A TENTATIVE KEY FOR SEX DETERMINATION OF COMMON REDPOLLS (*ACANTHIS FLAMMEA FLAMMEA*) IN THE NORTHERN UNITED STATES DURING WINTER

By WILLIAM S. BROOKS

INTRODUCTION

The method for sexing Common Redpolls (*Acanthis flammea*), as outlined in Wood's guide (A bird-bander's guide to determination of age and sex of selected species. Univ. Park, Pa., 1969) proved quite unsatisfactory for me during the winter redpoll invasion of 1971-72 By his method, any bird having a pink breast is considered to be a male and any bird without it is a female. However, what is "pink" depends upon the lighting conditions and the visual acuity, color perception, and judgment of the observer. The range of pinkness is very broad, from red to extremely faint pink. In nonred individuals the situation is complicated by the fact that different birds have varying distribution patterns of the red carotenoid pigment in the individual breast feathers. Some birds thus have a mottled pink-white or pink-buffy appearance, whereas others are quite uniformly light pink. Further, some males have no color, whereas many females have at least some, and fairly often, a large amount of bright pink on the breast. The last point in Wood's key, using the incubation patch and cloacal protuberance to sex nonred individuals, would normally clarify the ambiguity except for the fact that these characteristics are nonexistent in winter, the time at which most redpolls are banded in the continental United States exclusive of Alaska. Even in April, when many were reproductively advanced enough to sing, the cloacal protuberance and incubation patch were both undeveloped in central Wisconsin.

The present study mainly involves birds which the author assigns either to *A. f. flammea* or to *A. flammea* X *A. hornemanni* (Hoary Redpoll) intergrades (but which intergrades must arbitrarily be assigned to *flammea* on the basis of streaking and bill proportion: see Brooks, *Wilson Bull.*, **80**: 253-280, 1968). It does not involve typical Hoary Redpolls, other subspecies of *flammea*, or juvenile birds without red polls.

COLLECTION OF DATA

My interpretation of Wood's method is that even the faintest pink occurring anywhere on the breast, upper flank, or upper belly of a bird indicates a male. Others' interpretations doubtless differ somewhat, thus his method inherently contains considerable subjective bias. Had this method been used to sex 515 birds banded by me in the 1971-72 winter at Ripon, Wisconsin, 417 would have been designated males and 98, females. A population with 81% males and 19% females is unusual, and since this apparently fallaceous tendency toward a male preponderance was noted very early in the banding, I began to record measurements and obser-

vations of color that I thought might separate the sexes: wing length, breast color, and presence or absence of pink on the rump and cheeks. Later it seemed obvious that rump and cheek colors were not correlated either with breast color or sex (many with no pink on the breast had pink rump and/or cheeks; both known males and females with pink on the breast had no pink on cheeks and/or rump in some cases), and observations of these two characteristics were discontinued. During the same time, however, it had become apparent that poll length and poll color were both correlated with sex, and investigation of these characters was initiated. It was hoped that at least one of these four final characters would show an essentially nonoverlapping distribution that would separate the sexes, but this did not materialize, as is so often the case with biological materials.

Since the sex of relatively few of these banded birds was known with certainty, no correlations could be made that were not very speculative. However, 95 birds which had been caught and randomly selected throughout the banding period for experimental use in other research were sexed later in the year, either by cloacal examination, autopsy, or both. There were 50 males and 45 females which upon capture had been measured in the ways mentioned above, so that correlations with sex became possible.

A. *Wing length*—This was measured in the standard way (rounded to the nearest mm), with the primary feathers flattened on the ruler. It differs from the procedure given by Wood (1969), where the unflattened wing chord is measured. A flattened wing measurement was used because several factors could alter the curve of the primaries, and thus their length. Among these factors, humidity and bending due to capture and confinement seemed to be most important. MacBriar (*IBBA News*, **43**: 21-27, 1971) and Hilsabeck (*IBBA News*, **44**: 225-227, 1972) both indicated that in several species of birds the left wing is often longer than the right. Comparative measurements were not made to substantiate this for redpolls, but the right wing was measured in the present study and should be the one measured when using the key.

B. *Poll length*—The poll is here defined as the colored area (red to yellow) of the crown. Measurement was made looking down on the poll. It was made (rounded to the nearest mm) with the ruler centered over the poll, directed straight front-to-back (never diagonally), and included the extremes of the colored area. The feathers were smoothed to their normal position prior to measurement, and the ruler was not pressed down upon the poll. A better instrument for poll measurement is a caliper, but this instrument might be unavailable to many banders.

C. *Breast color*—Breast color, including the flanks and upper belly, was divided into six arbitrary categories: red, pink, slight pink, very slight pink, extremely slight pink, and no pink. Little correlation with sex was found except in the two extreme categories, and it is therefore unimportant to describe the other categories in detail. A "red" breasted bird has either a red or bright pink breast

that usually is clear of dark streaking and is solidly or smoothly colored rather than pink-white mottled. Birds in the four intermediate categories almost always had some dark streaking in the pink of the breast, especially toward the sides. For the "no pink" category it is important to distinguish between buffy and faint pink (melanin vs. carotenoid) pigmentation. To differentiate these pigments the feathers must be closely and sometimes individually scrutinized in good light. Fluorescent or outdoor light is best; incandescent light tends to have a yellowing effect, making pink appear buffy.

D. *Poll Color*—This was recorded in five arbitrary categories: red, red-orange-red, orange-red, orange, and yellow. The color was usually homogeneous, but sometimes a bird had, for example, perhaps 50% red feathers and 50% orange or yellow feathers (or some other combination of colors and percentages) in the poll. The polls in this example would be categorized, respectively, as red-orange and orange. If only one or two feathers were of a different color, these feathers were disregarded and the main color of the poll was recorded.

DISCUSSION OF DATA

A. *Wing length*—Table 1 shows that the right wing lengths of the 95 experimental birds overlapped widely between sexes. Of 343 banded birds whose sex was determined by using the key presented at the end of this report (or if the bird was a "red" male the key was unnecessary), 153 males had a range of 68-78 mm, and

TABLE 1. Mean values and ranges of certain measurements of 95 redpolls of known sex.

Characteristic	Males	Females
Wing length (mm)	73 (70–78)	71 (67–74)
Poll length (mm)	12 (10–14)	10 (8–12)
W/P Index	6.1 (5.2–7.3)	7.1 (5.8–9.2)

189 females, 66-74 mm, (66-79 mm if two probable *A. f. holboellii* females were included). The large overlap range, 68-74 mm, allowed only 14% of the males and 7% of the females to be identified with this character (males, 75 mm or more; females, 67 mm or less).

B. *Poll length*—This measurement also overlapped (Table 1) but not to the same extent. Of 244 banded birds for which poll length was recorded and sex was determined with the key, 116 males had the same range as the experimental birds and 128 females ranged from 7-12 mm. Although the overlap range (10-12 mm) was only three-eighths of the total range of variation, most of the birds (68% of 50 males, 70% of 45 females) fell in the overlap area. Therefore, poll length identified about 30% of each sex, better than wing length, but again insufficient if used as the sole sex identification character.

C. *W/P index*—A combination of wing and poll lengths was considered for further separation of the sexes. By dividing the wing by the poll length for each individual, a W/P index value (Table 1) was obtained (rounded to the nearest 0.1). The values used to separate the sexes were 6.0 or less for males, 7.0 or more for females. This system identified 44% of the males and 52% of the females, but 6% of the males fell within the female range (and would have been misidentified if this were the only character used), and 4% of the females fell within the male range. To change the values enough to bring about no error of misidentification would have decreased the number of birds identified by this character considerably (identified nonred males reduced by 54%, females by 40%). Thus, the best "compromise" values that could be found in the available data were 6.0 and 7.0.

D. *Breast color*—Except for the "red" and "no pink" categories, this was fairly inconclusive (Table 2). The second category ("pink": mottled pink and white or buffy, with some dark streaking, but still quite pink) proved interesting. Most persons would probably designate these birds males because of their distinct pinkness, but see category 2 in the table. These "pink" birds of both sexes often were intermediate also in other characteristics, so that only about

TABLE 2. Breast colors of 95 redpolls of known sex.

Sex	Category 1 (Red)	Category 2 (Pink)	Categories 3-5 (Intermediate pink)	Category 6 (No pink)
Male	21 (42%)	9 (18%)	19 (38%)	1 (2%)
Female	0	6 (13%)	25 (55%)	14 (31%)
Total	21 (22%)	15 (16%)	44 (46%)	15 (16%)

50% could be identified correctly by the key. Of the 9 males, 5 were identified correctly and 4 were classified as unknown. Of the 6 females, 3 were identified, 1 was misidentified as a male, and 2 were unknown.

Occasionally a bird has a few orange or yellow feathers scattered among the red or pink. These feathers should be considered as pink when classifying the breast color. It should be noted again that even in good light it is easy to confuse buffy with faint pink, even moreso with yellow, and so care must be taken.

E. *Poll color*—As is well known to banders who have handled many redpolls, the color of the poll is quite variable, ranging from dark purplish-red to bright crimson to orange to pale yellow. My category of "red" includes the purplish-red through crimson shades. Forty-four (88%) of the males had red polls, the remainder were red-orange to yellow. Thirty-two (71%) of the females had slightly red-orange to yellowish polls, the rest being red.

F. *Combination of all characteristics*—A key using the five previous characters was devised and then applied to the 95 redpolls of known sex. This key is presented in a later section, and its utility may be seen partially from the figures in Table 3. The 26% decrease from 34 to 8% misidentified (the same value, of course, as the 26% increase in correct identifications, from 66 to 92%) is considered significant enough for the method proposed herein to be of utility, even though some errors are still made and even though it might take longer for the bander to use.

To attempt to determine whether the key works only for the actual sample that it was devised upon, or whether it has more general application, we might look at 315 banded redpolls for which complete data (exclusive of sex) are available. The key gave these results: males, 116; females, 144; unknown, 55. These 55 unidentified birds comprise 17% of the total sample, quite close to the "expected" 19% (total unidentified in the 95-bird sample in which sex was known).

More females than males were identified, as expected. I will assume an approximate 50:50 true sex ratio in the banded population, not only for the reason that this is considered a normal ratio in most animal populations, but also because it showed up in the randomly selected group of 95 experimental birds which were collected throughout the period when the 315 birds were being banded. Knowing that 80% of the females and 70% of the males were correctly identified in the sample of 95, a simple ratio can be set up to show that with the number of females identified (144), the corresponding number of males should be 126. The actual number identified, 116, is only 10 birds from that value.

Of the unidentified birds in the 95-bird sample, approximately 40% (7 of 18, from Table 3) were female and 60% (11 of 18) were

TABLE 3. Comparison of sex identification of 95 redpolls of known sex by the Wood method and by the present method.

Method	Identification	Male		Female		Total	
		No.	%	No.	%	No.	%
Present Method	Correctly identified	35	70	36	80	71	75[1]
	Misidentified	4	8	2	4	6	6[2]
	Unidentified	11	22	7	16	18	19
Wood Method	Correctly identified	49	98	14	31	63	66[3]
	Misidentified	1	2	31	69	32	34[3]
	Unidentified	0	0	0	0	0	0

[1]Actually 92% of the 77 birds not termed "unidentified".
[2]Actually 8% of the 77 birds not termed "unidentified".
[3]The per cent will remain the same, since none was unidentified.

male. Also from Table 3, 4% of the females and 8% of the males were misidentified. By calculating (from these percentages) the appropriate values and by adding and subtracting from the 144 females and 116 males as necessary, an estimate of 160 females and 155 males in the 315-bird sample is obtained. This is very close to the expected 50:50 ratio.

The proximity to expected results in all these cases is one implication that the key can be used on populations other than the one upon which it was devised, and although I will not state that this means that the key is always valid, I believe that the proximity to expectation at least helps to uphold the validity of the key. Nevertheless, the key must be designated as tentative at this point, awaiting a larger sampling in the future.

It should be emphasized that the key is so designed that the earlier characteristics in it are less ambiguous (show less overlap between sexes) and therefore have less error associated with them (Table 4). Thus, the earlier in the key that a bird is identified, the more certain is its identification. In Table 4 the actual error is generally reduced from the theoretical because some birds that would have been misidentified by a particular characteristic have already been correctly identified at an earlier point in the key, and the ambiguous characteristic is never reached. In this connection, in using the key, it is important to understand that the first point at which a bird is identified in it is the last point at which the key should be consulted for that individual. Since different characteristics are present in different combinations in various birds, the total bird is not being considered here. Instead, one unique characteristic that an individual possesses and that indicates its sex is sufficient, for other characteristics may be contradictory. A partial illustration of this is in Table 4 (last column) where no females were identified by wing length in point three; two females with a wing length of 67 mm had already been identified earlier in the key.

In using this method, so much time can be spent in measuring, calculating the W/P index, etc., that at a time of heavy banding it might be impossible to keep up with the birds. It is suggested, therefore, that wing and poll lengths, and breast and poll colors be recorded at the time of handling the birds. When convenient at a later time the W/P values can be calculated and each bird run through the key. A thorough knowledge of the key is necessary, though, especially of the color characteristics.

The key was devised mainly upon *A. f. flammea* and it should probably be used only for this race, the principal subspecies wintering in the United States exclusive of Alaska. A few individuals of *A. f. rostrata* were banded, and two were among the 95 experimental birds. They seemed to be different from *flammea* primarily in being darker, having a longer bill, larger body, and relatively longer tail. They did not differ noticeably from *flammea* in the characteristics used in the key, but nevertheless were tested inadequately in this study, and whether the key works with them cannot be said. *A. f. holboellii*, however, almost without doubt will not be sexed properly because of points three and five concerning

TABLE 4. Theoretical and actual misidentification error percentages present in the key for 95 Redpolls of known sex, and the number of these birds correctly identified at each point in the key.

Key Point	Characteristic	Theoretical error percentage			Actual error percentage			No. correctly identified	
		Male[1]	Female[2]	Total	Male[3]	Female[4]	Total	Male	Female
1	Breast color (male, red)	—	0%	0%	—	0%	0%	21	0
2	Poll length (female, $\leq$ 9 mm; male, $\geq$ 13 mm)	0%	0	0	0%	0	0	6	13
3	Wing length (female, $\leq$ 67 mm; male, $\geq$ 75 mm)	0	0	0	0	0	0	3	0
4	Breast color (female, no pink)	1	—	1	1	0	1	0	7
5	W/P index (female, $\geq$ 7.0; male, $\leq$ 6.0)	3	2	5	2	2	4	9	5
6	Poll color (female, nonred; unidentified, red)	6	—	6	1	—	1	0	7
Total key		10	2	12	4	2	6	35	36

[1]theoretical error is defined to be the per cent of males that were female-like for the character; per cent based upon the total number of 95 birds.
[2]per cent of females that were male-like for the character.
[3]actual error is defined to be the per cent of males incorrectly identified by the key as females; per cent based upon the total number of 95 birds.
[4]percent of females incorrectly identified as males by the key.

wing length. If either a *rostrata* specimen or one of these unusually large, dark *holboellii* is encountered, it is probably best to designate it as an unknown unless its sex can be identified specifically in point 1a in the key. The key also may not work for typical specimens of the Hoary Redpoll in all cases. The pink of *hornemanni* is often of a lighter shade than of *flammea*, the birds are less streaked on the breast, and although no measurements have been made, from past experience of the author the poll seems relatively shorter. They, too, probably should be left unidentified unless they can be sexed in point 1a in the key.

CONCLUSIONS

A tentative key for sex determination of the Common Redpoll can be devised from the data reported herein that will be more accurate than that proposed by Wood (1969). This has been done, and the key follows. It can be used for *Acanthis flammea flammea* (the most common of the subspecies found in the United States exclusive of Alaska), but probably not for *A. f. rostrata* and *holboellii* or for *A. hornemanni* (Hoary Redpoll), unless the sex of the bird can be determined in point 1a of the key.

1(a) Most breast feathers completely colored red or bright pink, giving a solid red or pink effect; usually without distinct dark streaking.....male

(b) Breast (including upper flanks and upper belly) smooth, light pinkish; mottled pink-white or pink-buffy; or with no pink; usually with some dark streaking, especially toward sides.....2

2(a) Poll length 13 mm or more (measurement of total extent of colored area of crown, front-to-back, not diagonally; feathers smoothed down to normal position prior to measuring; caliper desirable but if using ruler, ruler must be held above poll so that feathers are not pressed down; measurement made looking down on poll; value rounded to nearest mm) .....male

(b) Poll length 9 mm or less.....female

(c) Poll length 10-12 mm.....3

3(a) Flattened right wing 67 mm or less, value rounded to nearest mm.....female

(b) Flattened wing 75 mm or more.....male

(c) Flattened wing 68-74 mm.....4

4(a) Breast with absolutely no pink (do not confuse buffy with pink; scrutinize in good light, preferably fluorescent or outdoor).....female

(b) Breast fairly pink to faint pinkish, sometimes very faint and easily confused with buffy; or with a few individual pink feathers.....5

5(a) W/P index 7.0 or more (wing length divided by poll length, rounded to nearest 0.1) . . . . . female
(b) W/P index 6.0 or less . . . . . male
(c) W/P index 6.1-6.9 6

6(a) Poll red-orange, orange, yellowish-orange, or yellow . . female
(b) Poll purplish-red to crimson . . . . . unknown

Department of Biology, Ripon College, Ripon, Wisconsin 54971.

Received 5 October 1972, accepted 16 November 1972.