NOTES ON THE ANATOMY AND BREEDING HABITS OF CROSSBILLS

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The following rather unrelated facts, first in regard to the structure of the skull, and second in regard to certain peculiarities in the breeding habits in the crossbill, *Loxia curvirostra*, appear to have gone until now unnoticed or unappreciated.

Chapin (1917) has described a curious condition in three genera of Weaverbirds in which the foreparts of the frontal bones of the skull never assume the usual two-layered adult passerine character. He also mentions a similar condition in the African certhiid, *Salpornis salvadori*. A like condition exists in *Loxia curvirostra*, at least in the race *bendirei*.

We have under examination eleven flat skins of the race *bendirei* with complete skeletons and two ordinary study skins with the scalp removed—four completely red males, one yellow-orange male, five greenish-yellow females, one streaked male with heavy spotting of red and yellow but no molt in progress, and three streaked females with little or no postjuvenal color yet apparent.

Of the red males, one (no. 1086 T. T. and E. B. McCabe) has a considerable area of the anterior part of the frontals in which there is no evidence of two layers or of cleavage perceptible under a thirty-power binocular; two (nos. 1081 and 1082) have the layers, while closely adherent, separable with the aid of a fine-pointed blade and open enough to have admitted an infusion of blood; and one (no. 1089A) is open with columellae clearly visible, but the layers still much closer than in other adult passerine birds. The orange male is single and without perceptible cleavage. Of the five females, two (nos. 1070 and 1076) show no visible cleavage, one (no. 1080) has the layers close but separable, and infused with blood, and two (nos. 1085 and 1088A) show a wider, but not normally wide, interstice. The streaked male with heavy splashes of color shows cleavage but no interstice. It must be remembered that in these cases the single wall does not resemble the delicate roofing of an early juvenal skull. The bone is unusually dense and hard, opaque, and not flexible or papery.

The four juveniles represent stages from a papery transparency of the whole roof of the brain case to a similar condition restricted to small, transversely oval areas in the forepart of the frontal bones, corresponding to the hard single areas in the older skulls.

The single layer of the roof of the brain case seems to hold good as an age determinant for young birds, at least up to the middle of the postjuvenal molt, if we remember that *thinness and transparency*, not singleness, are the criteria. After that, the process of doubling seems to be irregular. The streaked male, with heavy color spots, which is not half way through the postjuvenal molt, shows more doubling than several of the pure red males and greenish-yellow females. Two supposedly fully adult birds, a male and a female, show maximum doubling.

A good deal of anatomical work has been done on the muscular dimorphism which follows the crossing of the mandibles and their peculiar use, notably by Hesse (1907), Duerst (1909), Stubbs (1909), Ticehurst (1910), Böker (1922) and others, without notice of the character under discussion, though Hesse opens a cogent line of speculation when he speaks of the bones of the bill as more than usually massive and less spongy, perhaps to meet the lateral pressure to which they are subjected.

It is an unexpected fact that examination of four skulls of *Loxia leucoptera* from specimens in adult plumages shows a normal, or nearly normal, degree of doubling.

To turn now to the principal subject of this paper, in 1864 Mr. H. W. Wheelwright, better known under the sobriquet "An Old Bushman," published a volume called "A Spring and Summer in Lapland." We have not had direct access to the book, but it is quoted by Ticehurst (1915) to the effect that *Loxia curvirostra* was found breeding in various plumages, including "the striped plumage of youth." To this, Ticehurst appends an emphatic footnote: "Surely an error.—C. B. T." In spite of the endlessness of European crossbill literature and recurring controversies over plumages, immature and adult, male and female, none of the controversialists have taken this suggestion seriously, though obscure hints of the same thing occur elsewhere, unconnected and unheeded. Wheelwright (1862), in spite of continued interest in crossbills, did not follow the matter up, but was misled into futile polemics in support of the finality of the orange-yellow plumage, a doctrine in regard to these and allied forms evidently shared by Linnaeus (1758, p. 171, "Junior ruber, Senior flavus" of "*Loxia enucleator*") and many others (cf. the Macpherson, 1889, and Howse controversy) and which probably had its origin, as it certainly did in the case of Wheelwright, in a natural misunderstanding of the well-known tendency of crossbills and other red fringillids to revert to an orange dress in captivity. Breeding in immature plumage was not mentioned again for almost thirty years, when Ussher (1890), describing Irish nestings in County Waterford, said of one breeding female, on March 20, "She is of a brownish grey, smaller than the male, and her beak less evidently crossed," and of another, on April 11, "She was of a brownish grey. I could see neither yellow nor green about her." This was not looseness of observation or vocabulary. Another breeding female is described as "an olive coloured bird with yellow rump."

The next rather unsatisfactory hint comes seventeen years later from Wyoming (*L. c. bendirei*), when Peabody (1907) wrote as follows: "On the 27th [of November] I was rewarded by finding what appeared to be a family of the past summer, still together. The adult male was still not an adult, if the reader will permit the contradiction. His plumage was still semi-juvenile. Yet he was in breeding condition, the testicles being of nearly maximum size."

In England, Walpole-Bond (1910b), writing of a nest seen on April 15 in Surrey, says "The cock at one nest was, however, of a dull brown, with only a tinge of red on the rump and breast", and again (1914), of a nesting in Sussex in April or May, "the male at one of the nests I found was a brown bird merely slashed with red on breast and rump."

Finally, at Indianpoint Lake in central British Columbia in the summer of 1931 we took two females (nos. 1055 and 1056) on August 19 and 20 with hard-shelled eggs in the lower oviducts, and two males (nos. 1046 and 1053) on August 3 and 13 with testes measuring 5 x 4.1 mm. and 5 x 3.8 mm., respectively, "in the striped plumage of youth" as described by Wheelwright in Lapland sixty-eight years previously. The two females have not replaced a juvenal feather. The two males are very sparsely flecked with yellow, and one has a feather or two of red. Not only is the plumage juvenal, but the anterior parts of the frontals in all four skulls are paper-thin, transparent, and flexible, though more so in the younger females. These birds were taken on north latitude 53° at an altitude of over 3000 feet in the cold interior of the Province.

Only two explanations, about equal in inherent improbability, can be suggested. First, complete juvenal plumages and skulls had persisted through the winter and

the ensuing breeding season. Second, the birds had bred the year they were born.

Two circumstances lend some semblance of probability to the first suggestion—the evidence that exists for very late fall breeding, which would require the young to undergo molt under conditions of great severity; and the sometimes puzzling course of the first fall change of plumage, which the following citations reflect. Molt appears to follow age rather than season, and the irregularity of breeding time, which makes it possible for young to be present in either dress or any combination of the two from early spring far into winter, adds to the confusion.

Brown (1883), who collected very large series in November, 1882, in Maine, found "specimens illustrating almost every known phase of plumage except that of nestlings. Of males there are highly-colored red birds, yellowish birds, greenish birds, and birds in a garb of mixed colors. In the cases of some of them traces of the first plumage unmistakably indicate immaturity, and these birds agree exactly with all of the others in an osteological condition which stamps the entire lot as young of the year. The vertex of the skull is incompletely ossified; it is easily indented by the edge of my thumb-nail; and it is *perfectly transparent* . . . According to my experience, resulting from the dissection of nearly four thousand specimens of North American birds, this is a condition which cannot exist in any Passerine species after maturity." The quotation has secondary interest in view of the common attribution of the "discovery" of this age character to Dwight (1900).

Collett (1881, cited by Ticehurst, 1915) speaking from wide experience in Scandinavia, says "traces of the striped juvenile plumage may yet be seen in February." He goes on to surmise that such birds may not reach sexual maturity by the normal breeding season, and so may provide the "abnormal summer and autumn breeding" which sometimes occurs.

Gloger (1861) after castigating various Scandinavian authors for maintaining unrighteous doctrines on the subject of crossbill plumage, translates Lilljeborg with approval as follows: ". . . wir an jungen Männchen . . . beobachtet haben, dass bei ihnen diejenige Tracht, welche auf das erste Jugendkleid folgt, gelblich mit röthlichem und grünlichem Anstriche ist, und zwar nach vollendeter Mauser ziemlich dunkel." To which Gloger adds an explosive "Ja wohl! so, und nicht anders."

Finally Witherby (1920, p. 85) appears also to believe that a certain number of juvenal feathers may last through the year: "Frequently a varying number of striped juvenile-feathers remain, especially on breast and belly."

No one, however, has suggested the retention of complete juvenal plumage except Bechstein (1856) for captive birds. We have not had access to the original (1795-7) edition, or indeed to any of the older editions of his popular and long-lived "Naturgeschichte der Stubenvogel," but the English translation of 1856 (page 173), "with considerable additions" by H. C. Adams and incorporating the whole of Sweet's Warblers, says "It is curious that the young ones, which are bred in aviaries in Thuringia in great numbers, never acquire in confinement the red colour, but in the second year either remain grey, or immediately receive the greenish yellow colour of the males who have twice moulted." (Bechstein shared the widespread belief in the maturity of the yellow male plumage.) None of this is repeated by Russ (1873) who may have found it untrue or apocryphal.

On the other hand the several authors who have examined large series and worked intensively on crossbill molt, such as Tschusi (1888), R. Schlegel (1914), Ticehurst (1915), Witherby (1915, pp. 173-175), and von Tischler (1917), do not mention incomplete first-fall molts nor suggest the possibility of the omission of such a molt. Ticehurst gives June 23 (completed) and November 30 (still in

progress) as the extreme dates for this molt known to him (presumably in England), and speaks of irregularity consequent upon variable breeding time, but thinks that completion in a manner "much the same as in other finches" is obvious.

Omitting the enormous literature of scattered notes of occurrence, especially relating to the great European "incursions," more or less extended series of observations have been reported, or large series collected and discussed by Tufts (1906) in Nova Scotia; Munro (1919) in British Columbia; Willett (1917 and 1921) in Alaska; Bunyard (1911, 1912, 1913, 1915), Gilroy (1910, 1922), Hale and Aldworth (1910), Riviere (1911, 1926, 1932), Stanford (1919), Tomlinson (1910), Tracy (1910, 1915, 1919, also cited by Riviere, 1926), and Walpole-Bond (1910 a and b, 1914) in England; Blasius, Müller, and Rohweder (1882), Klaas (1930), and Nolte (1930) in Germany; Munn (1921, 1930, also cited by Jourdain, 1927) in the Balearic Isles, and Prazák (1897) in Galicia. None of these mention irregularities of the first fall molt or breeding in juvenal plumage.

Only one circumstantial account (Silver, 1911) of crossbills bred in captivity, with information on plumage, has found its way into the literature, which states that by September 13 all the young had molted into yellow or red.

Within the scope of our own experience, twenty-four *L. curvirostra* (subsp.?) trapped at Indianpoint Lake in central British Columbia between December 1 and 6, 1927, were all in full bright-colored dress except one, which showed doubtful traces of juvenal feathers. Fifty-five others trapped at the same place between April 17 and June 11, 1929, were likewise all in full color. Of 107 streaked *bendirei*, trapped and carefully examined for molt at the same point between September 3 and October 7, 1931, ninety-one were molting into colored plumage. When this latter period is divided into equal fractions and the successive percentages of birds *showing molt* calculated, this percentage rises rapidly and would have reached 100 per cent by the first week of October had not a single newly-fledged bird appeared on October 7. The subsequent history of that bird, could it be ascertained, would be more important for our present purpose than all that was learned from the 1200 others banded during the summer and fall.

When a series of skins is studied the post-juvenal body molt of crossbills is puzzling, because streaked young can be found with dots and slashes of yellow or red, but showing, upon intensive examination, no molt in progress. It appears, however, that such a mixed plumage is not the result of true molt, but rather of casual losses, largely through preening. It is especially noticeable in this species because of the striking contrast in color between the juvenal and post-juvenal dress, and because the plumage is apt to be badly caked with pitch, which causes excessive preening, even to tearing out clusters of feathers, which are of course replaced in the color of the subsequent plumage. By carefully going over a series it is possible in most cases to separate such skins from older specimens in the course of true molt. True molt, once started, seems to us to be regular and continuous, and we believe that the late traces of streaked feathers so often referred to simply indicate late-hatched young. The sternal region of the ventral tract (central feather rows) and the pelvic region of the dorsal tract start simultaneously. The former works backward. The latter works forward, but not in regular sequence, for the forepart of the interscapular region takes up the molt rather before the waves from the rear reach it, and specimens with a hiatus of color in the middle of the back are common. Dwight (1900) indicates the same principal points of origin for the dorsal tract, but says that normally "the first place where new feathers show is at a spot in the interior interscapular region." Certainly in the crossbill skins at hand, new feathers in this tract

first appear over the pelvis. After these tracts are well advanced, the cervical regions (dorsal and ventral) begin and work forword to join scattered molt which has begun about the head. The last streaked feathers remain on the posterior termination and on the margins of the ventral tracts.

Finally, if, contrary to such evidence as we can assemble, not only incompleteness but occasional elimination of the first fall molt were proved and accepted in explanation of the records of the streaked breeding birds of Wheelwright, Ussher, Peabody, and Walpole-Bond, still our own "breeding juveniles" from Indianpoint Lake would not be accounted for. To believe that our four birds carried their juvenal dress for a year and bred in it is difficult. To believe as much for the condition of the skulls is impossible. That even in such a bundle of abnormalities as a crossbill the transparent and paper-thin condition may persist for the minimum of some ten months required if the birds had been hatched the previous October (an extreme date not likely to apply to all four) is the last hypothesis to which experience would warrant our turning. We are inclined, therefore, to accept the remaining alternative—that the birds were hatched the year they bred or very late the preceding calendar year.

For intelligent consideration of such a phenomenon we need definite knowledge of the breeding season. All breeding records available are presented here in tabular form, but, numerous as the records are, especially for the Old World, we feel, as will be explained below, that the summary as a whole is probably misleading, and the late summer and fall, especially in the New World, inadequately represented.

BREEDING RECORDS OF LOXIA CURVIROSTRA

	August	September	October	November	December	January	February	March		April		May	June	July	Totals
England	....	1	....	1	4	9	42	14	57	34	20	....	7	....	....	189
Ireland	....	....	....	....	....	....	2	1	6	....	2	2	1	....	....	14
Scotland	....	....	....	....	....	1	....	....	3	....	3	....	1	....	1	9
Central Europe	1	1	1	....	8	14	4	....	7	....	1	....	1	1	....	39
N. Russia in Europe	....	....	....	....	....	....	....	....	6	....	1	....	....	....	....	7
Belgium	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	1
Norway	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	1
Balearic Islands	....	....	....	1	....	....	....	....	2	....	....	....	....	....	1	4
Algeria	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	1
U. S. and Canada															
minor	....	....	....	....	....	3	3	2	6	....	4	....	....	....	2	20
bendirei	....	....	....	....	1	....	....	....	5	....	....	....	....	....	....	6
stricklandi	....	....	....	....	....	1	1	....	....	....	....	....	....	....	....	2
percna	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	1
Totals	1	2	1	2	13	30	53	17	92	34	32	2	10	1	4	294

The accompanying table of records is based on the time of laying the first egg, which is roughly computed from the recorded facts. Needless to say, numbers of records have been rejected on account of insufficient data for such treatment. Often, while the other data are satisfactory, it is impossible to say whether the first egg was laid late in one month or early in the next. For such cases an intervening column has been interpolated between the two months.

Records which depend only on the gathering of nest material, records of unfinished nests without later history, and of supposedly newly-hatched young being fed are excluded with one exception, a record of young *stricklandi* in Arizona when the recorder was William Brewster and the condition of the young very specifically stated. In one or two cases records of adults taken with eggs nearly ready to lay are included.

To construct or use such a table we need supplementary information on the breeding habits of the bird. For the rate and duration of the various portions of the breeding period we have several positive statements by Old World ornithologists. In all cases these are unsubstantiated, but seem to be based on unpublished material or obscure local records inaccessible to us, probably supported by age-long experience in lands where crossbills have been the favorites of tradition and folklore from time immemorial. Dalla-Torre and Tschusi (1885, p. 480, *fide* J. Demuth) say "Das Weibchen brütet die Eier allein in 14-16 Tagen aus." Evans (1891, p. 62) depending upon Naumann and Tiedemann gives 14-15 days incubation for *L. pityopsittacus* and 14 for *curvirostra*. Jourdain (note to Sowels, 1919) says the "period from the laying of the full clutch to the date of leaving the nest is thirty-two days." Heinroth (1922, p. 227) gives "Brutdauer" as 14 days, and Russ (1873) says "Brut 15 Tage."

No intensive observations of breeding, from beginning to end, have been published, but the following fragments of information roughly substantiate the statements just quoted.

As to the rate of building, Wilson (1932) recorded progress "from the foundation of the nest to the completion of the lining" in three days.

As to the interval between completion and the first egg, Wilson (*ibid.*) found one egg four days after the completion of the lining; Hale and Aldworth (1910) found three eggs seven days after the completion of the nest; Hancock (1861) three eggs five days after the birds had been watched building; Hunter (1908) found the female sitting on three eggs twelve days after the nest had been begun; Norman (1868) some final construction and four eggs in six days, and Wynne (1929) one egg six days after finding the nest "not quite finished."

For the rate of laying, over and above the data just mentioned, Walpole-Bond (1910) recorded the laying of two eggs in three days, Tutt (1910) five eggs in five days, and Munro (1919) two eggs in two days.

For incubation, Munro (*op. cit.*) found two young hatched and a third hatching twenty days after some stage of "building." Wynne (*op. cit.*) records forty-four days from a time when the nest was "not quite finished" to the departure of the young. If we allow one more day for completion this would agree precisely with Nolte (1930) who records forty-three days from a finished nest to the flight of the young. Nolte also records three new-hatched young twenty-three days after "building" was observed.

A strong tradition of double-brooding, that is, two broods in rapid succession, repeatedly crops up. It was categorically asserted for the genus by Bonaparte and Schlegel (1850), and has been vigorously advocated lately by Walpole-Bond and others, but without good evidence. Witherby (editorial note to Walpole-Bond, 1910) cites Yarrell, Jourdain, Dresser, and Seebohm as favoring such a belief, and to these should be added Kirkman. Martin (1926) is reported to have evidence of regular breedings in January and April in Schleswig, but we have not had access to the original paper. Likewise Demuth (in Dalla-Torre and Tschusi, 1885) in Bohemia. There is one important observation which has been neglected, published by Tschusi and Dalla-Torre (1888) quoting Hanf and Paumgartner, in Austria, who watched a pair tearing down a nest (which had been used) in order to build another with the same material. A double breeding cycle, with early and late breeding periods many months apart, has also been suggested, but never, as far as we know, substantiated.

Munro (1919) gives the only record we have noticed of the abandonment of an unfinished nest. Apparently birds seen carrying nesting material may safely be set down as about to breed.

General statements which cannot be bound within the rigid limits of a tabulation are not to be neglected. Brehm (1924, p. 248) said that *curvirostra* had been recorded with eggs or young from every month of the year, and that he had himself seen birds in full molt feeding young, laying, and pairing. Prazák (1897) said that his collection contained nests and clutches from eastern Galicia taken in March, May, June, August, September, and October. Stanford (1919) said that he had heard crossbills singing in Suffolk every month of the year except July and November. Tufts (1906) tells of finding new hatched young in Nova Scotia on January 31 and adds: "During the following months, many other nests were found", and "The birds have been nesting ever since" (that is, up to May 7); and "Some years ago a nest of the American Crossbill was found on August 4 containing newly hatched young." Witherby (footnote to Noble, 1910) and Hagen (1930) say that eggs have been found in Denmark every month from January to May. We quote at length two statements by Willett (1917 and 1921) for southeastern Alaska, which suggest very prevalent late summer and early fall breeding in the race *sitkensis*, as well as rather continuous breeding by some part of the population through two-thirds of the year.

> . . . Birds shot by Mr. W. D. McLeod at Howkan in early September, 1916, showed from the condition of their reproductive organs that they would have bred in about two or three weeks. I had noted a similar condition in two specimens taken at Sitka in September, 1913, but had supposed them to be exceptional cases. . . . This seems the more extraordinary when we consider that at this time the bad weather has generally commenced and that it must be well along into early winter before the young leave the nest.
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> In late August, 1919, vicinity of Craig, birds were paired and males singing. Fully fledged young were plentiful in late September and early October. Again in late March and early April, 1920, many birds were paired and evidently nesting. A pair of breeding birds was taken April 1 and another pair, also breeding birds, April 2. On April 27 a pair of adults were seen feeding full-grown young on the ground.

Dalla-Torre and Tschusi (1885) quote an account by Ratoliska of coition observed in Braunau (Bohemia) at —12.5° C.

The north offers other examples of very early breeding, witness the Prairie Horned Lark, the Horned Owl and the Canada Jay, though none quite so early as the crossbill. It is cogent to ask why, if crossbills born the previous late winter or early spring can breed from the beginning of August on, should not some of the other forms just mentioned breed in the later summer or fall? Here Riddle's (1931) investigation of the season of origin as a determiner of the age at which birds become sexually mature is of pertinent interest. Riddle, working with many races of pigeons and ring-doves in captivity found a difference of fifty-two per cent between the ages at maturity of birds born in November, December, and January, and others born in March, April, and May, and correlates this difference with the periods of increase and decline of the thyroid, elsewhere shown to act inversely with the increase and decline of the gonads and in response to changes of temperature. On the basis of such a program the importance of delay in time of birth after midwinter would be greatly enhanced. An ever-increasing fraction of the favorable season, with declining thyroid, would be lost, and an ever-increasing share of the unfavorable season, with mounting thyroid activity, would be included in the period of maturation.

The determination of minimum age at maturity (4 months) for Riddle's ten races of doves and pigeons is a substantial fact. Birds of this group mature rapidly for their size, for figures for incubation and brooding are in some cases rather smaller than those just given for crossbills. H. A. Carr, editing Whitman (1919) gives incubation periods for pigeons and doves varying from 12½ to 19 days for different

races, with variations of as much as two days within a race, and adds, evidently for all forms, that the young leave the nest about two weeks after hatching. Seen in the light of our limited knowledge of potential age at maturity in passerine cage birds, the minimum age of 4 months seems rather great.

The annals of aviculture should be a mine of information on the subject, but it is almost impossible to find accurately detailed and dated facts, while the technique is designed to prevent breeding outside the humanly appointed "season." We have, however, found several items in A. G. Butler (1899) which show that sexual maturity may be reached by small passerine birds in a far shorter time than four months. Thus (page 109) of the Zebra Waxbill, *Sporaeginthus subflavus*, in captivity, Butler says "after eight weeks [from hatching] the yellow becomes deep and shining. . . . Then the bird is fit to propagate its kind." Of the Amaduvade Waxbill, *S. amandava*, "After eight weeks, or thereabouts, the beak is red, and then the Tiger-finch (German trivial name) is fit to go to nest." The Common African Waxbill *Estrilda cinerea*, was also said by Butler to be capable of being bred from the fifth to the eighth week. A record of the Ribbon Finch, *Amadina fasciata*, is cited (page 185), of which two males and two females left the nest in the "second week of September", while both females began to lay on October 12. Of this form Butler adds categorically: "Young female already capable of nesting after two or three months." Of Zebra finches, *Taeniopygia castanotis*, he says that the young are like their parents and ready to breed eight weeks after leaving the nest.

These species are all from warm climates, and the achievement of maturity may, like reproductive frequency, be more rapid in tropical birds. But there seems to be no reason to think it physiologically impossible for crossbills born between January and April to breed by August, nor for a bird born in the late fall to breed in March, as recorded by Ussher, except that other northern forms are not known to do so.

Environmental factors that have been proposed as actuating the annual cycle of gonad changes are increasing or decreasing hours of light, working through the amount of physical activity (Rowan, 1926, 1929), and change both in quantity and constitution (wave lengths) of light (Bissonnette, 1932, and papers by others), perhaps operating through an endocrine mechanism. Crossbills have unquestionably bred in many months while the hours of daylight were decreasing, and do so habitually while both amount of light and red-ray content are at a very low ebb.

It is natural to look for other characteristics of the group which may have developed by selection and adaptation, along with such breeding habits, or which, coming into being as the result of unknown vital forces, have made the habits possible or necessary. First, is the peculiar bill, and its high efficiency for opening cones, though in passing we note that its equally high efficiency for other less habitual purposes has drawn emphatic comment (Taverner, 1922). Second, the crossbill is one of the rather rare forms which is potentially independent of insect food in the breeding period. It is true that the American races, at least, are far from being exclusively graminivorous. In reality they have been shown at certain times and seasons to be predominantly insectivorous (Henderson, 1927, and others), a fact not reflected in Old-World literature. None the less the stomachs and crops of the birds which were brooding or rearing young in central British Columbia in March, 1931, contained only coniferous seeds, and the ability, on such a diet, to feed the young by regurgitation seems unquestionable. This ability must be called into play in most cases of winter breeding in the north. Third, the habit, long familiar in tradition and fairly well substantiated by scattered modern observations, of *continuous brooding* (the

female is generally supposed never to leave the nest) may be a response to the problem of low temperatures. American spruces and firs ripen and shed their seed in the fall, and it is hardly possible that the seeds are better or more available in late winter or early spring. None of the characteristics mentioned is unique or likely to make the peculiar breeding period necessary or advantageous.

In other words if we ask why a bird of deep-seated boreal affiliations should thus resist the forces which have reduced the sexual cycle of most of the temperate bird world to some approach to a basic pattern, no answer is apt to be forthcoming from the philosophy of selection and adaptation. Spread in relatively small numbers over a gigantic and uniform circumpolar range of almost uninterrupted conifers, possessing the power, rare in the north but perhaps more common in the tropics, to wander gypsy-like in search of favorable pasture, under as little competitive pressure for food or nesting sites or materials as any northern passerine bird—what process can be suggested to force such an organism into so eccentric a habit, and permit it to realize, in the face of evident obstacles and disadvantages, physiological potentialities elsewhere revealed only under artificial or tropical conditions? It is hard to escape the suggestion that the whole reproductive cycle is more a genetically, less an environmentally, controlled phenomenon.

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