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The fat and weight cycle in Wisconsin juncos

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THE FAT AND WEIGHT CYCLE IN WISCONSIN JUNCOS

In an earlier issue of this Bulletin (Vol. 1, No. 1) I described some of the objectives and procedures involved in studying birds at the UWM Field Station. This work has continued until the present and this report summarizes four winters of intensive study of the weight and fat cycle in the Slate-colored Junco, one of the most common of Wisconsin's winter birds.

The Junco has been a favorite subject for study in many parts of the country; investigations specifically of body weight and fat conditions have been carried out in Massachusetts, Pennsylvania, North Carolina and elsewhere. Nevertheless some important questions and inconsistencies remain. Our study was aimed at answering three specific questions. First, do wild Juncos in Wisconsin exhibit spring premigratory fat deposition? It is a paradox that Juncos have been widely used in experimental laboratory studies of fat deposition in relation to migration, yet field workers in the areas mentioned above generally have found that their wintering Juncos began their journey northward without having laid down much if any fat. Some workers have suggested that the birds may migrate all the way to their breeding areas in Canada without depositing fat. Our first objective then, was to determine whether Juncos spending the winter in Wisconsin as well as those migrating through Wisconsin from wintering areas farther south, did or did not show spring fat deposition.

Second, it has been reported that during the winter, fat deposits and body weights are high during cold periods and lower during warm spells; in other words fat condition is inversely temperature-dependent. Some workers have disputed this on various grounds too technical to mention here furthermore I have been unable to duplicate this effect by experimental manipulation of temperature in the laboratory. Captive Juncos in winter condition maintain a nearly constant body weight no matter how low or high the temperature, or how abruptly or how often the temperature is changed. Our second objective then was to get large samples of weights and fat conditions under a variety of winter weather conditions in order to test the reality of the inverse temperature-dependence claimed by others.

Third, we wanted to investigate the diurnal patterns of fat deposition. Previous studies have generally shown a straight-line gain in fat or weight during the course of the day as the birds fed, or in some cases a rapid gain during the morning with a leveling off in the afternoon. A number of recent experiments however, (e.g. those concerning the role of the hormone prolactin in fattening) have suggested that other patterns may occur, especially during the spring. Thus we wanted to gather some direct field evidence on this question (provided vernal pre-migratory fattening did indeed occur).

Table 1 Winter Populations of Slate-colored Juncos at UWM Field Station

Year	Est. Population	Number banded	Sex ratio	Age ratio	Number of returns from previous years and % of population	Spring Migration		
			Males: Females (in %)	Imm.: Adult (in %)		First major exodus	Last major exodus	Median departure date
1966-67	120	66	92:8		7 (11%)	Mar. 27	Apr. 11	Mar. 30
1967-68	110	105	75:25		10 (15%)	Mar. 27		Mar. 27
1968-69	80	68	78:22	47:53	15 (22%)		Apr. 6	Apr. 1
1969-70	140	127	69:31	57:43	15 (12%)	Mar. 18	Apr. 14	Apr. 7

RESULTS

A. The Junco Population

Table 1 summarizes some of the salient features of the Junco population at the UWM Field Station. Despite rather large differences in weather during the four winters, and differences in the number of artificial feeding areas (three in the first winter as compared with six in subsequent winters) the population has remained nearly the same except for a markedly low size in 1968-69. Since this was accompanied by a high percentage of returning adults and a low percentage of immatures in the total population, it can be inferred that the 1968 nesting season was an unproductive one for Juncos—for what reason of course it is impossible to say. Note also the preponderance of males in the population. Presumably this is characteristic of winter populations of Juncos in southeastern Wisconsin.

Of the 366 winter resident Juncos captured during the study, five (1.4%) were believed to be Slate-colored Junco-Oregon Junco hybrids or intermediates, three in 1967-68 and two in 1969-70. None of these could be ascribed without reservation to *Junco oreganus*.

Some information concerning the timing of migration is also shown in Table 1. It can be seen that wintering Juncos do not begin to depart in substantial numbers until almost the end of March, and that most of them are gone by the middle of April. The median departure date varied over a period of 11 days during the four springs, depending on weather conditions during late March and early April.

Similar information for the fall arrival of wintering birds is hard to come by, since we did not start artificial feeding until November of each year. Miscellaneous observations suggest that the birds began to arrive in late October and were at first widely scattered in small groups in the dense cedar thickets. We have noted three major periods of recruitment of new birds to the winter flock: first, when the feeders were put into operation in mid-November, second, when the first hard winter weather struck, usually in mid- or late

December, and third in late February. I do not believe that the last movement represents early spring migration, as often thought by bird-watchers, but rather these are birds that have wintered in the general area and are induced to wander either by exhaustion of food supplies or simply by the relaxing of the hard winter weather.

B. Seasonal Changes in Body Weight and Fat

Figure 1 shows the seasonal changes in fat deposits as measured independently by fat class, a semi-quantitative direct visual inspection of the fat beneath the skin, and by body weight which is more quantitative but unfortunately reflects changes in water content, muscular development, food in the digestive tract and many other things in addition to fat deposits. Nevertheless the two curves are nearly identical and mutually show that fat deposits are extremely low when the birds arrive in autumn, increase gradually during the early winter and reach a peak in mid-January at about the coldest time of winter on the average. Fat then declines in late winter and reaches another moderately low point at the time of the pre-breeding molt in March. The evidence is clear that beginning just about the first of April there is a period of very rapid fat deposition.

Since the first major exoduses of winter birds occur in late March it seems that some of the birds depart before depositing fat; however, those lingering into April nearly all have put on at least some fat by the time they leave.

What about transient Juncos that have spent the winter farther south? These begin to arrive in southern Wisconsin shortly after the middle of March, depending on the weather. The first noticeable influxes of transients were observed on March 25, 1967; March 16, 1968; March 20, 1969, and March 27, 1970. Large samples of these birds (over 600) revealed a pattern of fat deposition and body weight change almost exactly like that of the winter residents. That is, those arriving in late March were fairly lean and still molting; those arriving in early April were beginning to deposit fat and those arriving in mid-April generally had heavy fat stores.

It can be concluded that Slate-colored Juncos, regardless of whether they spend the winter in the southern states or in Wisconsin, have a period of fat deposition in early April, thus providing a positive answer to the first of our three questions. This takes place after the southern birds have already migrated several hundred miles and are crossing the general latitude of Wisconsin. The question then arises, if the birds are able to travel all this distance without the extra energy provided by fat reserves, and have only 200 or 300 miles farther to go, why do they put on fat at all? Fat deposition requires some profound endocrine and metabolic changes. It must have evolved in the Junco as an adaptation for surviving in the face of some specific stringent environmental threat.

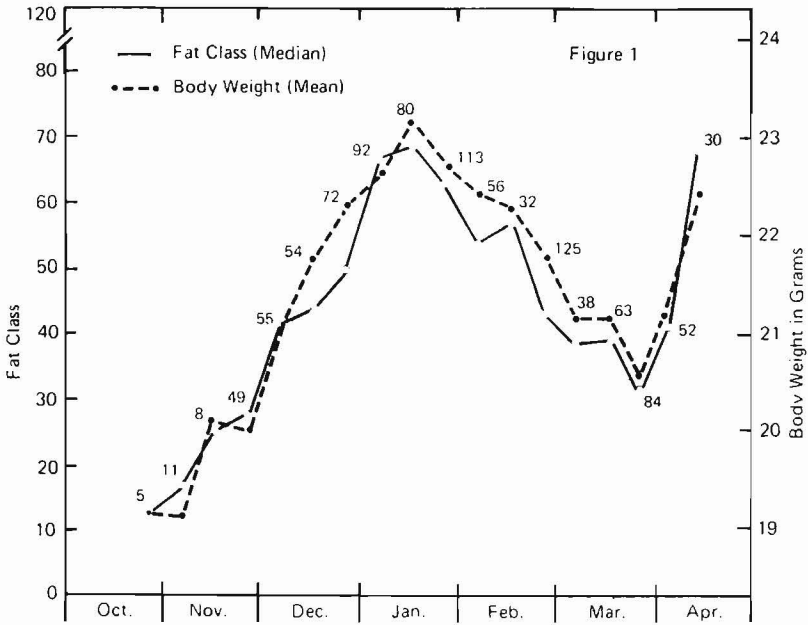


Figure 1 Seasonal changes in fat deposits and body weight in Slate-colored Juncos in Wisconsin. Winter residents only. Composite of 4 years, arranged by 10-day periods. Numbers at each point show sample size.

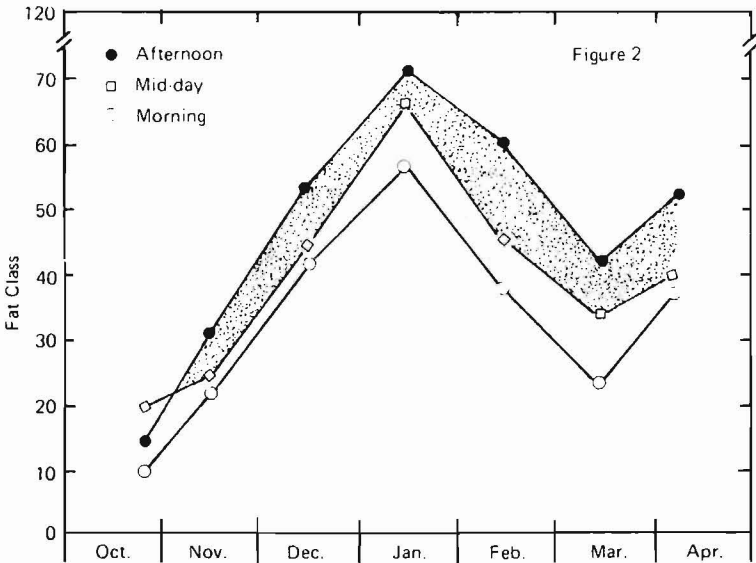


Figure 2 Seasonal changes in the diurnal pattern of fat deposition in winter resident Juncos. Composite of 4 years, arranged by months.

A possible answer is provided by studies of Reid Bryson (*Air Masses, Streamlines and the Boreal Forest*, Geographical Bulletin 8: 228-269, 1966) on the climatic factors that determine the boundaries of the Boreal Coniferous Forest, where Juncos breed and spend the summer. Bryson shows that in April when these birds are migrating, the average position of the Polar Front extends in a narrow belt across southern Wisconsin. This results in two conditions, both of which would operate as selective forces favoring the evolution of fat deposition in birds migrating northward at that time. One is that north of the front there are still frequent spells of cold and snowy weather which would inhibit food-finding and feeding as well as demanding extra energy for body temperature regulation, just as is required in winter. The second is that north of the front the prevailing winds are from the north, while south of it, they are from the south. Thus Juncos from the southern states would have favorable winds for migration flights until they reached the latitude of Wisconsin in early April, when they would suddenly be confronted (on the average) with adverse winds and unfavorable flying conditions, creating a demand for extra energy for flight. The remarkable thing is the delicacy and precision of the timing of this adaptation, so that it occurs at just the time when needed. A similar precision has been found in the autumn in Swainsons Thrushes and other birds that attain maximum fat condition in the southern states just as they are ready to depart on the long over-water flight across the Gulf of Mexico.

C. Relationship Between Fat and Environmental Temperature

To answer the second of our questions, concerning the reality of the inverse temperature-dependence of fat deposits in winter, requires an elaborate regression analysis which has not yet been done. It is obvious from Figure 1 that maximum weight and fat peaks are reached during the coldest part of the winter, but is this directly due to temperature, or is it another case of the physiological mechanism being so precisely regulated by day length that the peak condition coincides with the time of winter which is, on the average, the coldest? If we graph the weight-fat curves for each winter and compare them with the composite shown in Figure 1 we find that there were conspicuous departures from the composite in two of the four winters. In 1967-68 the weight-fat curve was significantly lower than the composite during the entire January-February period. A similar comparison of temperatures however shows that the largest departures in the fat conditions coincided with abnormally cold winter weather. In other words a direct rather than an inverse temperature dependence is suggested.

The other year that departs strongly from the composite is 1969-70, again in late January and February, this time the fat condition being unusually high. Examination of the temperature record does reveal weather somewhat colder than usual during part of this period.

Thus, these simple methods of analysis give inconsistent results and a final answer to our second question must await more sophisticated treatment of the data.

D. The Diurnal Patterns of Fat Deposition

Juncos, like most other birds, do not feed at night, yet require a large amount of energy for metabolically maintaining their body temperature. Fat stores are used for this purpose during the long cold winter nights. During the migration seasons fat is used in addition as a source of energy during long migratory flights, which also take place at night. During the day then, the bird must lay down sufficient fat to meet its needs during the night, preferably with some to spare as an insurance against unusual conditions such as extreme cold, snow or rainstorms, or adverse migrating conditions.

Earlier investigators of the daily gain in fat and weight in birds have reported it to be essentially linear during the day, but they failed to look for possible seasonal differences in the pattern. Recent experiments (e.g. A. H. Meier, *et al*, *General and Comparative Endocrinology* 12: 282-289, 1969) have shown that the hormone prolactin is involved in the physiological regulation of fat, and that there is not only a daily rhythm or cycle of prolactin secretion, but also that this daily rhythm changes according to season.

In order to study this in the wild population of Juncos we attempted to get samples of birds at all times of the day. In analyzing the results we have organized these data by 4-hour periods. The results are shown in Figure 2. The lower curve (open circles) shows the fat condition during the early morning, the middle curve (squares) represents mid-day values, and the upper curve (solid circles) represents late afternoon. The shaded area then represents afternoon fat gain while the unshaded area between the middle and lower curves represents morning gain. If fat gain during the day is linear, the shaded and unshaded areas should be equal in width.

Disregarding the October data which are too few to be significant, it can be seen that during periods when fat is, in the long run, increasing, i.e. in November, December and April, more fat is deposited during the afternoon than during the morning. During the other months, morning and afternoon gains are more nearly equal, indicating an essentially linear gain. These results fit in nicely with the prolactin experiments mentioned above which had shown that in January the peak of prolactin secretion was at dawn, with maximum fat gain during the morning, while in April the peak of prolactin secretion was about noon, with maximum fat gain in the afternoon. Our field evidence then tends to support the hypotheses and ideas concerning the role of prolactin in regulating the fat-weight cycles of birds.

E. A Word of Thanks

Such a study as this would have been impossible without the aid of many UWM students and other voluntary helpers. In addition to those named in Volume 1, Number 1 of the Bulletin, the following have been invaluable: Christine Fredrich, Jeff Fredrich, Wallace MacBriar, Kate Katcher, John Meyer, Cynthia Feil, Mark Pleyte. I trust that in working with these birds these people received not only enjoyment but also an educational experience of a type not ordinarily possible in a formal college course program.

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