A TECHNIQUE FOR RECORDING MIGRATORY ORIENTATION OF CAPTIVE BIRDS

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CERTAIN birds when held in small cages during the migration seasons exhibit a nocturnal restlessness which has been interpreted as an expression of migratory condition and termed *Zugunruhe*. In 1949 the late Gustav Kramer demonstrated that Red-backed Shrikes (*Lanius collurio*) and blackcaps (*Sylvia atricapilla*), placed in cages under the night sky, often tended to orient their *Zugunruhe* toward the side of the cage corresponding to the normal migration direction. This observation suggested a new approach to the elusive problem of migratory orientation, an approach which has since been exploited by several investigators under a variety of conditions.

The general procedure has been to place a bird which is in migratory condition into a circular cage and record the orientation of its activities. The recording has been accomplished either directly by visual observation from below (Kramer, 1949; Sauer, 1957; Hamilton, 1962a) or automatically through the use of microswitch perches, electronic counters, and operations recorders (Farner and Mewaldt, 1953; Mewaldt *et al.*, 1964). While both of these methods have produced interesting and important data, each is severely limited in the number of birds it can process at a time. Data accumulation has therefore been slow and expensive, and adequate replications for studies of variation and of statistical significance have not been obtainable.

The technique described in this paper eliminates the necessity of prolonged direct observation and bypasses the problem of expensive and cumbersome equipment. It thus provides a means of obtaining simultaneous records on moderately large samples of birds.

To date the technique has been tested over 1,000 times both in the field and in planetaria. The authors wish to thank Helmut Mueller for assisting with the field tests, and Harrison B. Tordoff for commenting upon the manuscript.

TECHNIQUE

The apparatus consists of a blotting paper funnel, an ink pad base, and a screen top (Figures 1 and 2). In the unit illustrated the walls are formed from a white desk blotter which is cut, rolled, and stapled in the shape of a funnel with a slope of 45 degrees, a top diameter of 35 cm, and a bottom diameter of 10 cm. This funnel rests on the rim of a two quart aluminum pudding pan to the bottom of which is glued a thin sponge sheet kept moist with black printers' ink. A square of one-half inch mesh

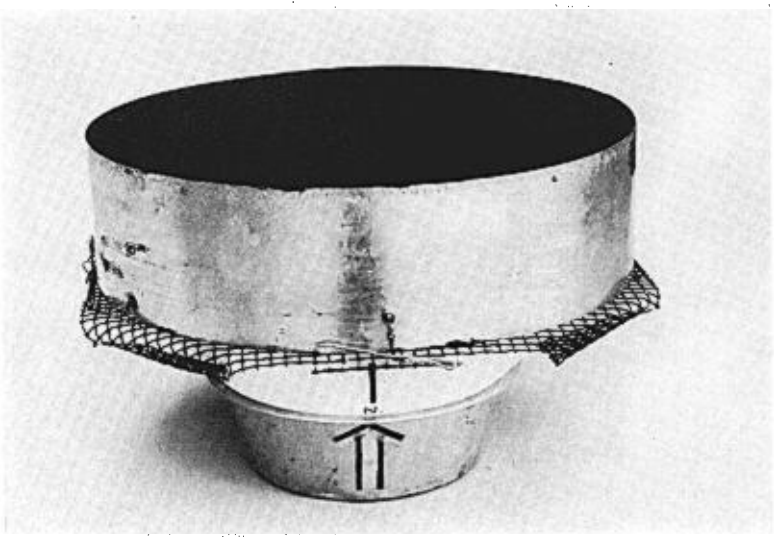

Figure 1. Photograph of the standard test unit.

hardware cloth, folded down at the four corners to hold it in position, caps the funnel. (Plexiglass lids proved to be impractical since they frequently clouded with condensation.) The complete cost of such a unit is about 65 cents, and replacement blotters for successive tests can be obtained in bulk for 4 cents each.

The size of the funnel can be varied in accordance with the size of the bird to be tested, but we obtained good results with our unit for birds ranging in size from kinglets to thrushes.

A bird placed inside one of these orientation funnels finds itself standing on the ink pad surrounded by outwardly sloping walls of white blotting paper; the sky is visible overhead and trees and other objects comprising the horizon are screened from view. Thus placed, a bird (for example, a White-throated Sparrow, *Zonotrichia albicollis*, White-crowned Sparrow, *Z. leucophrys*, or Indigo Bunting, *Passerina cyanea*) in migratory condition stands in one place or turns slowly in a circle, its bill tilted upwards, its wings partially spread and quivering rapidly—postures and movements closely resembling those described as *Zugunruhe* behavior for sylviids by Sauer (1957) and Bobolinks (*Dolichonyx oryzivorus*) by Hamilton (1962b). At frequent intervals the bird hops forward onto the sloping white paper, only to slide back and continue its pointing and quivering. Such hops from an ink pad leave clear black prints on the blotting paper and it is the accumulation of these inked footprints which produces the orientation record of the bird's activity.

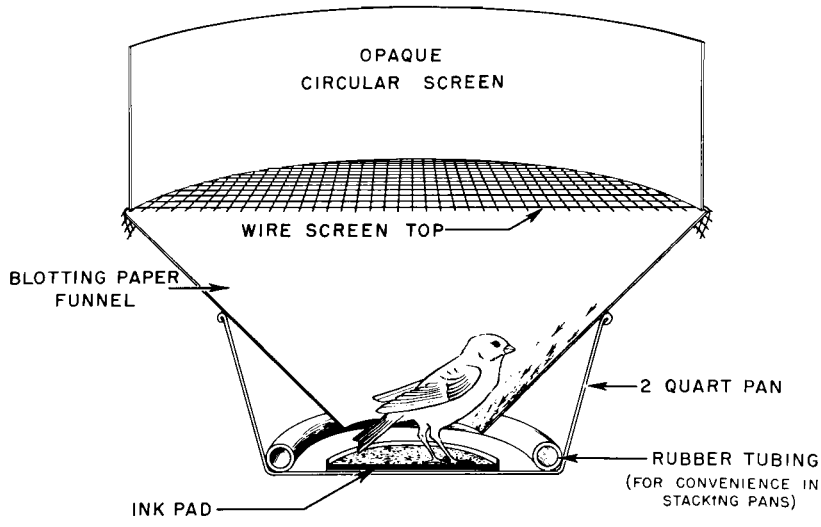

Figure 2. Diagrammatic view of the standard test unit.

In an actual operation a series of up to several dozen units can be transported to a planetarium or to an open, undisturbed area and assembled. Each unit is assembled bottom side up, on a disk of dark masonite slightly larger than the funnel top. The pans are then briefly lifted and one test bird is placed in the exposed small end of each funnel. With the pan replaced, each unit is righted, the masonite disk now serving as a cover to keep the birds in darkness and consequently inactive while the funnels are levelled and aligned with some distant object, the compass direction of which has been previously determined. The final step is to remove the masonite covers, exposing each bird to the sky. The whole operation, setting up as many as 25 units, can readily be completed in less than one hour.

At the termination of an experiment the same procedure is followed in reverse. Lids are quietly replaced, the units inverted, and the birds removed by hand from the small ends of the funnels.

A blotter, unstapled and unrolled after a test, contains the complete record of a bird's *Zugunruhe* behavior during the test period. Quick inspection of such a record usually provides a good impression of the intensity, directional orientation, and amount of spread of the bird's activity (Figure 3A). For statistical purposes however, it is necessary to quantify the footprint records by translating them into numerical form. To do this we subdivided each circular record sheet into 24 sectors of 15 degrees each. The amount of activity in each sector was then evaluated by directly comparing the density of its ink prints with densities on a

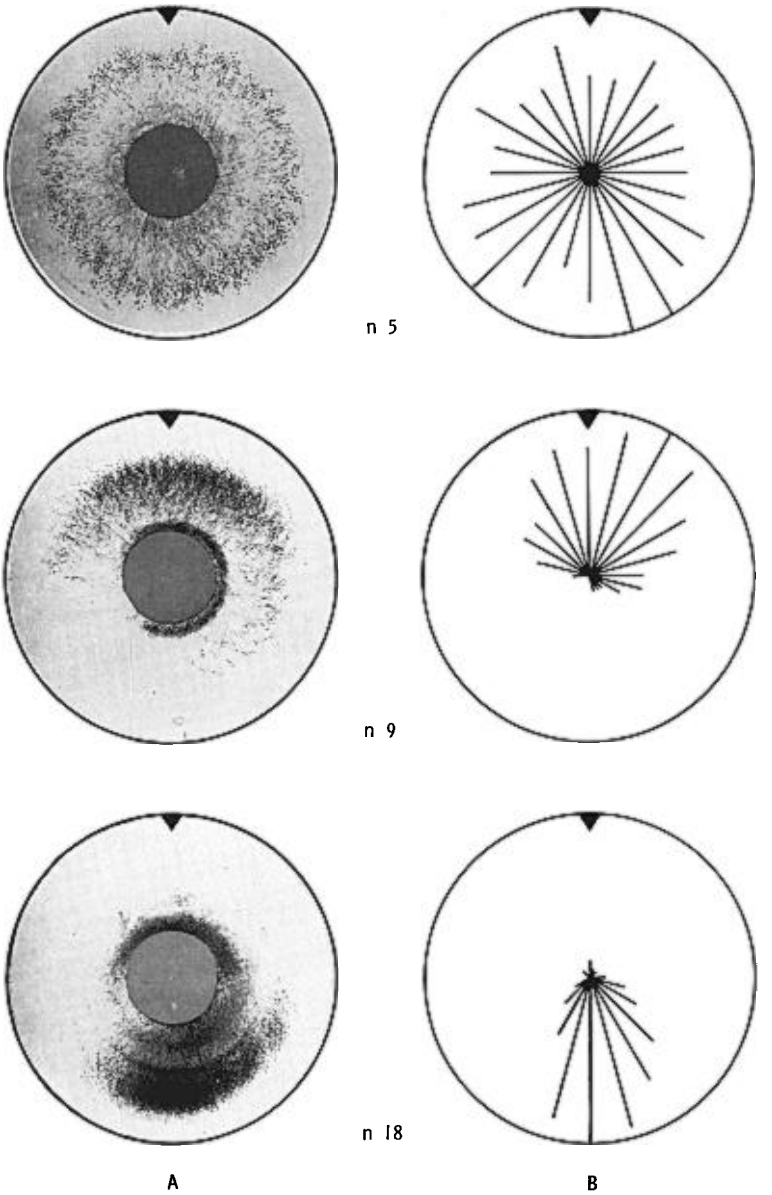

Figure 3. Sample footprint records (A) and their resulting vector diagrams (B). Top: a Swamp Sparrow (*Melospiza georgiana*) tested under the night sky in spring, 1964; center: an Indigo Bunting tested in spring, 1965, under a planetarium sky set for local conditions; bottom: a White-crowned Sparrow tested in spring, 1964, when a full moon was in the southern sky. The n values refer to the greatest number of units of activity in any one 15 degree sector.

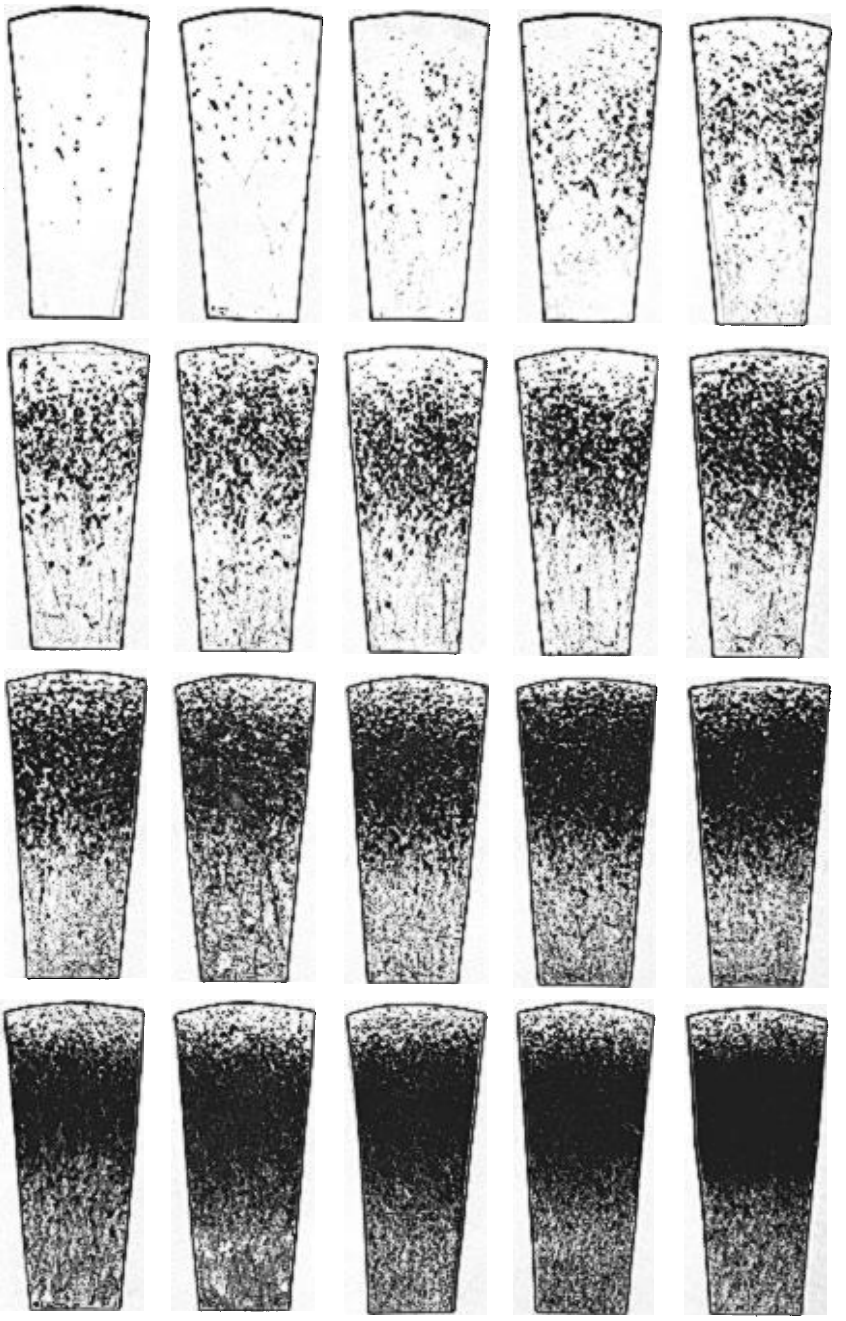

Figure 4. Reference scale (1 to 20 units of activity) used in translating footprint records into numerical form. See text for full explanation.

reference key designed to depict 20 equally increasing increments of activity (Figure 4). A fan-shaped stencil card with slots facilitated quick evaluation of blotter records. In this manner each sector was assigned a numerical value and the overall record for each test could then be plotted as a vector diagram (Figure 3B) and subjected to appropriate statistical tests.

DISCUSSION

Several potential sources of error must be considered when using this or any other known technique for recording migratory orientation in captive birds. Most serious is the common tendency for caged birds to respond directly to moonlight and horizon glow (Sauer, 1957; Hamilton, 1962a). No way is known to offset the attraction of the moon in the sky or the disrupting effect of the pattern of light and shadow which the moon casts on a paper funnel. The investigator is simply forced to limit his outdoor experiments to moonless nights. The attraction of horizon glows, however, can be eliminated by conducting tests far from artificially lighted areas and by shielding each unit with an opaque circular screen high enough to block out the lower portions of the sky (as seen in Figures 1 and 2).

A second possible source of error stems from the tendency of freshly caught birds and occasionally others to flutter for extended periods against the sides and top of the funnel in apparent attempts to escape. Fortunately the ink-print record of such fluttering birds is characterized by many scratch marks and feather smudges and can thus be identified and distinguished from those of birds showing normal *Zugunruhe*. The danger of misinterpreting a record is thus less than in mechanical orientation cages in which no qualitative evaluation of activity is possible.

It is also conceivable that directional cues within the apparatus itself (the position of the paper overlap in the funnel, the grid pattern of the screen top, etc.) might influence the orientation of the bird. To date no such tendency has been detected in any of the birds tested. It is considered desirable, nonetheless, to vary, in a random manner, the placement of the various features of the apparatus between tests.

The data derived from the footprint technique cannot be analyzed as a function of time except as blotters are replaced at certain intervals. The advantages of the technique lie in its simplicity, its low cost, and the relative ease with which tests can be replicated for statistical evaluation. Light weight, portability (the parts are easily stacked), and independence from cumbersome electrical and mechanical gear are also important considerations for many types of field work, while small size of the unit

is an asset in minimizing the problem of parallax in planetarium experiments.

SUMMARY

A simple, inexpensive technique is described for obtaining data on oriented *Zugunruhe* in captive migrants. Test birds are placed in small, wide-mouthed funnels of white blotting paper mounted over moist ink pads and topped with screen covers. Each time a bird hops, it leaves inked footprints on the sloping blotting paper in the direction of the hop before sliding back down to the pad. The footprint records on the blotters then can be translated into numerical terms suitable for statistical evaluation.

LITERATURE CITED

FARNER, D. S., AND L. R. MEWALDT. 1953. The recording of diurnal activity patterns in caged birds. Bird-Banding, **24**: 55–66.

HAMILTON, W. J., III. 1962a. Bobolink migratory pathways and their experimental analysis under night skies. Auk, **79**: 208–233.

HAMILTON, W. J., III. 1962b. Evidence concerning the function of nocturnal call notes of migrating birds. Condor, **64**: 390–401.

KRAMER, G. 1949. Über Richtungstendenzen bei der nächtlichen Zugunruhe gekäfigter Vögel. Pp. 269–283 *in* Ornithologie als biologische Wissenschaft (E. Mayr and E. Schüz, eds.). Heidelberg, Carl Winter, Universitätsverlag.

MEWALDT, L. R., M. L. MORTON, AND I. L. BROWN. 1964. Orientation of migratory restlessness in *Zonotrichia*. Condor, **66**: 377–417.

SAUER, F. 1957. Die Sternenorientierung nächtlich ziehender Grasmüchen (*Sylvia atricapilla, borin* und *currura*). Zeits. f. Tierpsych., **14**: 29–70.

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