Orientation of Song Perches in a Piedmont Population of Northern Mockingbirds (*Mimus p. polyglottos*)

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INTRODUCTION

Free-living diurnal animals are often illuminated by the sun, and many theories of animal coloration have taken this into account. A prominent example is the theory behind countershading color patterns (Thayer 1918). Briefly, if an animal is uniformly colored and illuminated more strongly from one direction (as from the sun), a brightness contrast is formed between the illuminated area and the shadowed area. This brightness contrast makes the animal more visually detectable both because it gives the animal a more round appearance (a photograph in Cott [1957] gives an excellent demonstration of this) and because lateral inhibition in vertebrate retinal cells perceptually enhances such light-dark contrasts. Countershading, generally defined as reduced reflectivity on illuminated surfaces and enhanced reflectivity on shadowed surfaces, allows an animal to effectively cancel out the brightness contrast formed by its own shadows. As such, the animal appears more uniform in brightness, which reduces conspicuousness. Countershaded color patterns are so prevalent that any animal that exhibits them is typically assumed to do so to in order to decrease its conspicuousness to potential predators or competitors.

The orientation of a bird with regard to the sun is critical to the effectiveness of countershading color patterns. The darker areas must face the sun and the lighter areas must be shadowed. For a typical upright-perching passerine at midday, when the sun is overhead, a darker dorsum and lighter ventrum would effectively countershade. However, except for the hours around midday, the sun is nearer the horizon and thus not illuminating from directly above. When the sun is near the horizon, a perched bird with light underparts and dark upperparts facing away from the sun would be countershaded in the classic sense because the darker dorsum is illuminated and shadows are cast on the lighter ventrum. Facing the sun, however, would *increase* its conspicuousness because its lighter ventrum is illuminated most strongly while its darker dorsum is further darkened by shadowing.

Northern Mockingbirds (*Mimus polyglottos*) have gray upperparts and white underparts. By orienting toward the sun, mockingbirds increase the intensity of the illumination on their highly reflective underparts and cast a strong shadow on their more-absorptive upperparts. To humans, the brightness of the breast feathers is very noticeable and the bird takes on a very plump appearance when it is facing the sun. In addition, the dorsoventral contrast is enhanced, which may make the bird more noticeable from the side. In contrast, by orienting away from the sun, the dark upperparts are illuminated and a shadow is cast on the light underparts, which decreases the dorsoventral brightness contrast and also presumably decreases the detectability of the bird. To humans, the bird looks almost uniformly light gray in such lighting and somewhat flatter in profile; against a background of vegetation the bird is typically more difficult for humans to locate when facing away from the sun (personal observation).

During the breeding season (mid-March through mid-July), male mockingbirds generally begin singing at or before dawn and sing through approximately 1200hr, and again from about 1600hr through dusk (personal observation; Derrickson & Breitwisch 1992). Note that very little singing is performed when the sun is overhead. Rather, virtually all singing is done when the sun is nearer the horizon. Unmated males sing far more than mated males (Merritt 1985), while females do not sing during the breeding season.

The bulk of the data collected thus far indicates that male mockingbird song functions primarily in mate attraction (reviewed in Derrickson and Breitwisch 1992). Although occasionally observed singing from the ground, most song perches are out in the open and rather high, typically above 5m and often above 10m (personal observation; Derrickson and Breitwisch 1992). Many perform flight displays, in which they spiral straight up approximately 1 - 3m and spiral down to the same or a nearby perch. This display exposes their white wing patches, which may be involved in male-female communication (Justice and Justice 1995). Presumably these behaviors make the male more detectable to potential females. Males' detectability to females may be further enhanced through combining their countershading color pattern with a particular orientation. If mockingbirds orient so as to maximize their visual detectability while singing, then one would hypothesize a trend toward facing the sun while singing.

Alternatively, mockingbirds may decrease their conspicuousness while singing in order to avoid predators which may have detected the song. This hypothesis makes the opposite prediction of the one above, namely that male mockingbirds should face away from the sun when they sing. They may sing from exposed perches for other reasons, such as acoustic benefits, while trying to remain as visually inconspicuous as possible and performing flight displays only when no predators have been detected.

A third hypothesis is that perch orientation is dictated more by physiological thermoregulation than by communicative signalling (Butcher & Rohwer 1989). Darker surface areas tend to absorb electromagnetic radiation (EMR) from the sun while lighter areas are more reflective. Thus, mockingbirds may face the sun at warmer temperatures in order to reflect EMR with their white underparts, and face away from the sun at cooler temperatures in order to absorb heat from incident EMR.

There may be, of course, numerous additional factors which affect a mockingbird's orientation during song, most notably the location of detected potential mates, and thus variability in orientation is expected. The purpose of the present study was to determine whether mockingbird orientation during song exhibits either 1) a tendency to face toward the sun, as predicted by the "conspicuousness hypothesis," 2) a tendency to face away from the sun, as predicted by the "crypsis hypothesis," or 3) a tendency to face the sun at warmer temperatures and to face away from the sun at cooler temperatures, as predicted by the "thermoregulation hypothesis."

METHODS

Subjects. The mockingbirds used in this study were from a population of approximately 60–70 wild mockingbirds residing on the 72-hectare suburban residential campus of The University of North Carolina at Greensboro (36°N 79°W). The study population is male-biased. Accordingly, about 15% of the males in this population were unmated during the study, which was performed during the breeding season of 1995. Each male in the population was sampled 1–3 times.

Measuring Orientation with Regard to the Sun. To measure the direction the mockingbird was facing with regard to the sun, a 180° protractor was photocopied twice onto a sheet of paper in mirror images (forming a circle from the two 180° arcs) and a rotatable arrow was attached to the center of the circle. Upon observing a singing mockingbird, the protractor was held horizontally and 0° was pointed at the sun. The arrow was then rotated until it was parallel to an imaginary line which would be perpendicular to a line tangent to the center of the bird's breast (Figure 1). The angle, in degrees, was then read from the protractor and recorded. Thus, a bird directly facing the sun would score 0°, a bird facing directly away from the sun would score 180°, while all other positions would score somewhere in between. The temperature was also recorded. Mating status, where known, was determined through field notes from routine monitoring of the population.

Criteria for data collection. Three criteria for data collection were established so that the hypotheses could be tested properly. First, the sunlight had to be strongly directional. With extensive cloud cover the resulting diffused light would fail to illuminate the bird strongly from any one direction, and thus would not providing the directional light needed to take advantage of countershading coloration. Thus, no data were collected 1) when the extent of the cloud cover prevented objects from casting well-defined shadows, 2) before the sun had fully risen, and 3) after the sun began to set. Second, the sun needed to be near the horizon. When the sun is directly above, the bird would have to adopt a very unnatural posture in order to face its ventrum toward the sun. Thus, no data were collected between 1100hr and 1600hr. Third, the bird had to be perched out in the open. On several occasions mockingbirds were heard singing from within trees and shrubs. However, the focus of the study was how mockingbirds orient themselves when they are out in the open and in directional sunlight, and thus no data were collected if any part of the bird was in the shadow of another object.

Sampling Procedure. Initially, the sampling procedure was simply to use any male that was heard singing during the course of routine monitoring of the population. Fifty-five data points were collected in this way. However, the lack of a definite sampling procedure in this initial phase may have produced biases in the data collection of which the observer was unaware. Therefore, 21 more data points were collected using a more definitive sampling procedure. Specifically, on five occasions the observer walked a specified route which intersected all mockingbird territories on campus. Every time a male mockingbird sang continuously for at least thirty seconds while the observer was in the territory, the bird was located and the angle of orientation assumed by the bird was recorded. The data collected in this way yielded the same results as the data collected without the sampling procedure, and thus all data points are combined for the results presented below.

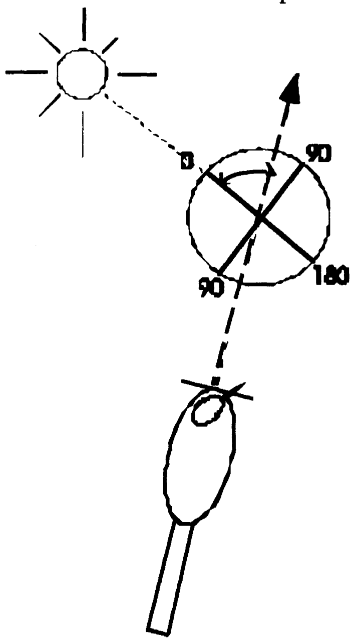

Figure 1. Schematic of a passerine and the imaginary line which was used to measure orientation with respect to the sun.

Statistical Analyses. To test the conspicuousness and crypsis hypotheses, the exact angles recorded in the field were grouped into 12 classes (0-14°, 15-29°, and so on). All classes of orientations should be observed with equal frequency under the null hypothesis. Males known to be mated were analyzed separately from those known to be unmated, in order to determine if mating status affects orientation. A G statistic for goodness-of-fit to the null distribution was calculated. The G statistic was corrected to better approximate a χ^2 distribution using Williams' correction, as suggested by Sokal and Rohlf (1981). In all cases, data points from adjacent classes were pooled where necessary (according to the guidelines provided in Sokal and Rohlf 1981), resulting in varying degrees of freedom for the different tests performed. Where pooling of classes for proper use of the G statistic lowered the degrees of freedom to eight or less, an X^2 statistic was also calculated because it required less pooling of classes. In all cases the two statistics yielded very similar results.

To test the thermoregulation hypothesis, angle of orientation was correlated with temperature using a Pearson's r coefficient of correlation.

RESULTS

Both mated and unmated males tended to orient towards the sun while singing (Figures 2 and 3). For $n = 37$ males known to be mated, $G = 18.30$, $df = 4$, $0.001 < p < 0.005$; $\chi^2 = 22.12$, $df = 9$, $0.005 < p < 0.01$. For $n = 27$ males known to be unmated, $G = 19.82$, $df = 2$, $p < 0.001$; $\chi^2 = 27.33$, $df = 7$, $p < 0.001$. A total of $n = 76$ observations results from combining known mated males, known unmated males, and males whose mating status was unknown; these are graphed in Figure 4 ($G = 47.42$, $df = 9$, $p < 0.001$).

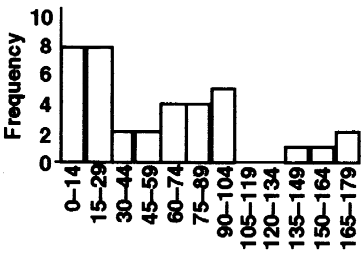

Figure 2. Histogram of orientations observed in mated males.

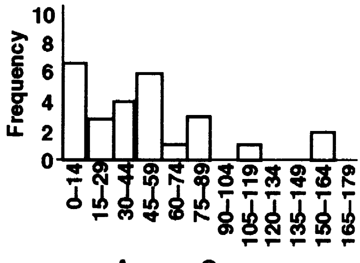

Figure 3. Histogram of orientations observed in unmated males.

Temperature was recorded for 55 data points and ranged from 45°F to 80°F. Angle of orientation was not related to temperature ($r = 0.131$, $p = 0.339$).

DISCUSSION

The data indicate that mockingbirds singing from exposed perches during the breeding season tend to face the sun when the sun is shining low in the sky, and that the angle of orientation with regard to the sun is not affected by temperature. This supports the conspicuousness hypothesis and weakens both the crypsis hypothesis and the thermoregulation hypothesis.

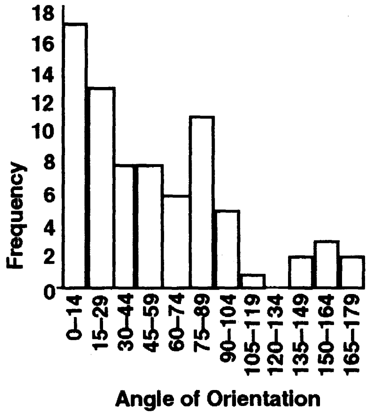

Figure 4. Histogram of orientations observed with known mated males, known unmated males, and males of unknown mating status combined.

Although mockingbirds singing from open perches are very noticeable, facing the sun enhances their conspicuousness further. In such an orientation on an open perch, they are conspicuous from below (against the uniform brightness of the sky), from the front (due to illuminating the white breast feathers), and from the sides (due to the increased dorsoventral contrast). Any other orientation would decrease conspicuousness. Thus, by facing the sun, mockingbirds remain as conspicuous as possible even during breaks in singing and when not performing jump displays. Given the male-biased sex ratio in the population, even a slight increase in conspicuousness may dramatically increase fitness if it results in the acquisition of a female.

If perch orientation influences the effectiveness of countershading, this presents a semantic problem: the term "countershading" is intended to indicate a color pattern which promotes camouflage by "countering" the effects of shading. However, the dark dorsum-light ventrum pattern can be used to either increase or decrease conspicuousness depending on the orientation of the bird and the position of the sun. Indeed, the present data show that singing mockingbirds orient themselves so that their color pattern *enhances* their conspicuousness. A color pattern is literally countershading only when the animal's posture and orientation illuminate darker surfaces and shadow lighter surfaces. Thus, although many animals have a countershaded color pattern, it cannot be assumed this pattern always functions only to camouflage.

To correct this, the terms *countershading* and *countershaded* should refer to behaviors, not color patterns. Specifically, for animals which 1) are in an environment typically illuminated by the sun, 2) have a brightness border on their body surface, and 3) are shaped and behave so as to cast a shadow on themselves, *behavioral countershading* could describe the behavior of orienting so the darker areas are illuminated and the lighter areas are shadowed, making the animal less detectable. *Behavioral contrasting*, on the other hand, could describe the behavior of orienting so that the lighter areas are illuminated and the darker areas are shadowed, making the animal more conspicuous. There will be variability across animals in the extent to which their behavior can enhance or counteract countershading coloration. For example, while the mockingbirds in the present study could simply rotate in space, quadrupeds may be less able to adopt those postures that behavioral contrasting would demand.

The relative incidence of behavioral contrasting and behavioral countershading should depend largely on the level of predation pressure. Adult mockingbirds have relatively few predators in general, and their noisy aggressiveness may make them less desirable to predators relative to other similar-sized passerines (Derrickson and Breitwisch 1992). Further, at the study site hawks and owls are uncommon to rare during the breeding season (H. Hendrickson, personal communication, 1995). Thus, two predictions can be made. First, a broadly comparative approach may show that the incidence of behavioral countershading may be positively related to predation pressure across species. Second, the incidence of behavioral contrasting versus behavioral countershading within a species may also vary with predation pressure. Mockingbirds may tend to behaviorally countershade in areas where potential predators are more numerous, such as open countryside and forest edges, in contrast with the behavioral contrasting found presently on a busy urban campus. As predation pressure increases geographically or even chronologically (if higher predator density and/or likelihood of attack varies with season or time of day), the incidence of countershading should increase relative to contrasting.

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1995 Spring North American Migration Count in North Carolina

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The 1995 North American Migration Count (NAMC) was held on 13 May and included reports from North Carolina for the the second year. No reports were received for two counties that were listed in 1994 (Craven and Jones), while reports for five counties (Ashe, Avery, Moore, Onslow, and Wilkes) were received for the first time. This resulted in a net increase of 3 counties for a total of 15 North Carolina counties reporting.

The spring NAMC is conducted annually throughout North America north of Mexico on the second Saturday in May. It was begun in 1992 by Jim Stasz, a birder in Maryland who is attempting to determine the pattern of migration in North America. Unlike traditional Christmas and spring counts, the NAMC obtains an annual "snapshot" of the continent by organizing volunteers in each state (and province) to count birds in an entire county on a single day.

The annual date of the NAMC can be one to two weeks after many migrants have passed through some parts of North Carolina. However, the purpose of the count is not to determine how many migrants are in a state at the peak of migration but rather to identify the density and distribution of bird species throughout the whole continent at a given point in time. Therefore, some species will be gone from some southern states and will not have arrived yet in other states and provinces further north.

The number of reports in 1994 and 1995 is far short of the potential for migration counts in the 100 North Carolina counties. Currently, most geographic regions are poorly represented, with only the mountains receiving fair coverage. Clearly, data regarding the density and distribution of bird species during spring migration in North Carolina and the continent will benefit from the inclusion of more counties in each region in the future.

The following is the list of counties (and county seats) for which reports were received for the 1995 North American Migration Count in North Carolina:

Alleghany (Sparta), Ashe (Jefferson), Avery (Newland), Buncombe (Asheville), Brunswick (Southport), Cherokee (Murphy), Cleveland (Shelby), Guilford