SOME SEASONAL CHANGES IN MORPHOLOGY OF THE RUFOUS-SIDED TOWHEE

By JOHN DAVIS

Seasonal changes have been demonstrated in a number of avian tissues and organs and in bird weight. Such changes indicate not only seasonal changes in morphology but they may, in some instances, suggest the nature of the morphologic and physiological adjustments made by the individual as it passes from one season to the next. This study is concerned with seasonal changes in bill length, in length of the intestinal tract, or gut, and in weight of a resident race of the Rufous-sided Towhee, *Pipilo erythrophthalmus megalonyx*. Data were derived from samples of males and females collected at, or as close as possible to, two-week intervals near the Hastings Reservation, two and one-half miles east of Jamesburg, Monterey County, California, from January 5, 1955, to May 10, 1956.

Each specimen was autopsied in the field and the gonads were either removed (males) or examined *in situ* (females). Each bird was weighed on return from the field, its intestinal tract was measured, the amount of stored fat was estimated, and the skin was saved. In addition, the stomach contents were examined and a rough estimate was made of their composition.

BILL LENGTH

Skins were stored for a minimum of three months before bill length was measured to allow for possible shrinkage of the bill. Measurements were made from the anterior edge of the nostril to the tip of the bill. In a previous paper (Davis, 1954), seasonal variation in bill length was demonstrated in a number of passerines which change from an almost exclusively vegetable diet in the late fall and winter, when the bill is short, to a diet which includes a prominent component of insect material in the spring and summer, when the bill is long. Such variation was ascribed to the increased wear put on the constantly-growing bill tip by the more abrasive winter diet. Like these other species, the Rufous-sided Towhee shows a similar seasonal change in diet, as indicated by examination of the stomach contents of the specimens collected. In addition, the stomachs of towhees taken in winter contained large amounts of dirt and grit, whereas such material was present in much smaller amounts in the stomachs of birds taken in summer (table 1). The more frequent picking up of such inert, abrasive material in winter may accentuate the wear imposed on the bill tip by the winter diet. In each sex, the bill length of the winter sample is significantly less than the bill length of the summer sample (fig. 1). Thus, the Rufous-sided Towhee shows the same type of diet-correlated seasonal variation in bill length that was demonstrated for the passerines discussed in my earlier paper (Davis, *op. cit.*).

INTESTINAL TRACT

The intestinal tract of each specimen was removed at the gizzard and at the vent, thus including the cloaca. The intestines were freed from their mesenteries and laid along a ruler in as straight a line as could be achieved without stretching. Since the same technique of measuring was used for each specimen, the relation of measurements taken at different times of the year should not have been influenced by the technique. Three measurements were taken: small intestine, from the gizzard to the origin of the colic caeca; large intestine, including the cloaca, from the origin of the colic caeca to the vent; and total length of the entire tract. It should be pointed out that measurements were not taken of the intestines of every specimen, and in some cases only the entire intestine or the small intestine was measured. Thus, sample sizes vary.

TABLE 1

OCCURRENCE OF INERT MATERIAL IN STOMACH CONTENTS

	0	+	++	+++	++++[1]
January	1	4	10	12	
February	1	2	9	9	
March	1	9	6	12	
April	4	15	3	1	
May	5	7	4	....	
June	7	1	....	1	
July	5	4	2	1	
August	....	3	3	7	
September	....	6	4	3	
October	2	5	1	2	
November	....	....	2	8	
December	....	1	2	7	1

[1] Estimated amounts from none (0) to considerable (++++). Data include seven juveniles.

Leopold (1953) demonstrated intergeneric variation in the relative length of the intestinal tract and caeca for several genera of gallinaceous birds. The intestines and caeca were relatively long in browsing genera, which depend on low-quality food sources in winter, and relatively short in seed-eating genera utilizing higher quality winter diets. He also showed that there were similar differences between coastal and interior populations of the California Quail (*Lophortyx californicus*) subsisting on relatively poor and relatively rich diets, respectively. He concluded that greater intestinal length in forms utilizing relatively poor diets allowed for more thorough digestion and perhaps for more complete absorption of the essential elements in the diet.

In this study, it has been possible to demonstrate significant seasonal variation in the length of the gut within a single restricted population of the Rufous-sided Towhee. As can be seen in figure 2, the entire intestinal tract was significantly longer in the winter sample of each sex than in the summer sample. The same is true of the small intestine (fig. 3). The large intestine is significantly longer in winter males but not in winter females (fig. 4). Since the large intestine, as measured, included the cloaca, the lack of significant seasonal variation in the females may reflect sexual dimorphism in the relative proportion of the length of the large intestine to the length of the cloaca.

The greater length of the intestine in winter correlates with the primarily vegetarian winter diet, a diet which would be lower in protein content than the spring and summer diet. Thus, intestinal length appears to be correlated with the relative richness of the diet, agreeing with the findings of Leopold in gallinaceous birds. The longer intestinal tracts of towhees taken in winter apparently allow for a longer period of digestive breakdown of the lower grade vegetable matter which forms most of the food at that season.

Since it is possible to demonstrate significant seasonal variation in intestinal length within a single restricted population of towhees, it seems likely that the difference in intestinal length found by Leopold (*op. cit.*) between coastal and interior populations of California Quail does not represent a genetically controlled interpopulation difference but merely represents the somatic response of the individuals within each population to different diets.

WEIGHT

Linsdale and Sumner (1937:163) present a number of weights for Rufous-sided Towhees live-trapped and weighed repeatedly. Their data are fragmentary and their table 4, which presents the data by months, is most difficult to interpret and does not

make clear how many individuals were involved in the monthly mean weights. Therefore, I am unable to make any direct comparison between their findings and mine.

Weights of males only are considered here, as my samples of females were too small to permit satisfactory analysis. Further, the enormous development of the reproductive

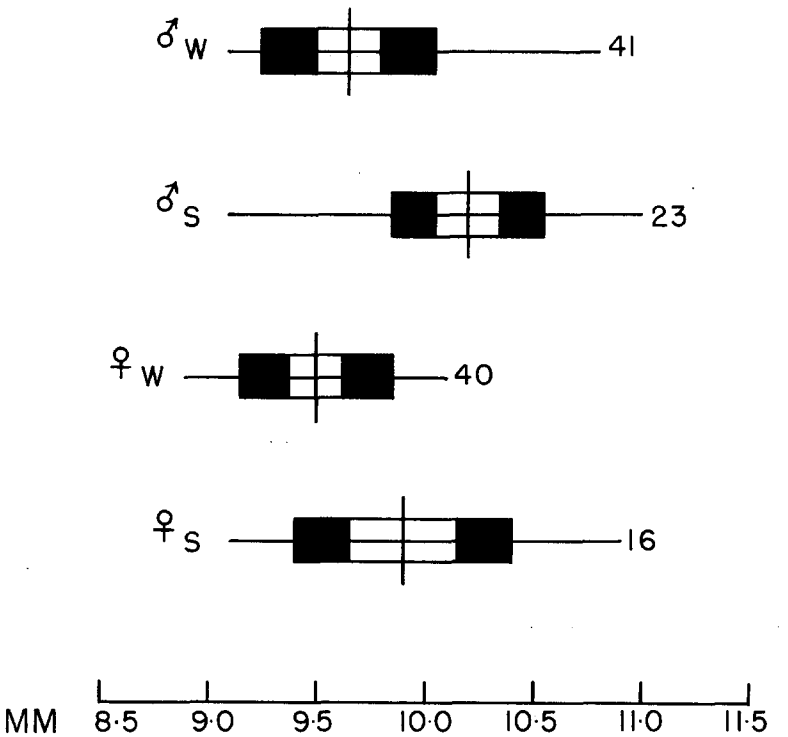

Fig. 1. Seasonal variation in bill length of the Rufous-sided Towhee (*Pipilo erythrophthalmus*). Samples of males are of adults only, samples of females are of adults and of first-year birds collected after December 1. Winter samples (W) were collected from October through April; summer samples (S) from May through September. Sample size is indicated to the right of each diagram. The vertical line represents the mean, the horizontal line the range; the white rectangle equals two standard errors on each side of the mean, the black rectangle one standard deviation on each side of the mean.

tract in breeding females seriously affects weight and makes it impossible to compare the weights of females collected during the breeding season with the weights of females collected at other times of the year. For example, a female collected on April 27, 1956, weighed 48.3 grams, of which 4.4 grams, or 9.11 per cent, was accounted for by the enormously expanded oviduct and the full-size egg, ready to be laid, at the terminus of the oviduct. The ovary, which was not weighed, contained two large, yolky follicles measuring 6 mm. and 12 mm., and it would have accounted for a still further percentage of the total body weight.

Since the testes were removed from each specimen in the field, it should be emphasized that the weights presented in figure 5 are of males without the gonads *in situ*. Specimens were collected purely at random, and such variables as time of day and the amount of time elapsing prior to weighing are minimized. Desiccation of these specimens

autopsied in the field prior to weighing was apparently of no importance, as samples collected in July, August, and September averaged higher than the sample taken in June, although air temperatures were higher in July, August, and September (table 2), and desiccation should have been greater in those months than in June. Conversely, the

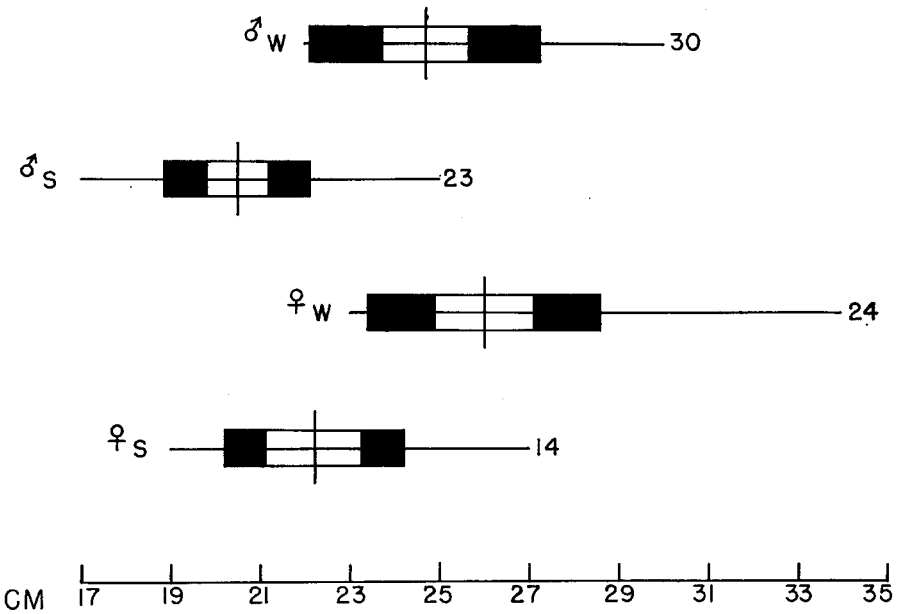

Fig. 2. Seasonal variation in total length of the intestinal tract of the Rufous-sided Towhee. Samples of males are of adults only; samples of females are of adults and first-year birds. Winter samples were collected from September through March; summer samples from April through August.

sample taken in February was considerably lighter than either of the samples taken in December or January, although February was a colder month than either December or January (table 2).

TABLE 2

MEAN TEMPERATURES IN DEGREES FAHRENHEIT FOR 1955 AND 1956

	Maximum	Minimum	Mean
June[1]	78.4	44.0	61.2
July	80.3	47.0	65.1
August	92.4	52.5	72.5
September	88.7	49.8	69.2
December	60.0	39.4	49.7
January	57.0	34.4	45.7
February	59.7	31.2	45.4

[1]January and February temperatures are for 1955 and 1956 combined; all others are for 1955.

The annual weight cycle of adult males is given in figure 5. The greatest irregularity was found between July and November. With the exception of the sample collected in October, the differences among the other four months span a range of only 1.2 grams, and the difference between any two of these four months is undoubtedly not statistically significant. In the period from July through November, weight is probably maintained,

somewhat above the June mean, in nearly straight-line fashion. I cannot account for the marked increase in weight shown by the sample taken in October.

First-year males were considered only from January to May. Samples collected between September and December consistently averaged lighter than samples of adults

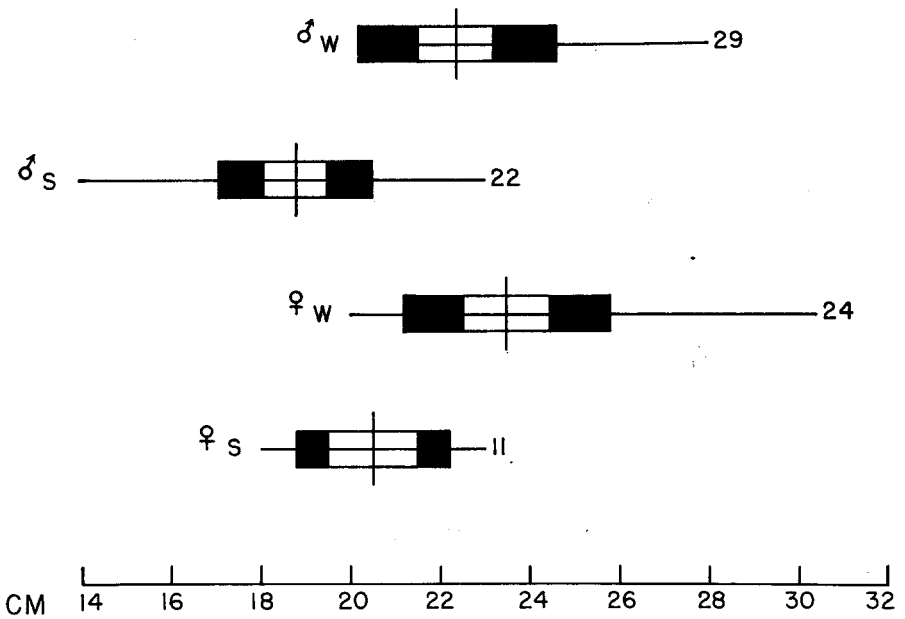

Fig. 3. Seasonal variation in length of the small intestine of the Rufous-sided Towhee. The composition and monthly limits of samples are as for figure 2.

and were not considered. Even the January sample of first-year males averaged 1.6 grams lighter than the sample of adults collected in that month. No first-year male was collected in June. Figure 5 indicates that the samples of first-year males collected between January and May showed a nearly steady decrease in weight which almost exactly paralleled the decrease in adult weight in the same period. The only divergence between the two age groups was found in the samples taken in April and May; the means of these were nearly identical in the adults, but the first-year males showed a further decrease in weight in May. In general, the two age groups show an almost identical pattern of decrease in weight from February to May. That this decrease is significant is indicated by a comparison of the mean weights of adults for the periods from October to January and from February to June, 43.33 ± 0.57 and 40.32 ± 0.33 grams, respectively.

The period of weight decrease from February to June virtually coincides with the breeding season of the males. The first signs of gonadal activity are noted in January, but Leydig cells do not become common in the testes of most males until about the middle of February (Davis, 1958:309, 312). Singing is first heard in late January or early February but it does not become widespread in the male population until mid-February (*op. cit.*:314). Thus, mid-February may be considered the beginning of the male breeding season. Testis regression was first noted in adults between July 6 and 20, but singing becomes less frequent by early July (*op. cit.*:309, fig. 1; 321, table 6). Nesting activities are over for most pairs by the end of June (Davis, 1960:435). Thus, the breeding season of the males comes to an end between early July and mid-July, and it

virtually coincides with the period of almost steady weight decrease from February through June.

It seems most likely that this weight decrease is brought about by one, or both, of two factors. First, it is possible that the change in hormonal balance brought about by

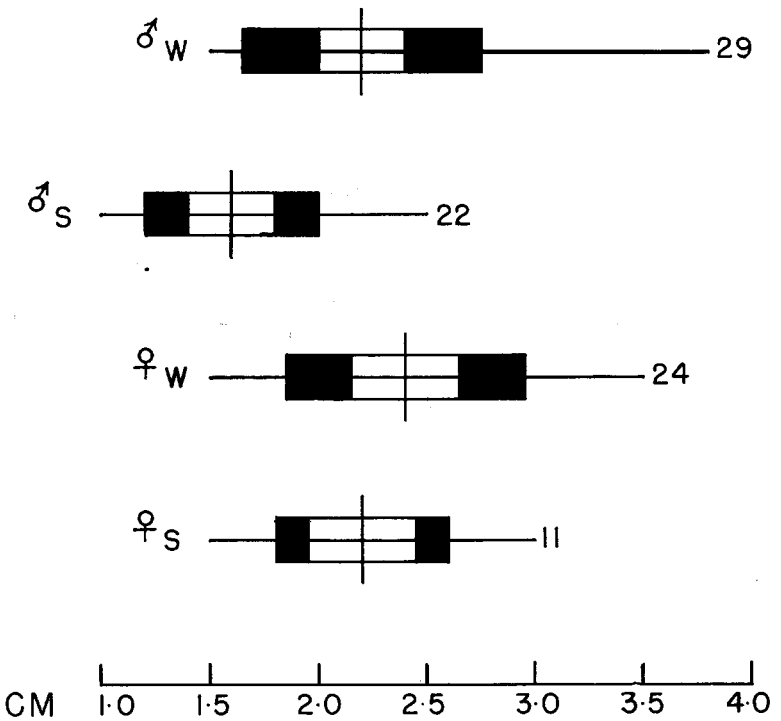

Fig. 4. Seasonal variation in length of the large intestine of the Rufous-sided Towhee. The composition and monthly limits of samples are as for figure 2.

the development of the gonads may account for part of the decrease in weight. Second, the diversion of time and energy from foraging and resting to other activities such as singing, other aspects of territorial defense, and nesting could bring about a decrease in weight during the breeding season. Of the two, the second factor may be the more important. Some idea of the amount of time spent in activities other than foraging and resting during the breeding season is given by the amount of time spent singing by certain individuals. The following data are taken from Davis (1958). An unmated male watched for eight hours on May 24, 1956, spent 84.3 per cent of his time singing. A nesting male watched during the incubation period sang 18.8 per cent of the time on one day and between 30.8 and 45.1 per cent of the time on the remaining eight days of observation; another, watched for seven days during the incubation period, sang from 30.8 to 62.9 per cent of each day. Thus, although the males do not incubate, they do spend considerable time singing. Once the young have hatched, the males sing less, but they spend considerable time gathering food for the nestlings (Davis, 1960). Earlier in the breeding season, considerable time is spent in singing, in patrolling territories, and in active territorial defense. As can be seen, once the breeding season is under way, foraging and resting time is sharply limited and time and energy are spent on a variety of other activities.

As soon as the breeding season is over, the males at once start to gain weight (fig. 5). Of interest is the fact that adult males gained weight throughout the period of molt, which began between July 6 and 20 and ended for most birds in late August or early September.

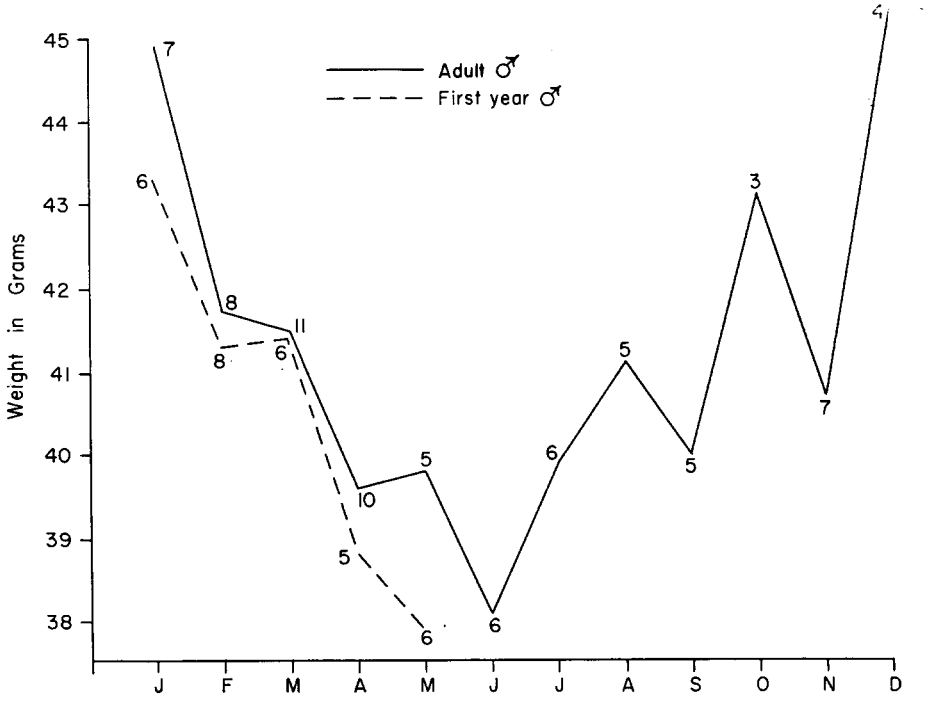

Fig. 5. Mean monthly weights of adult and first-year male Rufous-sided Towhees, weighed after the testes had been removed. Sample size is given by the numeral adjacent to each monthly mean.

Baldwin and Kendeigh (1938:446–448) found a positive inverse correlation between the curve of monthly mean air temperature and a composite curve of mean monthly weight of a wide variety of species. The low point in the weight curve coincided with the high point in the curve of air temperature. No such correlation is evident for the towhees considered in the present study, as the low point in the weight cycle was reached in June, but July, August, and September were all hotter months (table 2). In July and August, mean monthly weight increased, and although it fell somewhat in September, it remained above the June low. The highest mean weight was found in the combined samples of December, 1955, and January, 1955 and 1956. The combined samples of February, 1955 and 1956, were noticeably lower in weight (fig. 5), yet average temperatures were lower in February than in December and January (table 2). Therefore, it is not possible to find any correlation between average monthly temperatures and mean monthly weight.

Seasonal variation in weight cannot be accounted for on the basis of seasonal variation in fat deposition. The amount of fat present in 77 adult male specimens was estimated, after skinning, as none, slight, moderate, or heavy. Of these 77, 69 were classed as having no fat or slight fat. The remaining eight were classed as moderately fat. Four of seven collected in January were so classed, as were two of nine collected in February,

one of five collected in August, and one of three collected in October. January was the only month in which there was a marked tendency toward fat deposition. Of 40 first-year males collected from September through May, 38 were classed as having no or slight fat, and two of seven collected in January were classed as moderately fat. Again, January was the only month in which there was any evidence of a tendency to deposit fat.

Of the 64 adult and first-year females for which data on stored fat were recorded, only eight were classed as having moderate or heavy deposits of fat, as follows: three of ten collected in January; one of seven collected in April; three of four collected in October; and one of five collected in December. In the females there appeared to be two months in which fat was deposited, October and January.

The preponderance of fat birds in the October sample may have some relation to the sharp rise in the mean weight of the October adult males, although only one of three adult males collected in October showed even moderate deposits of fat. The only month in which some individuals of all four age-sex groups showed moderate to heavy fat deposits was January. With the exception of two females, one collected on January 18, 1956, and one collected on October 24, 1955, both with heavy fat deposits, no individual had more than moderate amounts of stored fat. In December, when the mean adult male weight was slightly higher than the mean for January and represented the greatest mean weight for any month, only one bird, a first-year female, of 11 representing all age-sex groups, was even moderately fat.

One must look for sources of weight loss other than consumption of stored fat to explain the significant difference between the mean weights for the periods of October to January and February to June in adult males. Three such sources are suggested to explain at least a part of this difference.

First, the adult males were weighed without the gonads in place. An adult male collected in May, 1960, had testes which measured slightly smaller than the testes of known breeding males which had been examined microscopically. The testes of the bird collected in 1960 weighed, together, 0.4 grams. On the basis of measurements, the testes of other, known breeding birds would have weighed slightly more, perhaps 0.5 grams. Thus, one would be justified in adding about 0.5 grams to the mean weights shown in figure 5 for the months of April, May, and June, when the testes were at, or near, full size. In other words, approximately 0.5 grams of the weight difference between the high and low points of the cycle might be accounted for on the basis of the growth and development of the testes, assuming a weight of close to 0.0 grams for the very small, undeveloped testes of birds collected in winter.

Second, as has been pointed out, the intestinal tracts of specimens taken in winter are longer than the intestinal tracts of specimens taken in the summer. The difference between the mean lengths of the gut in the two seasonal samples is about 4 mm. (fig. 2). The measurable intestinal tracts of three of four birds collected on February 13 and 14, 1960, were measured and weighed and an average figure was obtained of 0.1 grams per millimeter of the entire intestinal tract. On this basis, some 0.4 grams of the seasonal weight difference could be accounted for on the basis of the increase in the length of the gut in winter. Baldwin and Kendeigh (1938:434) suggested that "seasonal changes in weight may possibly be correlated also with changes . . . in length of digestive tract or other organs," and the present data bear out the validity of their suggestion.

Finally, as has been noted previously, there is a noticeable decrease in the amount of dirt and grit present in the stomach contents of summer-taken birds. The four birds collected in February, 1960, had considerable amounts of such material in their stom-

achs. The stomach contents of these birds averaged 0.9 grams and appeared to contain about 25 per cent inert material. Since dirt and grit undoubtedly weigh more per unit of volume than the seeds, chunks of acorn, and small insects which made up the remainder of the stomach contents, an estimate of 0.2 grams seasonal difference in the weight of the inert material in the stomach contents seems fairly conservative.

On the basis of testis growth, increase in gut length in winter, and seasonal variation in the amount of inert material present in the stomach contents, one can account for approximately 1.1 grams of the total difference between the highest mean weight, 45.04 grams for the combined samples taken in December and January, and the lowest mean weight, 38.10 grams for the sample taken in June. This is a total of 15.8 per cent of the total difference of 6.94 grams. One may hypothesize, since we are dealing with an essentially non-fat-depositing population, that the remainder of the difference is made up of the cumulative seasonal variation in weight of a number of organs and tissues. What is clearly needed is a detailed study of weight in a resident population which does not have a fat cycle, establishing seasonal variation in weight and attempting to correlate this with seasonal variation in the weight of the stomach contents and of as many organs and tissues as possible. Such a study would serve to explain, at least in part, just what is involved in seasonal variation in weight and it would also serve to demonstrate some of the adjustments made by the individual to seasonally changing environmental conditions.

SUMMARY

Significant seasonal variation is shown in bill length, length of the intestinal tract, and weight in a resident population of the Rufous-sided Towhee (*Pipilo erythrophthalmus megalonyx*).

The short bill and long intestinal tract of birds taken in winter apparently correlate with the vegetable diet utilized at that season; the long bill and short intestinal tract of birds taken in summer apparently correlate with increased consumption of insect material in the summer period.

Weight of adult males decreased sharply and nearly steadily during the breeding season, the decrease apparently correlated with the diversion of time and energy from foraging and resting to breeding season activities. Since the population under study did not have a well-marked fat cycle, seasonal variation in weight cannot be explained in terms of fat deposition and consumption. Part of the difference between the high and low points of the weight cycle could be accounted for on the basis of testis growth, increase in the length of the intestinal tract in winter, and seasonal variation in the amount of inert material present in the stomach contents.

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