When a female chose to leave one territory (*A*) for an adjacent territory (*B*), male *A* stopped at his boundary and permitted the female to walk into territory *B* without attempting to fight with male *B*. When disturbed by lion, automobile, elephant, or similar influence, the kob deserted the territorial ground by leaving along established routes. No antagonism between males occurred during such movements. Within 10 to 20 minutes after the disturbance was removed, the kob were again on their individual territories, brief fights occurring frequently as they reestablished themselves.

High population density may be essential for expression of territorial behavior of Uganda kob. In the Rutshuru Plains of the Congo, about 150 miles south of the Semliki Game Reserve, F. Bourlière (*5*) of the Faculty of Medicine in Paris did not observe the behavior in the same subspecies of kob, but the density of the population in the former region was about half of that in the latter.

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Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

References and Notes

1. I am indebted to my wife, Jimmie, for her keen observation and unbiased interpretation that led to the discovery of territorial behavior in Uganda kob. Research during 1957 and 1958 was supported by a Fulbright appointment and financial assistance from the Uganda Administration; in 1959 a grant in aid of research from the National Science Foundation permitted concentrated study of the phenomenon. Personnel of the Uganda Department of Game and Fisheries and the Uganda National Parks assisted greatly in field operations.
2. Estimation of the population from aerial counts was made in May 1958 with Dr. William M. Longhurst, University of California, who piloted a Stinson Voyager generously loaned to us by C. D. Margach, Kinyala Estates, Misindi, Uganda.
3. H. K. Buechner, A. M. Harthoorn, J. A. Lock, *Can. J. Comp. Med. Vet. Sci.* **24**, 317 (1960).
4. The film may be rented through the Audio-Visual Center at Washington State University, Pullman.
5. F. Bourlière, verbal communication.

28 October 1960

Bioluminescence in Chesapeake Bay

Abstract. Bioluminescence measurements made by stimulation of the organisms in a jet of water directed at the face of a phototube have increased the sensitivity of data by a factor of 1000 over "spontaneous" luminescence measurements. In light-baffled cells it has been possible to map the surface bioluminescence of large areas continuously in broad daylight. Measurements of intensity versus depth during both day and night do not show any appreciable diurnal variation in maximum intensity, although there does appear to be a vertical migration of intensity.

Measurements of bioluminescence in several regions of the Chesapeake Bay indicate that light-emitting microscopic marine organisms have a wide and general distribution in these waters. The equipment was designed to measure bioluminescence independent of external incident radiation. The sample cell consisted of a defined volume of 9 by 12 by 12 inches, open to the sea above and below but sufficiently light-baffled so as to exclude the effects of incident sunlight at the water surface even in broad daylight.

Light emission by many microscopic organisms occurs only on stimulation; consequently, in order to obtain a true measure of the luminous organisms present it is necessary to stimulate the population immediately in front of the photocell. This was done by means of a miniature impeller-type pump directing a small jet of water directly toward the face of an EMI 1-inch phototube, which was mounted on the opposite side of the sample cell housing. The turbulence in the jet stream was sufficient to stimulate emission of light in those organisms within the stream. The total volume of the sample cell was large enough to replenish, by convection to the jet stream, those organisms which had not yet been stimulated.

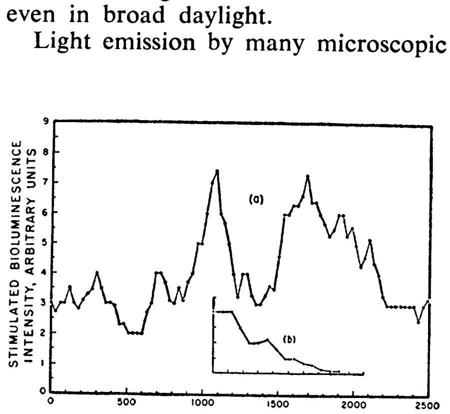

Fig. 1. Mapping record of stimulated bioluminescence in the channel of the Little Choptank.

This method of nondestructive stimulation increased the sensitivity of the bioluminescence measurements by more than a factor of 1000 over that obtainable by measuring "spontaneous" bioluminescence. These features provide what is considered to be a more precise and much more sensitive parameter for estimating the density of bioluminescent organisms than that described by G. L. Clarke and his co-workers (*1*). Further, the present measurements were made from the surface to depths of 140 feet.

The sensitivity of the technique was such that continuous measurements of bioluminescence could be made when the unit was towed behind the boat at speeds of 3 to 4 knots. In Fig. 1 are shown partial records of stimulated bioluminesmence taken with the light-baffled cell at a depth of 1 foot in bright sunlight. The speed of the boat was 6 ft/sec.

Figure 1*a* shows a representative mapping record over a distance of 2500 feet, as the boat was coming out of the channel of the Little Choptank River into Chesapeake Bay proper. The bioluminescence light intensities are not uniform and indicate the presence of "blooms" or colonies of bioluminescent organisms. Figure 1*b* is a portion of the mapping record showing the decrease in bioluminescence light intensity as the boat came into the main channel of the bay where the tide was running. The bioluminescence intensity measured in this particular mapping experiment extended over a range of 740. At the lowest level measured, at rip tide in the bay channel, the signal-to-noise ratio was still 300.

Figure 2 shows stimulated bioluminescence intensity as a function of depth made at anchor over a 140-foot hole in the bay floor. There is a shift in peak intensity with depth from about 25 feet during the day to just below the surface at night.

An important point is that there is no striking difference between the maximum light intensities measured in

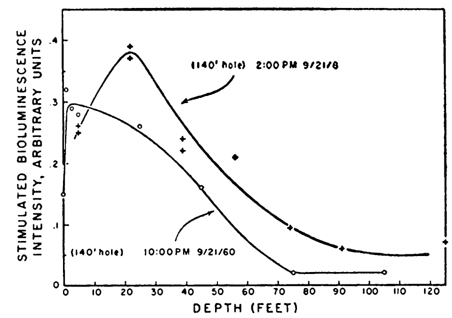

Fig. 2. Stimulated bioluminescence as a function of depth for day and night.

daylight and at night; in fact, the daylight intensities were all slightly higher. This would indicate that the light-inhibition of bioluminescence previously reported for the larger organisms, such as *Mnemiopsis* by E. N. Harvey (*2*), may not be general or else may be a secondary physiological response. Using laboratory cultures of the dinoflagellate *Gonyaulax polyhedra,* Sweeney and Hastings observed a diurnal rhythm of of luminescence. (*3*). Cells grown in daylight showed a dim luminescence during the day which increased in brightness at night. The bright luminescense observed at night could be inhibited by light. It was surprising, therefore, that such a rhythm was not observed in the bay. From the data presented in Fig. 2, it appears that the organisms migrate to a deeper region during the day and consequently maintain maximum luminescence.

A careful study of the relationships between photosynthesis and luminescence in these organisms may reveal that the type of rhythm observed by Hastings and Sweeney is offset in nature by a rhythmic vertical movement which prevents exposure to strong illumination. Additional studies on the type and number of organisms present are necessary before any definite conclusions can be made.

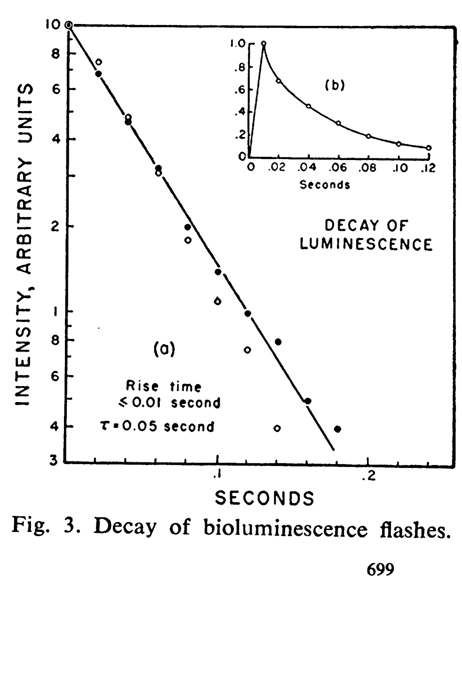

Fig. 3. Decay of bioluminescence flashes.