

SUN COMPASS ORIENTATION IN A NOCTURNAL MIGRANT, THE WHITE-THROATED SPARROW

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Migratory birds are known to be capable of using several environmental cues for orientation (see Em- len 1975 for a recent review). The sun is a poten- tially important source of compass information and many vertebrates possess sun compasses that are time- compensated via the internal clock. Nocturnal mi- grants cannot refer directly to the sun during migra- tory flight, but solar cues could be useful in determining take-off directions or in correcting for in- flight displacements. A logical first step in analyzing the potential role of the sun in the orientation of noc- turnal migrants is to determine if a functional sun compass exists in a spectrum of these species. Here we report the ability to perform sun compass orienta- tion in the White-throated Sparrow (*Zonotrichia al- bicollis*).

METHODS

We trained birds to seek mealworms in feeders at given compass directions between 14 April–20 May 1975. Rewardless tests began on 8 May and continued until 22 May. The birds were also given intermittent training sessions with reward during this period. Rewardless phase-shifted tests were conducted 17 June–23 June. No training was done after the phase-shift began. Training sessions and tests were performed under clear to partly cloudy skies (sun po- sition clearly visible to experimenter) in an orienta- tion cage on the roof of the Biological Sciences Build- ing, State University of New York at Albany. The circular orientation cage was 70 cm in diameter and constructed of a Formica wall 38 cm tall. The height of the cage wall precluded all view of landmarks. Hardware cloth covered the cage top. The inside of the cage was painted flat black. Eight circular feed- ing cups were placed at 45° intervals around the periphery of the cage. Each feeder was 5 cm in di- ameter, 3 cm deep and was attached to the cage wall so that its top was 7 cm above the cage floor. The

Plexiglass cage floor was covered by opaque brown wrapping paper. The paper was changed and the cage rotated between successive trials with the same bird.

At the beginning of each trial, a bird was placed in the center of the cage from varying directions. An observer then positioned himself inside a dark en- closure beneath the cage and observed the movements of the bird in silhouette. Each visit to a feeder and the elapsed time were noted until the end of the ses- sion (training and tests were terminated at the end of 30 min if the bird showed no activity).

RESULTS

We attempted to train nine White-throated Sparrows to seek mealworms in several compass directions. Four of these individuals were successful in tests without reward conducted at times of day different from train- ing. Birds failed to become trained for different rea- sons. Some never investigated the feeders in the orien- tation cage in spite of long training sessions, whereas others visited the feeders but did not eat the meal- worms or ate them only sporadically. Three indi- viduals developed a "lazy" strategy: they circled the cage, landing on each food cup in sequence until they found the worms. In rewardless test situations they also circled the cage, making it impossible to assess whether they had learned the task.

We used either of two criteria to define successful tests. First we computed the mean azimuth direction of the first five feeders visited by the bird and per- formed a V-test (Batschelet 1972) to determine if this direction corresponded to that of the training feeder. If a bird went almost immediately to the appropriate feeder, subsequent choices might be meaningless in the context of its training direction because it would have already determined that no mealworms were to be found in the expected feeder. Therefore, as a second criterion we examined the se- quence in which the bird visited the training feeder over a series of trials on different days and computed the probability that the bird reached the feeder by random searching. We made the unrealistic, but con- servative assumption that second, etc., choices by the bird were made from among all eight feeders. This means that a feeder already visited during the test had a probability of being visited equal to that of an unvisited feeder (i.e., the birds sampled from a popu- lation of feeders with replacement).

TABLE 1. Results of rewardless tests conducted at times of day other than the training time.

| Bird No. | Training Direction | Test No. | Mean Direction | V-test P | Sequence of Training Feeder | P | Elapsed Time (sec) |
|----------|--------------------|----------|----------------|----------|-----------------------------|------|--------------------|
| 607 | W | 1. | 285° | <.050 | 1 | .215 | 14 |
| | | 2. | 260 | <.005 | 7 | | 30 |
| 631 | N | 1. | 10 | <.005 | 2. | .005 | 8 |
| | | 2. | 10 | <.005 | 2 | | 10 |
| | | 3. | 10 | <.005 | 2 | | 6 |
| | | 4. | 10 | <.005 | 2 | | 8 |
| 636 | E | 1. | 45 | N.S. | 4 | .015 | 22 |
| | | 2. | 113 | N.S. | 1 | | 2 |
| | | 3. | 90 | <.100 | 3 | | 20 |
| | | 4. | 90 | <.100 | 3 | | 53 |
| 805 | SW | 1. | 213 | <.001 | 3 | .468 | 462 |
| | | 2. | 235 | <.005 | 6 | | 349 |
| | | 3. | 215 | <.005 | 5 | | 456 |

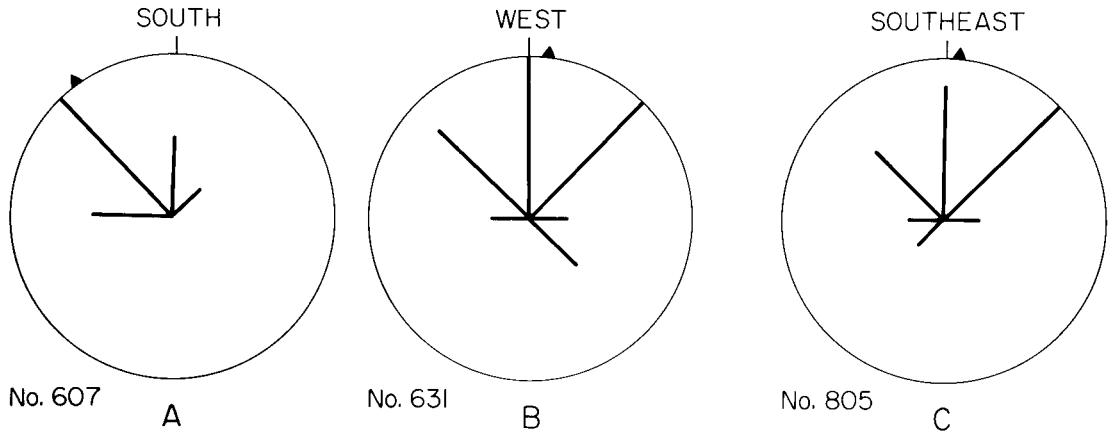


FIGURE 1. The orientation of phase-shifted White-throated Sparrows in rewardless tests under sunny skies. The figures are plotted such that the expected orientation direction is at the tops of the circles. Arrows on the periphery of the circles indicate the mean azimuth of orientation. The orientation data consisted of the first five feeders visited by the bird.

Table 1 shows that three of the four sparrows met the first criterion (nos. 607, 631, 805) and two met the second (nos. 631, 636). Following these rewardless tests we subjected the birds to a 6-h phase shift in the light:dark cycle such that lights-on occurred 6 h earlier than normal. This phase shift predicts a counterclockwise directional change of 90° based on a sun compass. Three individuals (nos. 607, 631, 805) chose feeders in the predicted direction (V-tests; see Table 2). The directional choices of these birds are shown in Figure 1. The fourth bird (no. 636) visited no feeders when tested.

We concluded that these White-throated Sparrows learned to locate appropriate feeders based on a time-compensated sun compass. These results do not preclude the possibility that the birds might be able to learn the directions based on other cue systems but the phase-shift data cannot be explained in that way. If multiple cues are involved, the sun must predominate in terms of this directional task.

DISCUSSION

Virtually no information exists on whether the sun plays any role in the orientation of nocturnal migrants. Emlen (1975) reviewed relevant data and speculated on possible roles for solar cues. In the phylogeny of avian navigation, diurnal migration based on a sun compass probably evolved earlier than the more de-

manding nocturnal orientation systems (Bellrose 1972). If this is true, it is reasonable to expect sun compass capability to be widespread among strictly nocturnal migrants.

The sun is a potentially useful cue to nocturnal migrants in determining initial orientation directions and as a component in a navigation system that could be used to correct for displacements suffered during nocturnal flight. However, the existence of a sun compass does not necessarily imply a role in the migration of a species.

A functional sun compass has not previously been demonstrated in any North American passerine nocturnal migrant. Years ago, von Saint Paul (1953) reported a sun compass in two typical European nocturnal migrants (*Sylvia nisoria* and *Lanius collurio*). Her results were based on outdoor tests at times of day other than the training times and responses to an artificial sun with fixed azimuth. More rigorous tests using phase shifts were not performed, but the results seem sound. Further experiments should be performed on a group of species selected to reveal the phylogenetic breadth of this ability among nocturnal migrants.

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TABLE 2. Results of tests performed with birds subjected to a 6-h phase shift.

| Bird No. | Training Direction | Expected Direction | Test No. | Mean Direction | V-test P | Sequence of Expected Feeder | P | Elapsed Time (sec) |
|----------|--------------------|--------------------|----------|----------------|----------|-----------------------------|------|--------------------|
| 607 | W | S | 1. | 151° | <.050 | 5 | .384 | 38 |
| | | | 2. | 135 | <.050 | 3 | | 46 |
| 631 | N | W | 1. | 297 | <.100 | 3 | .014 | 16 |
| | | | 2. | 265 | <.050 | 3 | | 45 |
| | | | 3. | 270 | <.005 | 2 | | 12 |
| | | | 4. | 300 | <.050 | 2 | | 43 |
| 805 | SW | SE | 1. | 145 | <.005 | 2 | .021 | 68 |
| | | | 2. | 135 | <.005 | 1 | | 10 |
| | | | 3. | 135 | <.050 | 4 | | 643 |

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SNOWY OWL PREDATION
ON SHORT-EARED OWLS

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A problem confronting Snowy Owls (*Nyctea scandiaca*) in their southern incursions is the shortage of food. This difficulty is raised by the presence of other raptors that feed on small mammals. This note shows how little food is found by migrant Snowy Owls and indicates a complex temporary ecological solution.

At Tatoosh Island, Washington (48°24'N, 124°44'W) on 25 November 1973, we observed a Snowy Owl near a cache of three dead Short-eared Owls (*Asio flammeus*). The latter appeared to have been killed and partially consumed. Their dorsal feathers had been ruffled, there were small wounds in the head, the pectoral musculature of two individuals had been eaten, and three of the six eyes devoured. We first saw the Snowy Owl when it was perched within 20 m of its alleged prey midden, during a time of severe food shortage for these large owls. In all, five Snowy Owls inhabited this small (6.5-ha) island. Of these, one was subsequently found dead, one was hand-caught by U.S. Coast Guard personnel, and the remaining three disappeared within 10 days. Total residence time of the owls on the island was less than three weeks, a further indication that this was unsuitable long-term habitat. The owls presumably left for the mainland, a distance of less than one mile.

The island vegetation consisted almost entirely of thicket, primarily salal (*Gaultheria shallon*) and salmonberry (*Rubus spectabilis*). There were only seven

small trees on the island. No non-domestic mammals exist there, and the condition of the dead owls makes unlikely the implication of domestic cats. Other raptors, especially Bald Eagles (*Haliaeetus leucocephalus*), occasionally visited the island. The circumstances strongly suggest, however, that the Snowy Owl had killed the Short-eared Owls. W. S. Brooks (Notes on birds from East Siberia and arctic Alaska 1915, in A. C. Bent, Life histories of North American birds of prey, Part 2, U.S. Natl. Mus. Bull. 170, 1938) previously reported Snowy Owls eating Short-eared Owls which he had trapped.

Migrating Snowy Owls in the normal range of Short-eared Owls take similar prey items. Both species feed, perhaps preferentially, on small rodents (not known to occur on Tatoosh) and will also take small birds. The Snowy Owl has a broader diet and it appears to be more opportunistic (for instance, it has been known to eat fish and offal), especially during migration (A. K. Fisher, U.S. Dept. Agric. Bull. 3: 1-210, 1893). When a large raptor kills and feeds upon smaller raptors of the same trophic level, as has been often reported in the literature, the larger raptor in the process of procuring food also annihilates a potential competitor. We emphasize, however, that our data are too circumstantial to allow an evaluation of the importance of this benefit.

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EFFECTS OF MOLTING
ON DUSTBATHING IN JAPANESE QUAIL
(*COTURNIX COTURNIX JAPONICA*)

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Dustbathing has been proposed as a mechanism for eliminating ectoparasites from the plumage (Edminster 1947). Recently it has been suggested that dustbathing serves as a regulatory mechanism by which an optimum amount of oil is maintained on the feathers. When the amount of oil increases over

some critical level, the bird dustbathes (Borchelt et al. 1973, Borchelt and Duncan 1974, Borchelt 1975). It has also been proposed that dustbathing is a method of applying heat to rapidly molting feather tracts that are not easily exposed to sunlight (Potter and Hauser 1974). To test this latter hypothesis, we induced molt in Japanese Quail (*Coturnix coturnix japonica*) and observed pre-molt and molt dusting behavior.

Four male and six female Japanese Quail were raised from chicks and kept in group cages. From 2-12 weeks of age, the chicks were intermittently provided with dusting material (dry sand). At 12 weeks of age each bird was placed in an individual wire cage (24 × 38 × 36 cm) with a metal tray floor. The sand was presented to the birds by filling the metal