NUMERICAL COLOR SPECIFICATION FOR BIRD IDENTIFICATION: IRIS COLOR AND AGE IN FALL MIGRANTS

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INTRODUCTION

An important clue to the age and sex of birds for banding is the color of soft parts. In contrast to measurements of structures or degree of skull ossification, the quantitative specification of color is particularly difficult using the inexact terminology of previous descriptions, such as "reddish-brown" or "yellowish-green." On the other hand, the specification of color in other fields, such as textile, paint, or inks industries, is well developed, and it appears useful to take over the quantitative methods used there for the purpose of bird soft-part specification. Ridgway (1886) attempted this method with a set of widely-used color standards and names for each hue. Others, such as Maerz and Paul (1951) or Villalobos-Dominguez and Villalobos (1947), have published color dictionaries, but unfortunately none of these is numerical. A numerical criterion is very useful in keys for identification as well as for computer manipulation of data, and such a system frees the color description from unwieldy adjective strings.

Two numerical systems of color specification are in scientific use. One, called the CIE (International Commission on Illumination) system, is applicable to much of optics and color vision. The other, the Munsell system, is more frequently used for textiles and paints, and has been used to a certain extent for biological materials. Munsell publishes charts designed for plant tissue colors, but zoological applications are scarce. Bowers (1956) used the system effectively on breast color of Wren-tits (*Chamaea fasciata*), and he included a detailed comparison of the available color systems. Miller (1958) examined the system, compared it to others, and concluded that it is particularly suitable for color problems in biology. But other than these, little use has been made of it by zoologists. We propose to show its utility in color problems in birds and how its use reduces previously qualitative descriptions to quantitative ones suitable for statistical and computer analyses.

THE MUNSELL SYSTEM

The Munsell system of color notation specifies a given color in terms of three characters: hue, value, and chroma. These characters are arranged in orderly scales of nearly equal steps of perception to the eye, giving a three-dimensional geometric space in which a given color is uniquely located. Hue, specifying redness, yellowness, blueness, etc., is arranged in a circular scale of 100 parts, whereas value, specifying whiteness or blackness (grayness), runs from 0 (black) to 10 (white). Chroma, which specifies the intensity of the hue from a pure gray to extreme vividness of color, extends

from 0 to 10 or 16 units depending on color intensity. A diagram of the three-dimensional space of the Munsell system is shown in Figure 1.

There are two common hue notations, one of which is purely numerical whereas the other uses letters conveniently indicating the hue, as R for red, YR for yellow-red, etc. For the purpose of keys and age criteria, it is recommended that the purely numerical notation be used, even though the letter convention is more informative for the novice. The convention for specifying a color is first, hue, then value, then chroma separated by slash marks. For example, 5/6/8 (5R/6/8) specifies a red color (hue 5 or 5R) that is quite light (value 6) but very intense (chroma 8). The color specified by 5/3/6 (5R/3/6) is a deep red of the same hue but lower on the gray or value scale (darker), and having less chroma (intensity). It represents a brownish-red appearance.

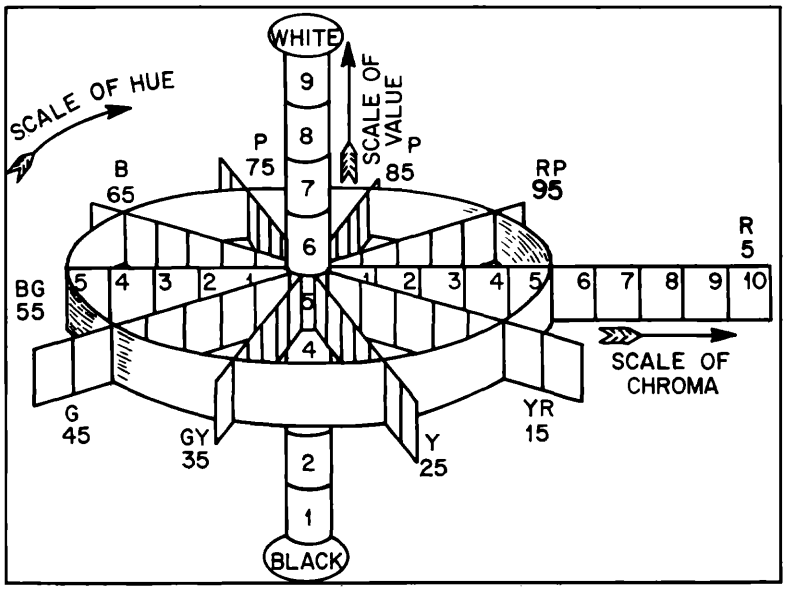

FIGURE 1. The relationship of hue, value and chroma in the Munsell color system. The circular band represents the hues in their proper sequences. The upright center axis is the scale of value. The paths pointing outward from the center show the steps of chroma, increasing in strength as indicated by the numerals. (From the Munsell Color Book).

The Munsell system is really based on a set of standards prepared with great care to represent equal steps in each of the three coordinates, and reproducible from one location to another. The system is used by comparing visually the surface to be measured and the standard surface and reading off the coordinates of the standard. A full set of standards containing 40 hues may involve

as many as 1500 "chips" made by coating paper rectangles with permanent coloring agents and the "Book of Color," constituted of chips arranged on pages of a given hue with value vertical on the page and chroma horizontal, represents the practical embodiment of the system. The conversion from the Munsell system to the CIE system via the spectrophotometric curves on which the CIE system is based has been documented by a special committee of the Optical Society of America (Newhall, Nickerson, and Judd, 1943), and Hamly (1949) has converted the Ridgway Atlas to the

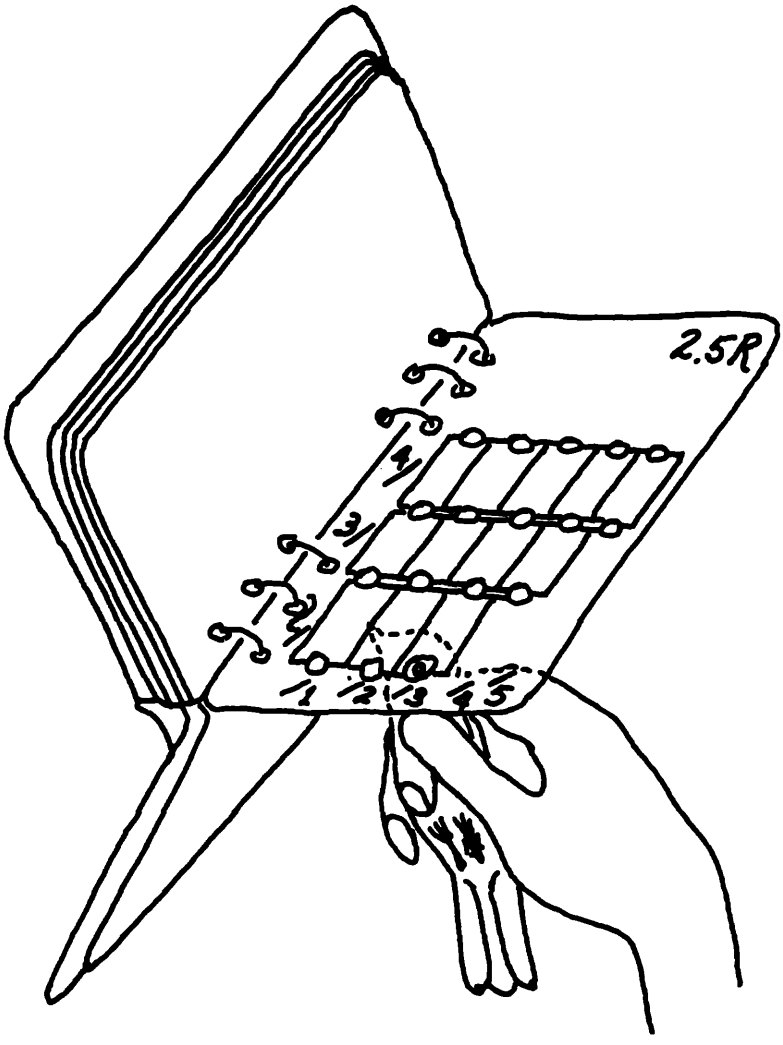

FIGURE 2. Munsell Book of Soil Color Standards being used to determine the iris color of a bird after banding.

Munsell system. A full treatment of the subject is to be found in various books on color (Judd and Wyszecki, 1963; Munsell, 1961).

Fortunately for the problem of iris color in most birds, there is a set of color charts designed for soil color specification in agriculture and related fields which contains the requisite reds, yellows, and browns commonly appearing in the eyes of birds. This abridged color book can be obtained from the Munsell Color Company, Inc. 2441 N. Calvert St., Baltimore, Md. 21218 for about $26.00. Extension with 5R and 7.5R hue charts adds about $8.00. The Munsell soil color charts form the set of standards we have used in preparing this report.

THE MUNSELL CHARTS AND BIRD EYE COLOR

Not only are the Munsell soil color charts suitable in having the appropriate colors represented, but also the charts are prepared with holes through the page next to the chip so that the object being compared can be placed very close to the standard. Figure 2 illustrates how the charts are used for the measurement of bird iris color. After banding, the bird is held so that the iris appears in the circular opening next to the color chip most closely matching the iris color. The coordinate values are then read off the page and recorded on the banding data sheet. It is good practice to use ample daylight for such color comparisons, and the results reported here were recorded that way. It is important to take great care to have the lighting constant, as with full daylight, since the apparent color may vary with the illuminant (metamerism).

RESULTS

Several species of birds have known iris color changes suitable for age criteria and some are common enough to provide a reasonable sample to test the method. We chose the Rufous-sided Towhee (*Pipilo erythrophthalmus*) and the Red-eyed Vireo (*Vireo olivaceus*), and the results show several features of the method.

Figures 3, 4, and 5 represent the data from 34 Rufous-sided Towhees, plotting the magnitude of each character separately against the number of individuals expressed as the per cent of the sample for each age class. The age of fall birds was confirmed using gape and plumage criteria (Wood, 1969). Inspection of the three figures shows that for this species, value is not a useful character to separate adult and immature (HY) birds, and that chroma is less than ideal because of overlap in the middle region. Hue, however, shows the total sample separated clearly into two age groups with a dividing line near hue 12/. It might even be practical to use a single chip to separate adults from immatures, in this case 12/3/6, by estimating whether the iris color is redder or yellower than the dividing hue.

The results for 58 Red-eyed Vireos are shown in Figures 6 and 7, plotted in the same manner as for the towhees. In this case again, the sample falls into two groups, but a small fraction of the sample overlaps for both hue and chroma. The two populations are in-

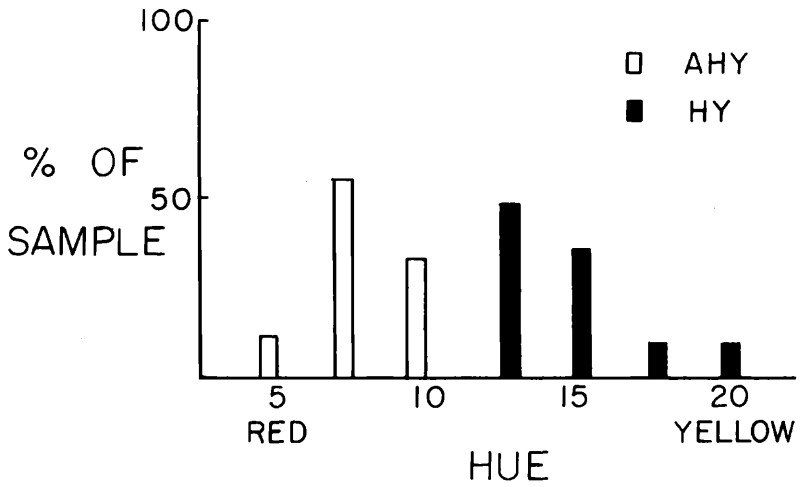

FIGURE 3. Hue character of iris color for Rufous-sided Towhees plotted with respect to per cent of sample in two age groups, HY and AHY.

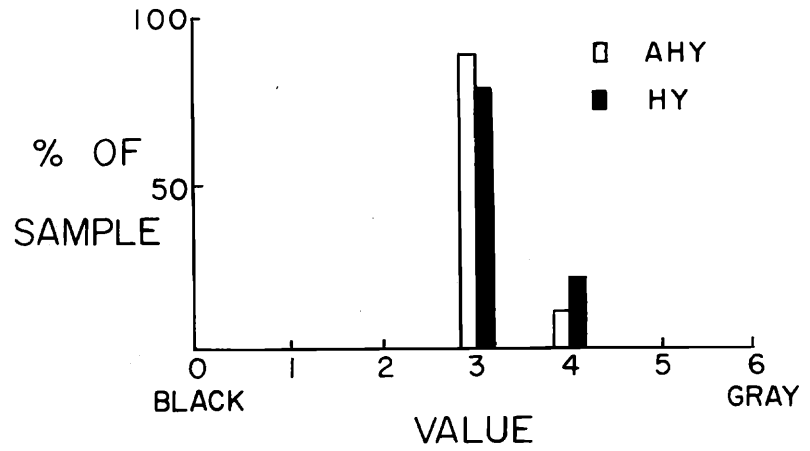

FIGURE 4. Value character of iris color for Rufous-sided Towhees plotted with respect to per cent of sample in two age groups, HY and AHY.

deed the HY and AHY age groups as determined independently by skull ossification (Norris, 1961). The overlap can be resolved for this species if a three-dimensional plot is made, using hue and chroma as independent variables and per cent of sample as dependent variable; this suggests that a more sophisticated approach than we have used here with two-dimensional plots might yield more clear-cut results in general. It is indeed common practice in complex color standardization to use the concept of vectors in the color space. It is likely, however, that the simpler criteria will be very useful in banding.

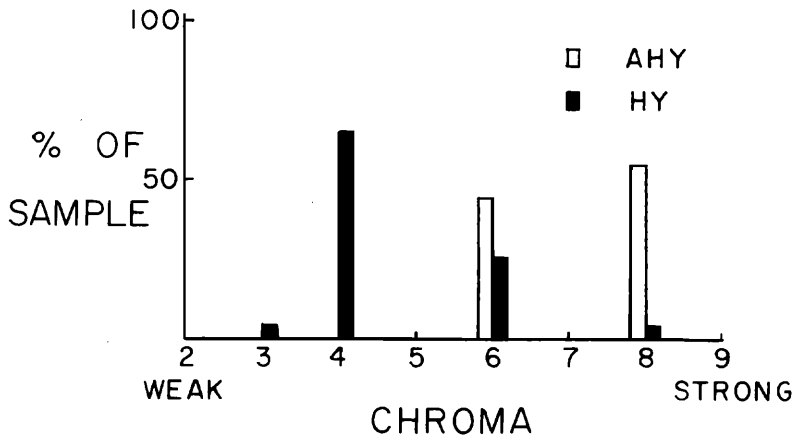

FIGURE 5. Chroma character of iris color for Rufous-sided Towhees plotted with respect to per cent of sample in two age groups, HY and AHY.

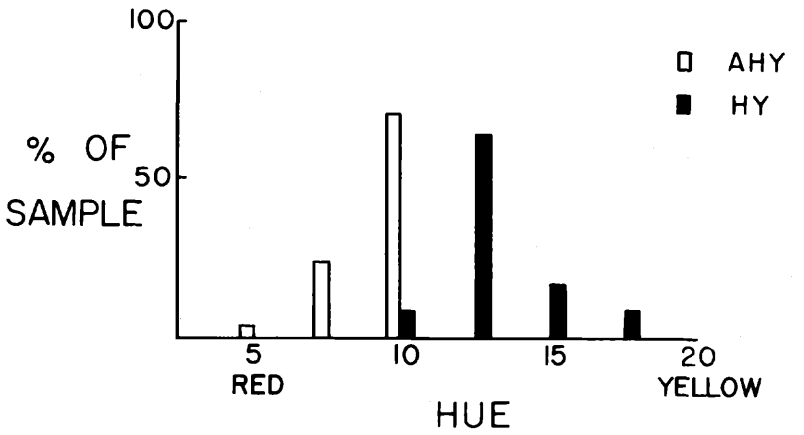

FIGURE 6. Hue character of iris color for Red-eyed Vireos plotted with respect to per cent of sample in two age groups, HY and AHY.

Iris color studies for the Downy Woodpecker (*Dendrocopos pubescens*), Yellow-shafted Flicker (*Colaptes auratus*), and Brown Thrasher (*Toxostoma rufum*) give data generally similar to those for the Red-eyed Vireos, with two populations (HY and AHY) and a small overlap region on the basis of hue.

We have extended the method to the measurement of iris color in a sample of 120 Tennessee Warblers (*Vermivora peregrina*) banded during 1971 and the results are shown in Figure 8. On the basis of hue, the sample divides with very little overlap into two populations having a dividing line at hue 18/. These two groups were

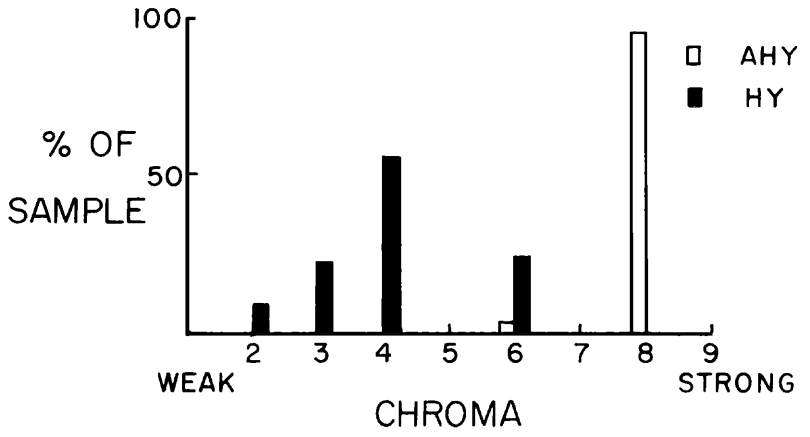

FIGURE 7. Chroma character of iris color for Red-eyed Vireos plotted with respect to per cent of sample in two age groups, HY and AHY.

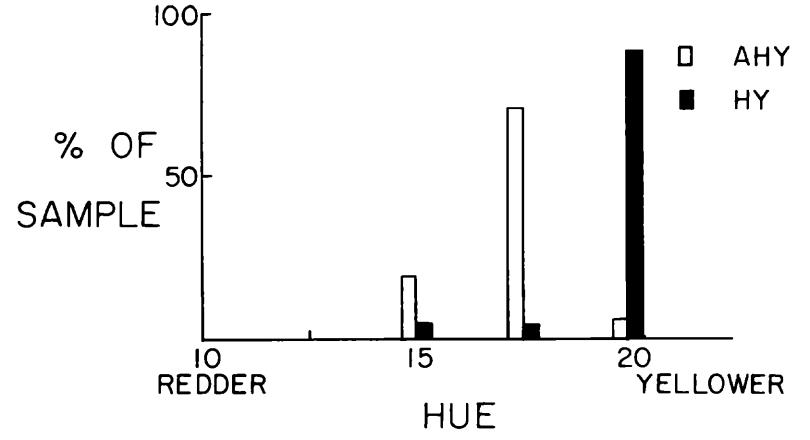

FIGURE 8. Hue character of iris color for Tennessee Warblers plotted with respect to per cent of sample in two age groups, HY and AHY.

independently confirmed as AHY or HY on the basis of skull ossification in fall birds or on time of year in spring birds. Of the total group, only 1 incorrectly fell into the hue 20 category and only 12 incorrectly fell into the others (15 and 17.5), giving a very significant 98% correct in the HY portion of the iris color criterion. It is reasonable to expect that other species would follow a similar pattern, and a new investigative tool emerges.

DISCUSSION

It is obvious that there is much more work that needs to be done with this method of color specification before it can become a standard part of the banding methodology. For example, little

information exists on the variation that different observers would encounter in determining the color of the same individual bird. These data could be accumulated in cooperative projects like Operation Recovery where there would be opportunity for several observers to measure the same bird on the same day. The variation from day to day for the same observer measuring the same individual bird could be detected for species that repeat often in a short span of time at a given station. It would also be desirable to study the time variation for repeating species as the bird ages, especially for those species in which no overlap in the color criterion occurs. More study of the effect of lighting conditions is also desirable.

We have discussed here only the determination of iris color, but many other applications for the Munsell color system for bird color specification could be found. For example, in keys for identifying Eastern *Empidonax* flycatchers (Bordner, 1971; Wood, 1969) the color of the plumage of the dorsal tract differs with the species. The green birds are Yellow-bellied (*E. flaviventris*) or Acadian flycatchers (*E. virescens*) whereas the brown birds are Least (*E. minimus*) or Traill's flycatchers (*E. traillii*). A single chip representing a color standard between the hue range for the two groups would be a useful reference for nearly every bander, particularly those who handle limited numbers of the flycatchers. It should be possible in a similar way to devise abridged color standards for other individual species where age or sex could be determined by a few chips, or even a single one. One can thus think of many situations where color criteria enter, and we suggest that the Munsell system be used to quantify these criteria.

SUMMARY

We have shown that the Munsell color system provides a useful way to determine iris color for aging criteria in some birds. The notation is suitable for numerical data processing and for computer entry. The abridged set of Soil Color Charts is suitable for bird iris color determination. The previously known color variation with age in Rufous-sided Towhees and Red-eyed Vireos has been quantitatively described using the method, and data for Tennessee Warblers suggest that with a quantitative method available, more species than have been previously reported, may show an iris color variation with age or sex. The method has other obvious applications for determining color of soft parts and plumage.

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