NOTES ON THE BREEDING CYCLE OF THE RED CROSSBILL (*LOXIA CURVIROSTRA*) IN MONTANA

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INTRODUCTION

The Red Crossbill (*Loxia curvirostra*) has been known to breed every month of the year (Griscom, 1937), thus seeming to defy the mechanisms postulated currently to control the breeding cycle of small passerines (Burger, 1949; Wolfson, 1952). It was with this thought in mind that the author decided to study the reproductive condition of a flock of Red Crossbills that arrived at the Biological Station of the Montana State University at Yellow Bay, Montana. The birds arrived during the middle of July 1954, and appeared in increasing numbers until the middle of August when it was possible to trap twenty-three birds in one day.

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METHODS AND MATERIALS

A total of 169 birds was examined. Of these, 163 were trapped during the period August 1st to 15th and four from July 13th to 31st; two birds were collected on June 22nd. No crossbills were noted by the author in the area prior to June 22.

With the exception of the two birds collected, all the birds were trapped in sparrow traps placed over urinated soil on which the birds were feeding. The ground was also salted with table salt. The traps were open continuously from July 13th to August 15th. Of the 169 birds observed 26 were prepared as study skins for subspecific identification and their gonads and vasa deferentia or oviducts saved for histological study. For an additional five males no skins were made, but their gonads, vasa differentia and seminal vesicles (glomera) were preserved. The gonads of 31 birds, 24 males and 7 females, were studied histologically. The remaining 138 birds were banded with U. S. Fish and Wildlife Service bands and released. For most of the trapped birds and for the 31 birds that were autopsied the following observations were made: body weight, length of exposed culmen, depth of culmen, length of chord of wing, (preceding three measurements after Baldwin *et al.*, 1931), amount of yellow in the plumage of the males (roughly estimated), presence and development of brood patch, cloacal development (Wolfson, 1954), and fat deposition. With the exception of the two birds taken on June 22nd, the birds autopsied were collected during the period of August 6-10. The material for histological study was fixed in AFA and then stored in 80% alcohol. Observations on the reproductive system included weight and extent of follicular development of the ovary, weight and greatest width of the seminal vesicle, extent of coiling of the vasa deferentia, and the size of the testis. The volume of the testis was calculated from the volume of an ellipsoid. The stages of spermatogenesis are those of Wolfson (1942). The gonads and accessory organs were weighed with a Roller-Smith torsion balance.

Body measurements were taken with a small ruler calibrated in millimeters. Measurements of recaptured birds showed that the original measurements were accurate to plus or minus 1 millimeter. Measurements of fresh skins taken with calipers showed similar agreement. This range is too great to permit accurate assay of subspecific status, except for the wing measurement.

According to Griscom (1937), in *bendirei,* the breeding race of the northern Rocky Mountains to central southern Montana, the male has a wing measurement of 86.5 to 94 mm; in *sitkensis,* the race breeding in the northwestern Pacific coast, the wing measurement of the male is 81 to 85.5 mm; in *benti,* the race breeding in southeastern Montana and the Rocky Mountain region of Colorado, the wing measurement of the male is 93 to 98 mm. The relationship between the latter two races is apparently poorly understood. The race normally breeding at Yellow Bay is *bendirei* (A.O.U. Check-list, 1957: 575).

TABLE 1

FREQUENCIES OF WING MEASUREMENTS

Wing measurement (millimeters)	*No. of Males*	*No. of Females*
95	0	0
94	4	0
93	2	0
92	16	0
91	15	0
90	18	2
89	26	1
88	15	3
87	9	3
86	4	2
85	8	2
84	6	3
83	1	8
82	1	1
81	2	6
80	0	5
79	0	0
78	0	1
77	0	0

The males with wing measurements from 88 mm. to 94 mm. probably represent the race *bendirei*. See the text for a discussion of this group. The males with wing measurements of 81 mm. to 86 mm. probably represent the race *sitkensis*. The wing range for the females of these races is not known.

MEASUREMENTS, PLUMAGE AND MOLT

Wing measurements: Table 1 shows the frequency distribution of the wing measurements of all the birds measured (155). On the basis of the wing measurements given by Griscom (1937), 96 of the males were probably *bendirei* and 22 were probably *sitkensis.* No attempt was made to ascertain the racial status of the trapped females. The wing-measurement frequency of the male birds was plotted for each day of trapping and revealed that the daily catches of birds were a mixture of both *sitkensis* and *bendirei.* The birds probably arrived as a mixed flock. Table 2 gives the summary of the subspecific status of the skins as determined by G. M. Bond of the U. S. National Museum.

There were 8 birds, 4 males and 4 females, identified as *bendirei,* and 4 birds, 1 male and 3 females, identified as *sitkensis.* The remaining 14 birds had the measurements of *bendirei,* but Bond reported (*in litt.*) that they ". . . do not agree in color with a presumably breeding series of that form from Idaho, Washington and Oregon, which are decidedly more orange in coloration. Instead, the underparts of the fourteen birds from Montana are a bright clear rosy red and approach the color of the *one* specimen of *benti* which we have for comparison. However, since the degree of relationship between these birds and *benti* is obscured by our lack of comparative material, I believe it best to refer all of these birds, at least tentatively, to *bendirei.*" The birds in Table 2 referred to as "*bendirei*" are these 14 birds, which for the purpose of this paper will be considered as representing the race *bendirei.*

Of the 138 birds that were banded in this study, only six were recaptured. The average interval between initial banding and recapture was 9 days, with a spread of 17, 11, 11, 8, 5, and 2 days. This low recapture rate from a flock which was presumably active reproductively is unusual and is discussed below.

Yellow feathers on the males: Notes were taken on the amount of yellow in 78 males by estimating the extent of the yellow area. Only two males were found that were all red, the remaining 76 showing some degree of yellowness. Two of the males were almost entirely yellow and had only a few red feathers; in addition to these two, there were 5 birds that were more than half yellow, 52 of the birds were noted as being less than 1/10 yellow. The remaining 17 were from 1/10 to ½ yellow. All of the birds skinned showed an adult type of skull. (See Tordoff, 1952 and Jollie, 1953 for a further discussion of this subject.)

Molt: Many of the birds examined were just starting the annual molt (postnuptial). The replacement of the primaries and head feathers had begun. Since many of these birds showed active gonads (Stage 5), the molt appears to be independent of gonadal regression. Bailey (1953) also found some evidence for this in the crossbill.

REPRODUCTIVE ORGANS

Gonads: Table 2 gives the weights and other data for the gonads and accessory organs. Two of the females identified as *sitkensis* were about to ovulate, and the testis of the male *sitkensis* was quite active. These birds appeared to be capable of breeding at the time the specimens were taken, though far from their supposed normal nesting range. It can also be seen from the data that a female *bendirei* was ovulating, having ovulated three eggs and about to ovulate a fourth. The female secured on June 22 had ovulated four eggs, one of which was in the distal end of the oviduct and was being covered with its shell.

With the exception of one specimen, all the testes were in active spermatogenesis (Stage 5), indicating that the population as a whole was probably in active spermatogenesis. The one exception was a bird for which no skin was saved that was collected on August 7th. It was in early regression from stage 5 according to Wolfson (personal communication) and may have been part of an *earlier* breeding population.

Vasa deferentia: The size and states of development of the vasa deferentia are given in Table 2. It can be seen that they were quite variable and that there were very few birds that had really well-developed vasa deferentia. Although little work has been done on their development, it is likely that it roughly parallels that of the seminal vesicles. Wolfson (1954) indicates that the fully developed and coiled vasa deferentia probably do not occur until the seminal vesicle (glomus) is well developed. The lack of fully developed vasa deferentia in birds with testes in Stage 5 probably indicates that the birds have not yet reached but are approaching breeding condition.

Seminal vesicle: Further evidence that the birds were approaching breeding condition was seen in the state of the seminal vesicles. Although none of them weighed more than 15 mgs., all of them contained sperm. Wolfson (1954) states that the development of the testis and seminal vesicles in other species starts at about the same time, but the fully developed seminal vesicle occurs only after the gonad has been producing sperm for some time. The data given by Wolfson (1954) indicate that the fully developed seminal vesicle for a bird of comparable size is several times the size of those obtained from the crossbills.

Cloaca of males: Observations on the cloacal region of 82 males also indicate that the population was just coming into breeding condition. In 18 of the birds examined the cloaca was well developed,

TABLE 2

DEVELOPMENT OF THE GONADS AND ACCESSORY ORGANS

Males—skins prepared

Subspecies	*Date Collected*	*Gonadal Right*	*Volume Left*	*Vas Deferens*	*Seminal Vesicle*
bendirei	June 22, 1954	—	82	3/4 coiled	—
"	Aug. 6, 1954	43	76	1/3 coiled	—
"	"	108	90	almost entirely coiled	—
"	"	57	51	almost entirely coiled	—
"*bendirei*"	Aug. 6, 1954	44	62	no coiling	—
"	"	89	99	1/2 coiled	—
"	"	83	75	entirely coiled	—
"	"	33	55	slight coiling	—
"	"	63	109	slight coiling	—
"	"	84	80	moderate coiling entire length	—
"	"	23	27	slight coiling	—
"	Aug. 7, 1954	42	70	2/3 coiled	—
"	"	64	85	almost entirely coiled	—
"	"	59	76	almost entirely coiled	—
"	"	68	79	slight coiling lower 3/4	—
"	"	55	80	slight coiling lower 1/2	—
"	Aug. 8, 1954	42	52	2/3 coiled	—
"	"	55	55	slight coiling lower 1/2	—
sitkensis	Aug. 8, 1954	53	68	1/2 coiled	—

Males—no skins prepared

Wing measurement	*Date Collected*	*Gonadal Right*	*Volume Left*	*Vas Deferens*	*Seminal Width*	*Vesicle Weight*
89 mm	Aug. 6, 1954	66	86	1/2 coiled	2.5 mm	15.0 mgs
89 mm	"	68	92	1/3 coiled	2.5 mm	15.0 mgs
91 mm	Aug. 7, 1954	77	97	moderate coiling almost entire length	2.5 mm	13.4 mgs
87 mm	"	49 (regression)	79	slightly coiled entire length	2.2 mm	5.0 mgs
87 mm	"	53	60	1/3 coiled	2.7 mm	9.6 mgs

The volumes of the testis are in cubic millimeters. For a discussion of the group labeled "*bendirei*," see text. When skins were prepared the seminal vesicles could not be preserved for measurement. The measurements of the seminal vesicle are for one vesicle.

TABLE 2 (CONTINUED)

Females—skins prepared

Subspecies	*Date Collected*	*Ovary Weight*	*Largest Follicle*	*Weight of Oviduct*
bendirei	June 22, 1954	ovulating	1.7 mm	egg in shell gland
"	Aug. 5, 1954	ovulating (3 eggs ovulated)	10.2 mm	egg in oviduct
"	Aug. 6, 1954	29.2 mgs	1.0 mm	54.4 mgs
"	Aug. 7, 1954	36.8 mgs	2.3 mm	22.2 mgs
sitkensis	Aug. 6, 1954	39.6 mgs	2.4 mm	123.8 mgs
"	Aug. 8, 1954	208.2 mgs (no follicles ovulated)	7.0 mm	629.4 mgs
"	Aug. 10, 1954	146.6 mgs	4.7 mm	793.8 mgs

The weights of the oviducts and ovaries are used as an index of activity, therefore no weights are given for the two birds that were laying.

but only 8 birds showed the nodules on the lateral walls of the cloaca (produced by the enlarged seminal vesicles). (See Wolfson, 1954, for the anatomy of this region.) In 15 of the 82 birds, there were no signs of any cloacal development; the remaining 49 birds showed various gradations up to the "fully" developed state. Table 3 gives the measurements of several of the cloacas. Wolfson distinguishes two types of cloacas, a bulbous type and a cylindrical form, based mostly on the position, form, and extent of development of the seminal vesicles. In the bulbous form the seminal vesicles are nodular, meet in the midline, and protrude noticeably in the posterior aspect of the cloaca. In the cylindrical form the seminal vesicles are placed more laterally, and do not meet in the midline; they protrude less, thus not producing the characteristic bulge of the bulbous type. It is difficult to place the well-developed cloacas seen in this study in either group. The seminal vesicles were in the lateral position, as in

TABLE 3

CLOACAL MEASUREMENTS*

bendirei, male. June 22, 1954. Ant. wall 6½, post. wall 6, ant.-post. 5, rt.-left 6. This specimen noted as being well developed.

bendirei, female. June 22, 1954. Ant. wall 2½, post. wall 7, ant.-post. 6, rt.-left 6½. This bird was ovulating.

bendirei complex, male. August 6, 1954. Ant. wall 3½, post. wall 4, ant.-post. 4½, rt.-left 5. This specimen was noted as being moderately well developed. Seminal vesicle 15 mgs (each).

sitkensis, male. (Wing 84½). Banded August 4, 1954. Ant. wall 4½, post. wall 6, ant.-post. 4, rt.-left 5. This bird was noted as being well developed and having visible nodules. A drawing made in the field shows the nodules in a posterior-lateral position and protruding.

* All measurements in millimeters. Measurements of cloaca are given first for anterior and posterior walls; these are followed by the anterior-posterior and right to left widths.

the cylindrical form, but they seemed to protrude too much for the true cylindrical form. It seems best to classify them as a modified cylindrical type.

Cloaca and brood patch of females: Two of the 19 females examined had swollen cloacal lips like those observed in the ovulating females that were autopsied; 10 birds had cloacas that were well developed but they were not in the ovulatory stage. Two of the females showed no development at all. Most of the fully-developed female cloaca was due to the greatly enlarged distal end of the oviduct, thus probably many of the females were going to ovulate in the next few days or were ovulating.

Observations on the development of the brood patch (apterium) of 34 females also indicated that the females were sexually active. Nine of them had bare apteric regions; 7 showed some folding of the skin in the apterium, and 5 of them were quite vascular. The presence of a bare medium apterium indicates that the female either has bred since the last molt or a brood patch is just beginning. Only the presence of the folded or vascular apterium is evidence of incubation; hence probably five of the females were incubating.

Judging from the histological and cloacal picture in the male, the condition of the female reproductive tract, and the cloacal picture in the female, it seems highly probable that some of the birds were actually breeding. During the period of the study no nests and *no juvenile crossbills were seen.* Since the birds arrived in good numbers about the last of July and the first of August, and since it requires about 43 to 48 days from the time that nest construction starts to the end of the fledgling period (Bailey, 1953), juveniles should not have been present.

Discussion and Conclusions

The most probable explanation for the sudden occurrence of such a heavy density of crossbills was the excellent cone crop of the common conifers in the region. Douglas Fir *(Pseudotsuga menziesii)* Grand Fir *(Abies grandis),* and Engelmann Spruce *(Picea engelmannii)* had heavy cone crops. Ponderosa Pine *(Pinus pondersosa)* had a moderate crop, and the Western Larch *(Larix occidentalis)* had a light cone crop. There was, therefore, an excellent food supply to support the large number of crossbills.

There are several aspects of these observations of crossbills that merit discussion and further study. The fact that there was such a high density of birds in active spermatogenesis and apparently breeding, yet few recaptures of banded birds is puzzling. The fact that the birds were approaching breeding condition or actually breeding (judging from the condition of the reproductive organs and accessory structures) at a time when other birds were ending or had ended their breeding cycle appears enigmatic in terms of our present understanding of the control of the annual cycle. However, it is well established that crossbills can breed in every month of the year (Griscom, 1937).

The major problem seems to resolve itself into an understanding of the control of the breeding cycle of the crossbill. Light, or the relation between daily periods of light and darkness, has been shown experimentally to be a regulatory factor in the breeding cycles in some small passerines. In the case of the crossbills, it is difficult to conceive of light operating in the same way and as the sole regulatory factor of its breeding cycle, since the species is known to breed in every month of the year. Bailey (1953) states that in Colorado the resident race, *benti,* starts to breed in December. If day length initiates the cycle, crossbills would have to respond to the day length conditions which precede December. If day length is a factor, it is probably strongly modifiable by one or several other factors. Psychological stimuli are important for the development of the ovary and ovulation in the female. A female bird kept on photostimulative day lengths shows only slight elevation above the minimal gonadal condition, but a female in the wild with a photostimulative day length and proper behavioral (psychological) stimuli will ovulate. Thus, in the female, behavior and psychological stimuli are important factors. Burger (1953) showed also that in Starlings *(Sturnus vulgaris)* exposed to photostimulative day lengths males that were kept in cages with females showed greater gonadal development than those kept in cages without females. In the crossbill, it is possible that psychological stimuli are important for breeding in both sexes. Another factor that must be considered in the regulation of the breeding cycle of the crossbill is food supply and nutrition. When the cone supply is adequate perhaps the pituitary gland is stimulated to secrete more gonadotropins and thus maintain the bird in, or initiate, breeding condition.

SUMMARY

A mixed flock of Red Crossbills that arrived at Yellow Bay, Montana from the middle of July to the middle of August showed physiological and anatomical evidence of being in breeding condition while also beginning the annual molt. Since other birds in the region had finished breeding or had almost finished, the late breeding condition of the crossbills may be explained by the excellent cone crop and possibly psychological factors. It was not possible to deter-

mine whether a previous period of reproductive activity was being maintained or a new breeding cycle was being initiated. No nests or other signs of actual breeding were observed.

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