MIGRATORY BEHAVIOR OF THE ELF OWL

(MICRATHENE WHITNEYI)

by

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ABSTRACT

Five captive Elf Owls exhibited Zugunruhe and orientation, which have been shown to be characteristic only of migratory species. All ten captive owls deposited fat slowly from August to November. Molt in these birds was abnormal. Wild Elf Owls became more secretive in late July and finally disappeared in late September. Zugunruhe, orientation, and behavior of the wild Elf Owls are offered as more substantial evidence that the species is migratory.

INTRODUCTION

In 1938 Bent stated that the Elf Owl, Micrathene whitneyi, was nonmigratory. In 1942 Phillips suggested that the Elf Owl, along with the Flammulated Screech Owl, Otus flammeolus was migratory. The opinion of both authors was based primarily on the study of collection dates of museum specimens. Extreme records for the Elf Owl in southern Arizona are 16 February and 13 October. Elf Owls have not been collected or seen during the winter, but this could be the result of lack of vocalization during this time. The male is more vociferous than the female (Ligon, 1968). Two-thirds of the Elf Owls in the University of Arizona collection are males, which may indicate the ease with which a vocalizing bird may be collected. Although sex ratio has not been determined for Elf Owls, only two of the thirteen owls I collected were females. Only one of these was collected while vocalizing. The Elf Owl has been collected in the winter in Mexico within the southernmost extent of its breeding range, but not in Arizona, the northern portion of its breeding range.

No work involving banding and recapturing of Elf Owls has been done previously. Neither has there been any laboratory work done on phenomena related to migration, such as Zugunruhe and orientation of captive birds, premigratory fat deposition or timing of molt.

Zugunruhe is restlessness related to migration which is exhibited by captive birds. It has been demonstrated in many migratory species but not in nonmigratory species or races (Farner and Mewaldt, 1953; Eyster, 1954; and Weise, 1956). It may or may not be accompanied by premigratory hyperphagia and consequent fat deposition. Many species which exhibit *Zugunruhe* also display orientation of activity. However, orientation does not necessarily occur with *Zugunruhe* activity. Heavy molt and migration are often incompatible, and a relationship between body weight, activity, and molt has been indicated by Eyster (1954); Helms (1963); and Mewaldt, Morton and Brown (1964). I, therefore, decided to use the parameters of migratory restlessness, orientation, fat deposition and timing of molt, along with field observations to provide more conclusive evidence pertinent to the migratory status of the Elf Owl.

METHODS AND MATERIALS

Capture and Care of Birds

Mist nets were used successfully at night. Some birds were taken from saguaro tree holes. The birds were maintained singly in small animal cages (15 x 9 x 9 inches) when they were not being tested, and were located in a room which was air conditioned and received a normal photoperiod through large west-facing windows. When the Elf Owls were first adjusting to captivity, they were fed 40 to 50 crickets per night. Gradually live crickets were replaced by freshly thawed ones. After a week of captivity, cat food was added to their diet of thawed crickets. Ultimately their diet consisted of fresh chopped horsemeat and freshly thawed crickets. Aqueous ABDEC vitamins were added to their food once a week. Throughout the testing period the birds were fed *ad libitum*.

Migratory Restlessness and Orientation

Two groups of five owls each were tested for the presence of *Zugunruhe* activity and orientation from 2 August through 14 October. The groups were alternated so neither group spent two consecutive nights in the activity cages.

Group A consisted of five immature birds (R/W, W/B, B/B, O/B, and O/Y). These birds, representing three broods, had been removed from saguaro tree-hole cavities about a week before they would have fledged. Group B initially consisted of four adult birds (Al/Y, Al/R, B/Al, -/W) and one immature bird (Y/-) which was netted approximately a week after it had fledged. One adult bird (-/W) which escaped on 15 September was replaced by a juvenile (-/-) netted 6 September.

The activity cages were constructed of 1/8 inch hardware cloth. They measured 16 inches tall by 15 inches in diameter. The door to each cage measured 4 inches by 5 inches and was 7 inches from the cage floor.

Perches were constructed of 1/4 inch dowling. Each perch was attached to the cage by two bolts which acted as pivots. The bolts went completely through the hardware cloth and were anchored in place by a nut on either side of the wire. One bolt was longer than the other and to the end of this was attached a circular contact point in a horizontal plane. A spring was attached to this arm to keep the perch level when the bird was not on it. The arrangement of the nuts prevented the perch from moving too far once the bird landed on it.

The leads from the battery and Esterline-Angus event recorder were attached to the contact at the end of the bolt and to a wire firmly suspended above the bolt arm. When the bird landed on the perch, these two contacts met.

The activity cages were located on the roof of the Biological Sciences Building of The University of Arizona. The walls of the catwalk where the cages were placed are 48 inches high. They run in an east-west direction and restrict the birds' view of the north-south sky to an arc of 100° between 40° and 45° above the horizon. No trees or buildings were within the owls' field of view. However, a television tower with blinking red warning lights was visible to the west. The University is situated roughly in the center of the city and any distracting glow from city lights is subequal in all directions. The owls were transported collectively from their small cages to the activity cages. They were placed in the five cages so that each bird spent approximately an equal number of nights in each cage. To allow for a random distribution of the birds in the cages, I removed the first bird I could catch and placed that one in cage one. The next bird caught was placed in cage two. This procedure was followed until all five birds were in the test cages.

Since the birds could not be protected from storms, they were not placed in the experimental apparatus during inclement weather. However, they were placed in the activity cages during cloudy weather.

In August the birds in Group B contracted a disease of unknown origin. Their equilibrium was disturbed, but they continued to eat as long as they could remain upright. Because the disease did appear to be contagious, Group B was isolated from Group A and not tested from 6 August until 1 September.

The activity and orientation data were divided into an early period beginning 2-3 August and ending 11-12 September, and a late period beginning 12-13 September and ending 13-14 October. Since it was not possible to put the owls in the activity cages at the same time every night, a period of 10:00 p.m. to 6:00 a.m., common to all testing situations, was chosen for the basis of comparison.

Activity and orientation were measured by the number of hops per perch. All raw numerical values were changed into percentages so there would be a more uniform basis for comparison among birds. When considering restlessness, total cage activity per night was taken as a percent of total activity throughout the testing period for each individual bird. When considering orientation, the activity for each perch was taken as a percent of that night's activity for each individual bird.

In an analysis of variance on the orientation data, the null hypothesis that the orientation was distributed randomly was tested. For the data rejecting the null hypothesis, values were calculated for least significant differences for the mean activity on the perches in each cage. These showed the perches that were significantly different from the others. The *Zugunruhe* data were not analyzed statistically.

Fat Deposition

To determine whether fat deposition was associated with *Zugunruhe*, I weighed the birds daily throughout August, two to three times a week in September, and once a week in October and November. To obtain comparable weights, the owls were weighed each evening just prior to feeding. The data were divided into weekly intervals. An average was calculated for all weeks for which there was more than one weight.

Molt

From the second week of August through mid-September all captive and some wild birds were examined for degree of molt. In September the molt was progressing so slowly in the captive birds that they were seldom examined.

Field Observations

Wild birds were observed to determine if their behavior changed at the time of the supposed migration. I also attempted to find Elf Owls as late in the fall as possible. The main location for field study was 12 acres 0.2 miles east of the Catalina Highway on Soldier Trail, Pima County, Arizona. This location was chosen because it contained a high density of Elf Owls. It is approximately one mile from the location where I captured many of my experimental owls. The vegetation of the study area consists primarily of saguaro (*Cereus giganteus*), paloverde (*Cercidium floridum*), hackberry (*Celtus palida*), mesquite (*Prosopis juliflora*), and cholla (*Opuntia* sp.). To the south of the study area there is a small wash that originates in the foothills of the Catalina Mountains north of the study area. As a result of this wash, mesquite is particularly dense throughout the study area.

Elf Owls were also observed in other locations, such as east Speedway Boulevard, Tanque Verde Road, Reddington Pass Road, and all along Soldier Trail from Reddington Road to the Catalina Highway.

Eight of the owls in my study area were marked so I could distinguish them individually. In addition to Fish and Wildlife bands and colored plastic bands, some birds were marked with back tags (see Appendix A).

RESULTS

Migratory Restlessness

Of the two groups tested for Zugunruhe, only Group A showed a period of marked increase in activity. It exhibited a peak in activity between 22 August and 29 August. The greatest amount of activity, 13.69% of total activity during the test period, for this group as a whole occurred on 25-26 August (Fig. 1).

Individuals from Group A (with the exception of W/B) showed easily distinguishable peaks. R/W showed a peak in activity on 24-25 August. Of the bird's total activity for the experiment, 14.72% occurred on that night. Four percent occurred on the first night (4-5 August) and during subsequent nights activity ranged from 0.01 to 9.90%.

W/B did not exhibit a pronounced peak in the test period. Higher activity occurred on 22-23 August (9.26%), 29-30 September (10.59%), 11-12 August (10.20%), and 13-14 August (9.88%). Intermediate activity ranged from 1.82% (8-9 August) to 7.75% (8-9 October).

B/B peaked in activity on 24-25 August with 14.53% of its total activity occurring on that night. On other nights, activity ranged from 0.83% (2-3 August to 9.21% (11-12 October).

O/B showed greatest activity on 25-26 August of 25.53%. Two other nights of high percent of activity were 22-23 August and 24-25

August with 16.50% and 11.04% respectively. Activity on other nights ranged from 0.80% to 6.81% of total activity.

Bird O/Y exhibited a peak in activity on 25-26 August of 20.20%. This bird's activity was also high on the night of 28-29 August with 16.40% of the total activity taking place on that night. Activity on other nights throughout the testing period ranged from 0.03% on 2-3 August to 7.06% on 12-13 August (prior to the peak in activity) and 1.22% on 18-19 September and 5.93% on 20-21 September (subsequent to the peak).

There are no data for Group B for the period during which Group A exhibited its greatest activity. All five of the birds belonging to Group B were ill between 10 August and 17 August. The data from these birds with the exception of Y/- do not show definite peaks. On the first night tested, 2-3 August, Y/- showed 22.50% activity and on 1-2 September, 14.85%. Activity on other nights ranged from 1.03% on 9-10 September to 12.51% on 12-13 October.

The small peaks which did appear in the activity of birds in Group B did not occur simultaneously. Therefore, an average of the activity of these birds appears not to increase or decrease with any pattern (Fig. 1).

In summary, Group A, consisting of healthy juveniles, exhibited a peak in activity between 22 August and 29 August. Group B, a heterogeneous group of adults and juveniles, did not exhibit a peak in activity. Group B was not being tested during the time Group A exhibited the peak in activity.

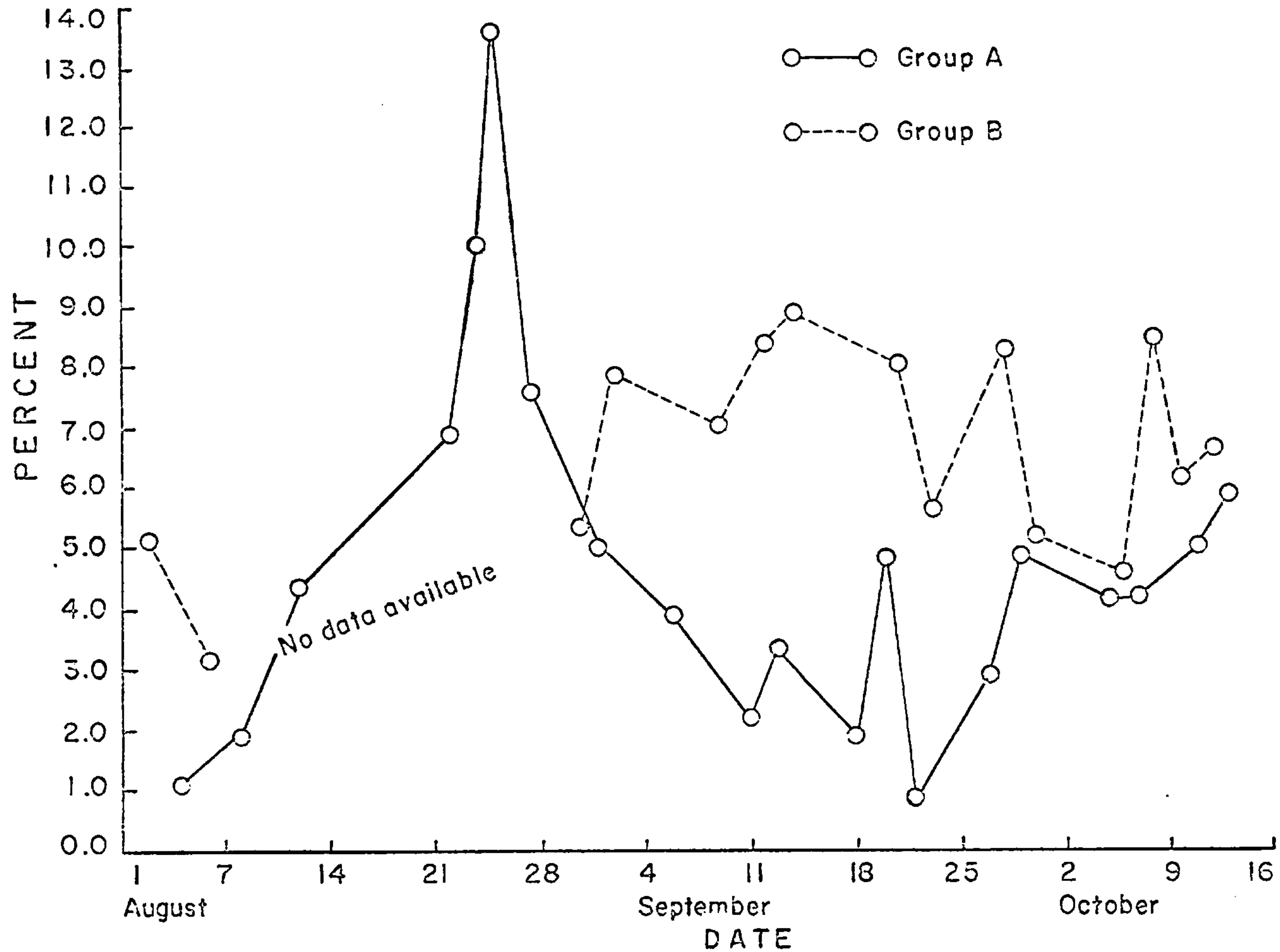

Figure 1. Nightly activity of Groups A and B as a percent of total activity.

<u>Orientation</u>

Three of the owls of Group A were more active on the north perch than on any other perch; activity on the east, south, and west perches was about equal (Figs. 2, 4, 6). A fourth bird was least active on the west perch and more active on north than either south or east (Fig. 5). The fifth owl did not show any difference in activity between the four perches (Fig. 3).

When the testing period was considered as a whole, R/W showed a significant difference ($F=3.60$, $.01 < P < .025$) in activity between the four perches. However, when the data were divided into the early and late periods, only the data for the early period showed a significant difference ($F=3.09$, $.025 < P < .05$). Of the total activity for the early period for R/W, 42.44% occurred on the north perch. Calculation of least significant differences showed significant differences between the mean percents for north with those of both west and east only.

The data for W/B showed no significant difference ($F=.434$, P .10) for the testing period as a whole, nor for either the early ($F=.524$, $P > .10$) or late ($F=.179$, $P > .10$) periods. The activity of this bird throughout the entire testing period was randomly distributed as indicated by the percent of activity on each perch: north--early period, 24.57% and late period, 29.00%; south--early period, 17.58% and late period, 25.25%; east--early period, 23.43% and late period, 20.04%; and west--early period, 34.00% and late period, 25.78%.

For B/B there was no significant difference for the whole testing period ($F=2.10$, $P > .10$). However, there was a significant difference for the early period ($F=6.01$, $P < .005$). The differences between the mean of north and those of all other directions are above the value for the least significant difference. Fifty-three percent of the activity for the early period occurred on this perch.

The data for O/B indicate a significant difference in activity between the various perches for the whole testing period (F=4.37, $.005 < P < .01$). Both the early and late periods also show significant differences (F=3.52, $.025 < P < .05$; and F=8.77, $P < .005$) respectively. Calculations of least significant differences for the early period show a significant difference between the mean for west and those for east and north. This does not indicate that the bird sat on the west perch more than the others. Rather, it shows that the bird, in fact, avoided that perch. Only 4.71% of the activity for the early period occurred on the west perch while 40.10% occurred on the north perch. The difference of the means between north and south (23.23% was not above the figure calculated for the least significant difference (26.13%). Neither was the difference of the means between north and east above this figure. However, they both approach the value for the least significant difference more closely than the remaining differences. In this instance, the avoidance of the west perch masked the choice of the north perch.

There is no significant difference (F=2.64, $P > .10$) between perches for the overall period for O/Y. However, there is a significant difference in perch activity during the early period (F=5.11, $.005 < P < .01$), although there is none for the late period. There is a significant difference between the mean for north and the means of each

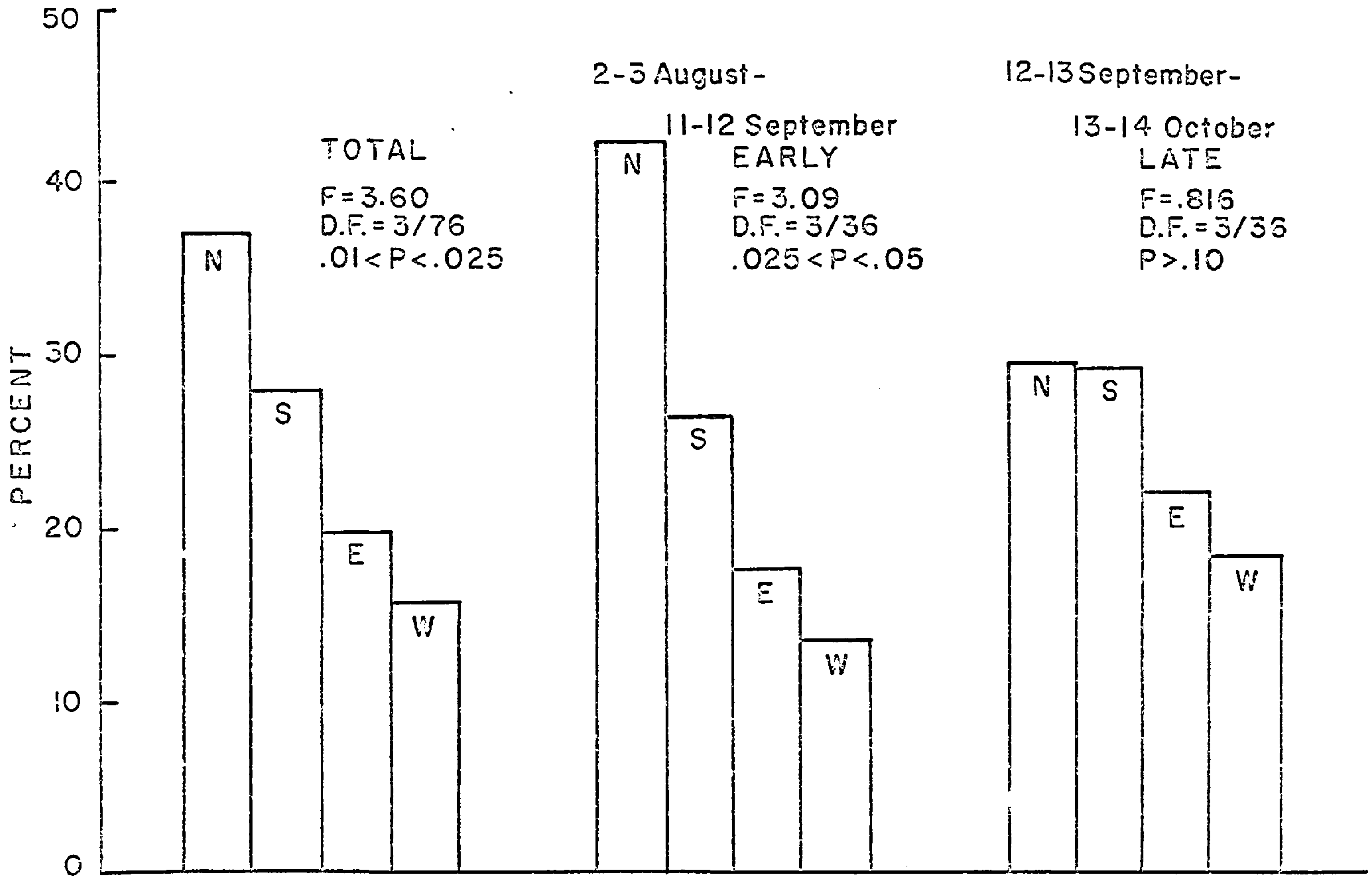

Figure 2. Directional orientation of R/W (Group A) as indicated by perch activity as a percent of total activity for the testing period.

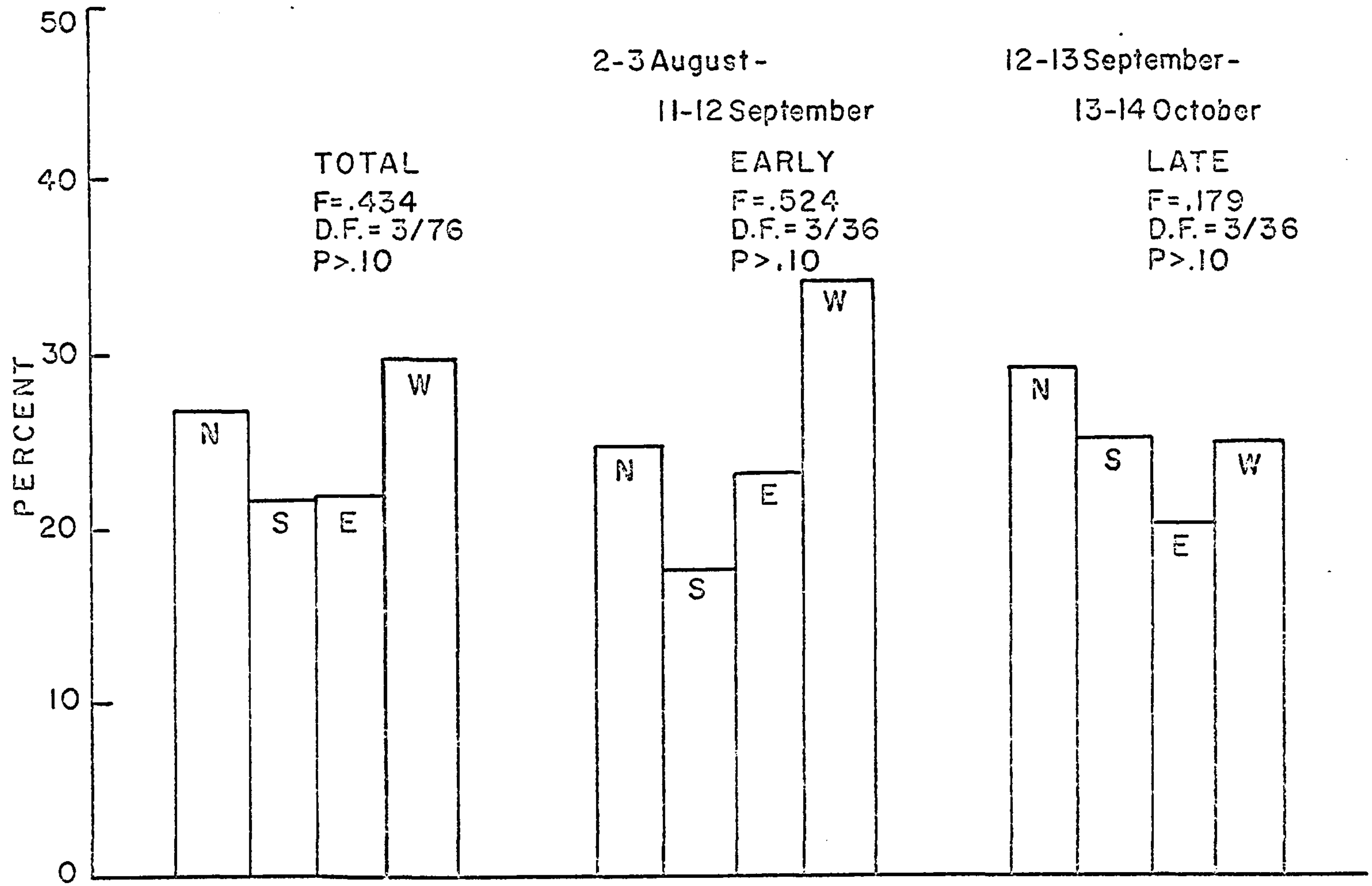

Figure 3. Directional orientation of W/B (Group A) as indicated by perch activity as a percent of total activity for the testing period.

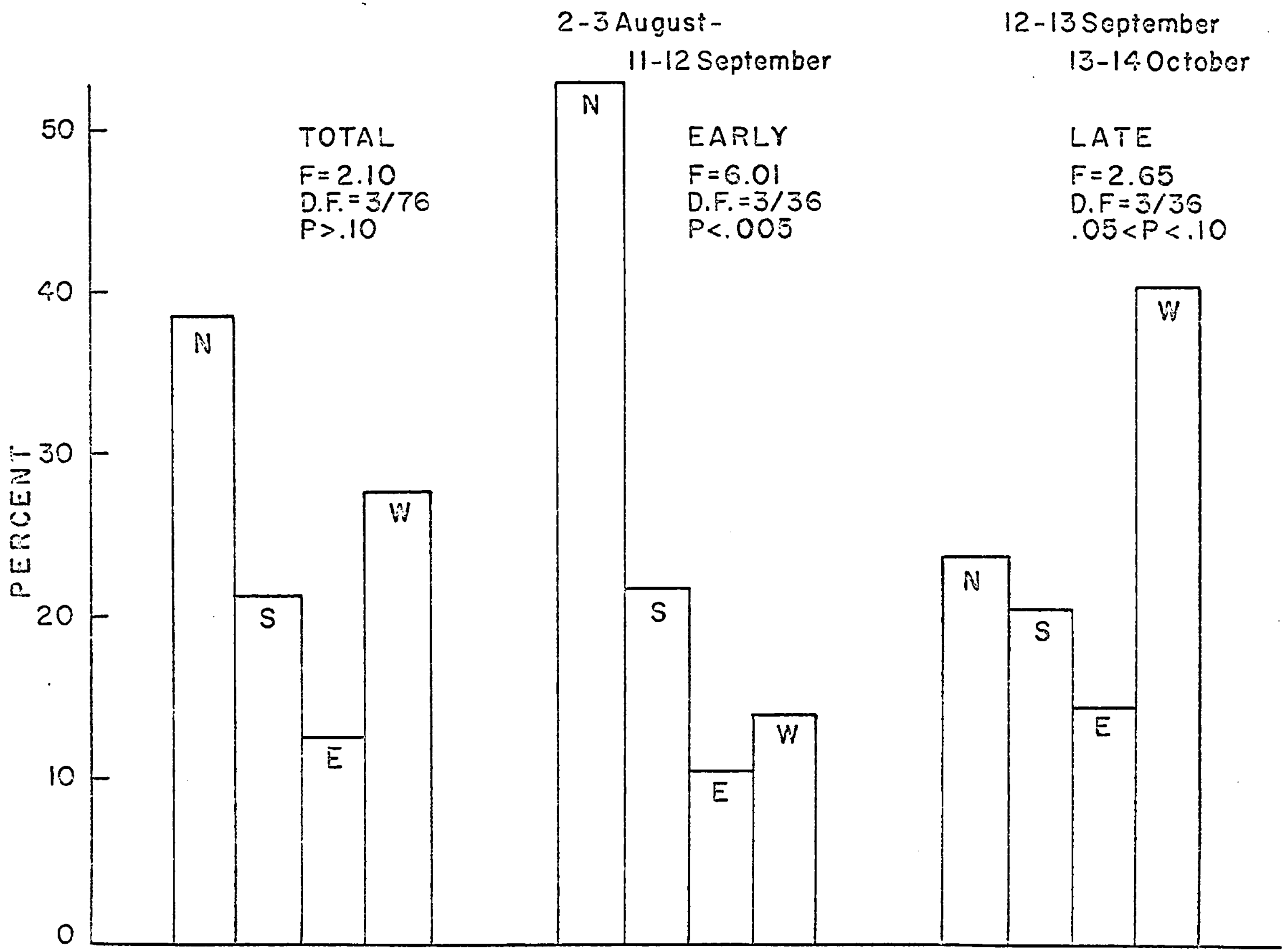

Figure 4. Directional orientation of B/B (Group A) as indicated by perch activity as a percent of total activity for the testing period.

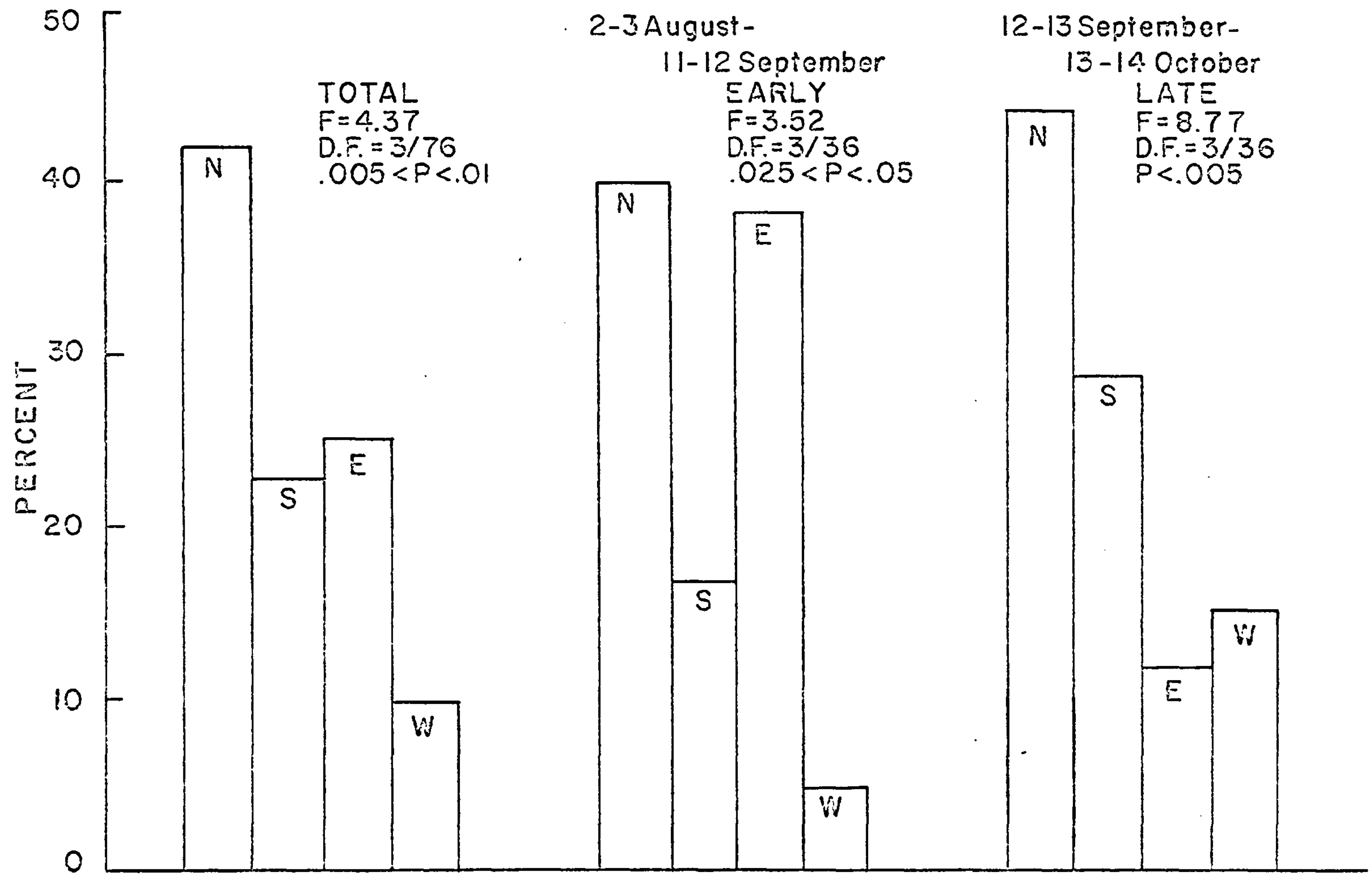

Figure 5. Directional orientation of O/B (Group A) as indicated by perch activity as a percent of total activity for the testing period.

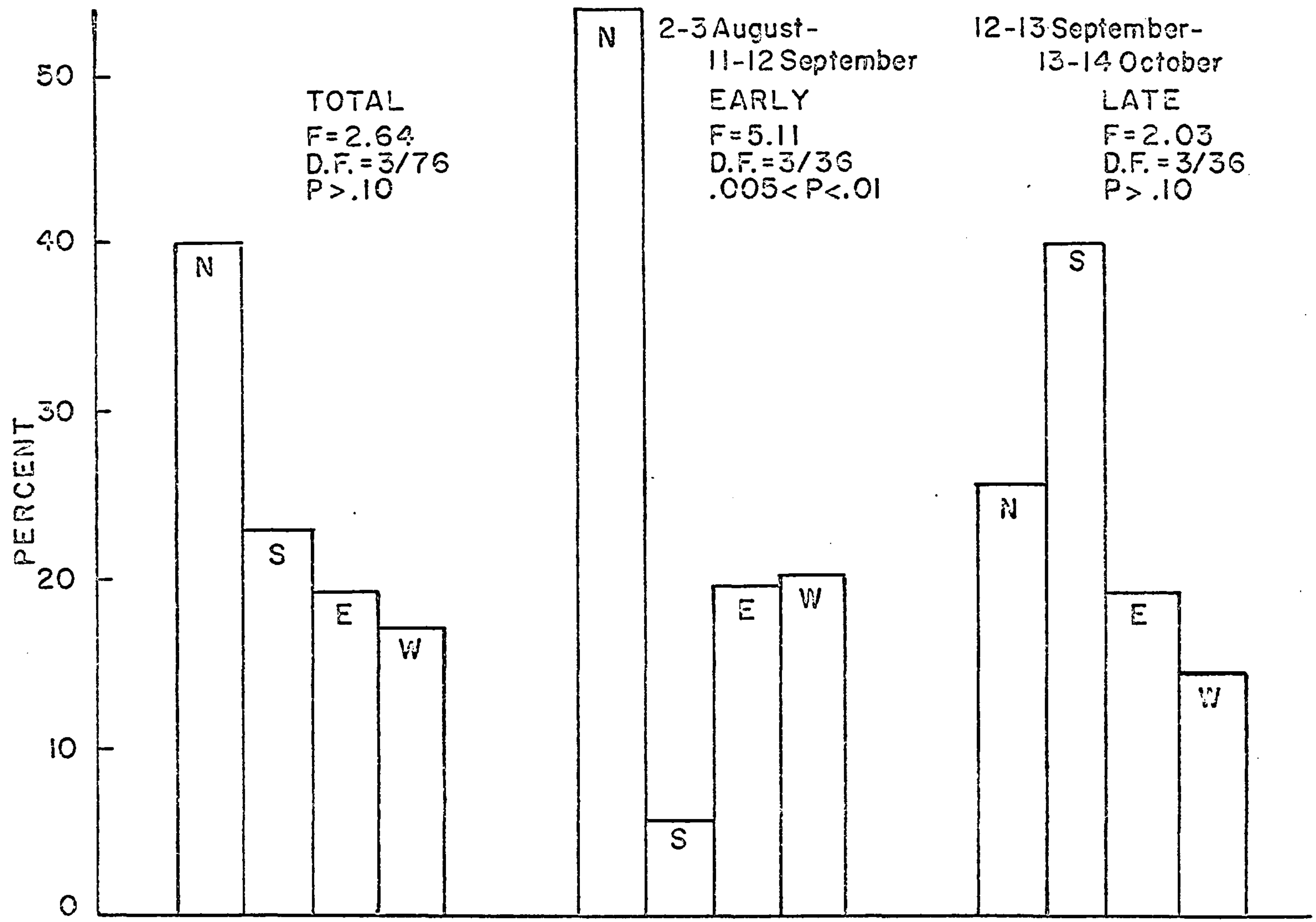

Figure 6. Directional orientation of O/Y (Group A) as indicated by perch activity as a percent of total activity for the period of testing.

of the remaining directions. The majority of activity did occur on this perch (54.26%).

In summary, four out of five owls of Group A were more active on north perches. One owl was equally active on all four perches. None of the birds of Group B exhibited a perch preference at any time during the entire testing period or during either half.

Fat Deposition

Weise (1956) found that fat class curves followed closely to weight curves in captive Slate-colored Juncos. He had no data for wild birds. Helms (1963) indicated that weight approximated fat in visible fat classes.

All ten captive Elf Owls steadily increased in total body weight from 10 August to 1 November (Fig. 7). An immature owl, B/B, gained the least amount. Its maximum weight of 49.3 grams was only a 28.4% increase from the original weight of 38.4 grams. At the other extreme, the maximum weight of 55.6 grams for an adult, Al/Y, was a 50.20% increase over its original weight of 36.9 grams. The birds were not weighed after 1 November.

The weight of the wild birds did not increase, but remained constant. However, few weights were obtained for wild birds, and the data are not comparable (Table 1).

Molt

Molt began as early as 2 August in one captive adult. It had dropped primaries 1 and 2 and showed light molt on the abdomen. The birds were not examined again until 12 August when two adults and one

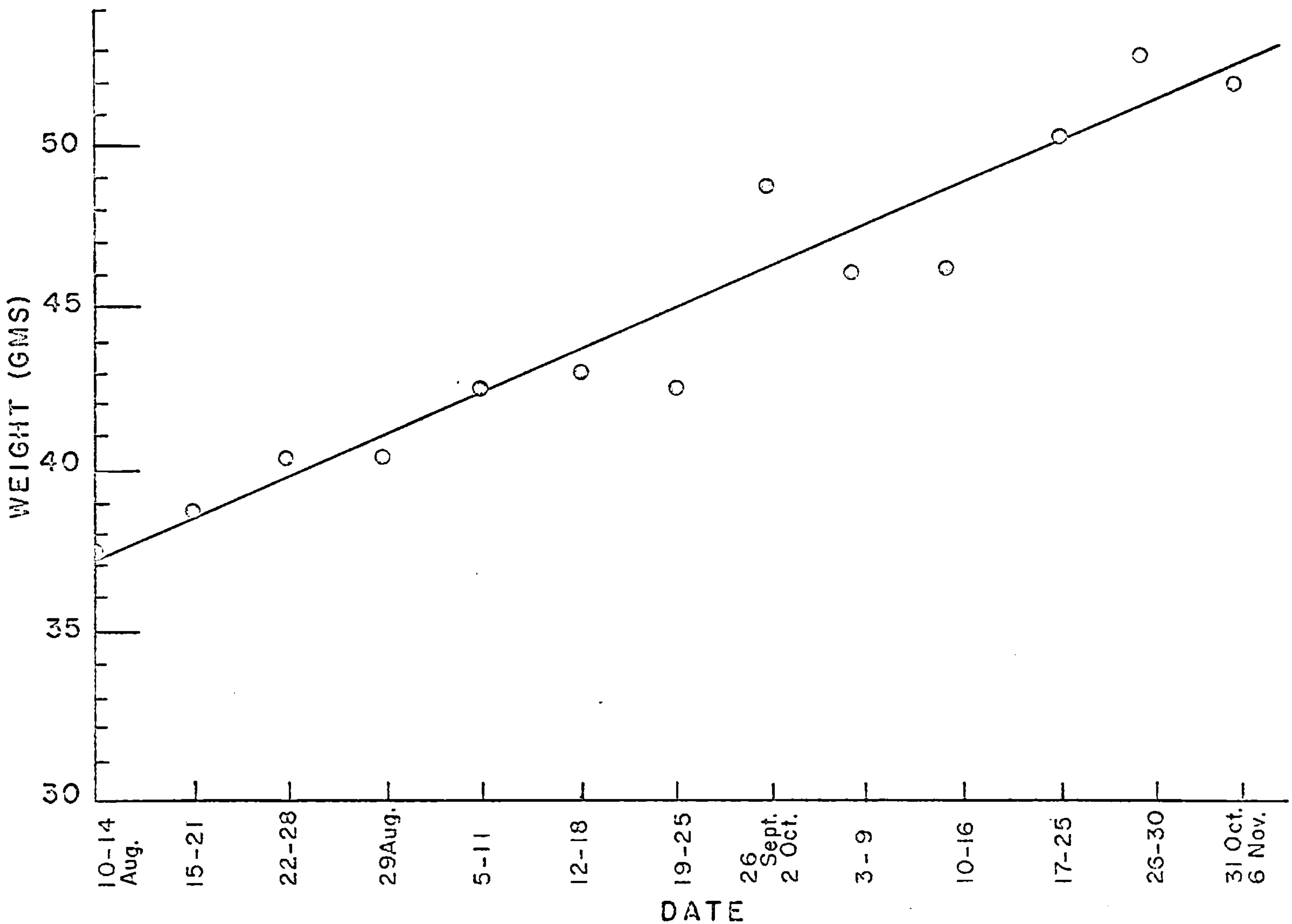

Figure 7. Average weekly weight of ten captive Elf Owls, from August 10 to November 1, 1967.

Table 1. Weights of wild birds, 1967.

Date	Weight (grams)	Remarks
21 April	40.8	Male
12 June	38.9	
13	37.2	
14	39.1	
15	34.9	
16	37.4	
17	50.1	Female
19	39.0	⍂ *
19	39.1	◇
20	53.6	⊖
24	40.9	○
24	40.5	☾
27	39.6	°o
27	40.6	°o Recaptured
27	56.9	V Female ?
27	41.6	T
6 July	40.0	S
6	37.7	+
9	39.3	
9	37.1	
10	37.1	Male
13	37.2	
13	36.4	
19	36.2	
21	38.2	Male
28	39.7	
18 August	35.4	Juvenile
30	43.8	Male
6 September	40.3	Juvenile
6	40.0	Juvenile
13	42.6	◇

* Back tag symbol

juvenile showed signs of body molt, all in the ventral tract. Al/R, an adult, and O/B, a juvenile, were molting heavily along the ventral tract. The most active period of molt was during the second, third, and fourth weeks of August. One individual, an adult, -/W did not begin molting until 2 September. One adult collected near Tucson on 30 August was in heavy molt: 50 to 75% of the capital tract was in late brush. The spinal tract was in moderate molt. All tail feathers had dropped and there were new sheaths, and two in the early brush stage. In the ventral tract, many late brush and new feathers were present. The crural tract was 80% pins while the femoral tract was molting only moderately. Primaries one through four were new, and the sheath on primary five was split open $1\frac{1}{2}$ cm. The sheath for primary six was just appearing. The primaries of both wings were similarly developed. On the right wing, secondary one was in a new sheath and secondary two had been dropped. No other secondaries were noted missing. On the left wing there was no indication of molting secondaries. The wing coverts were either new feathers or in sheaths.

On 6 September the molt of two netted juveniles had almost been completed. The plumage of both had much white and tawny mixed in with the gray.

On 13 September, I netted a molting adult in the study area. Primaries one through four were fully grown while primary five was almost fully grown and primary six measured 30 mm on the left wing. The right wing was the same. Body molt was light and all rectrices were fresh.

On 18 August a juvenile was netted in the study area. It was in heavy body molt. The breast and legs appeared to be in fresh plumage; they were more rusty than is usual in a juvenile bird.

The captive birds molted more slowly than the wild birds, and they were only occasionally examined after the testing period ended. In the spring of 1968 the three adults had finally replaced primaries. There was no molt of secondaries or tail feathers in any of the captive adult birds.

Behavior of Wild Birds

Throughout May, June and part of July Elf Owls were very easy to locate by playing tape recordings of their vocalizations. It was even possible to lure males into nets by setting the recorder on the opposite side of a net from a calling male. It was during this period I tagged the owls in my study area and captured others for experimental purposes.

July 27 was a clear, calm night, but Elf Owls were more difficult to locate. That night they did not readily respond to the tape recorder, although weather conditions were ideal. One Elf Owl collected on 29 July was very elusive, as it had also been on the previous night when I made my first attempt to collect it. My field notes from 29 July read as follows: "(the owl collected)..was very elusive last night as was one 0.9 mi north of Reddington Road on Soldier Trail..." Therefore, at least several owls were elusive and more difficult than usual to observe.

On 2 August, the bird 0.9 mi north of Reddington Road did not respond to the tape at all. During the same night I played the tape in the study area and no owls responded. Yet, there were at least eight tagged birds and some untagged birds there earlier in the summer.

On 18 August I set two nets in the study area and caught one juvenile.

On 30 August I collected an Elf Owl that was very difficult to follow. In order to collect it, I had to wait ten to fifteen minutes before it called after initial responses to the tape.

On the night of 2-3 September, I checked several locations east of Tucson known to be previously populated by the owls. Only two were heard. The one which I followed was very nervous and wary, and it was impossible to approach close enough to collect it. At dawn on 3 September I found several young and several adult Elf Owls north of Tucson on Ina Road. They, too, were nervous and wary.

On 5 September I followed an Elf Owl for 0.25 mi. Yet, I was never able to approach close enough to it to collect it.

On 6 September four nets were set on Ina Road 0.7 mi east of Skyline Drive. Two young owls were caught. Other owls were heard occasionally, but not for any length of time.

On 11 September there were no responses to playing of the tape in locations where on 28 and 29 July an owl had been present but elusive. Neither were there any responses to the tape in the study area.

The following night, 12 September, a few Elf Owls could be heard off in the distance at the study area; however, none responded to the tape from within the study area proper.

On 13 September I set six mist nets in the study area. One tagged bird was netted. There were not many vocalizations during the night.

On 14 September I set four nets in the study area, but did not capture any Elf Owls.

On 19 September I played the tape at five locations known to be previously inhabited by the owls. In only one location was there a response, a place where I followed an elusive bird on 2 September without collecting it. The owl was highly elusive on this night also.

On 20 September in the study area I occasionally heard vocalizations in response to the playing of the tape. These were scattered temporally and geographically. In four other locations there were no responses to the tape.

On the nights of 22 and 25 September there were no responses to the tape in the study area. On the nights of 30 September and 13 October I set two and four nets, respectively, in the study area. No owls were captured. Neither were there any responses to the tape.

DISCUSSION AND CONCLUSIONS

Migratory Restlessness

Zugunruhe refers to activity associated with readiness for migration. It has usually been measured in diurnal birds that are nocturnal migrants (Engels, 1962; Mewaldt, Morton, Brown, 1964). In diurnal species, there is little nocturnal activity except during the migratory period. Owls are nocturnal birds and are probably also nocturnal migrants. There was little indication of activity after sunrise in the captive birds other than that resulting from heat stress. If they migrate at all, it is unlikely that Elf Owls do so during the day because the days are still too warm when the owls begin disappearing.

If owls are nocturnal migrants, any measurement of *Zugunruhe* would be complicated by the presence of an underlying basic activity characteristic of nocturnal birds. The majority of this activity would be feeding. In the activity cages, the feeding dish containing thawed crickets was placed in the center of the cage; thus, feeding activity should be equal in all directions. There should not be any sudden fluctuations in activity attributable to feeding alone. In measuring restlessness of owls, it is necessary to assume that this underlying maintenance activity will remain relatively constant, and the increase in measured activity reflects *Zugunruhe*. In sparrows, diurnal activity decreases seasonally as nocturnal activity increases (Helms, 1963). If anything, subtraction of basic nocturnal activity might only enhance the amount of migratory restlessness actually expressed. Therefore, the increase in activity that reached a peak of 13.6% of total activity on 25-26 August was more than the usual nocturnal activity and indicates that the owls did exhibit Zugunruhe.

Full moons occurred on 20 August and 18 September, 1967. The peak in activity of Group A occurred after the first full moon, and there was no peak either prior to, during, or subsequent to the second full moon of the testing period. Therefore, the increased activity between 22 August and 29 August should not be considered as a response to the moon.

Farner and Mewaldt (1953) showed that extremely high temperature will induce restlessness not related to migratory readiness. Although the peak in activity occurred for Group A in August when the night temperatures are indeed warm, this peak should not be considered a result of high temperature. The Elf Owls roost by day in the open shade of mesquites and paloverdes and are also accustomed to the warm desert nights. The experimental birds were exposed to temperatures comparable to those in the natural habitat at night. The unrest due to increased temperature observed by Farner and Mewaldt (1953) was artificially induced at a time when the birds would have normally experienced cooler temperatures. The difference between daytime room temperature and rooftop night temperatures should not have caused a peak in activity during late August. If a peak were to result from this temperature difference, it would have occurred in early August immediately upon commencement of the experiment.

Also, the only time the birds seemed affected by temperature was when they remained on the roof until 10:30 a.m. on clear days. They were not only exposed to higher ambient temperatures, but also to direct sunlight. On several occasions, both clear and cloudy mornings, the owls were left on the roof as long as possible to determine if they did exhibit any diurnal activity. On cloudy days there was none. Neither was there any activity between dawn and 10:00 to 10:30 a.m. on clear mornings. Therefore, the mid-morning activity shown by the owls was a result of heat stress. This would be further indicated by their panting until removal from the roof.

The sudden onset of nocturnal restlessness exhibited by the captive Elf Owls is similar to that of other species, notably Bobolinks (Engels, 1962) and White-throated Sparrows (Helms, 1963). Weise (1956), Engels (1962), and Helms (1963) all noted that in most of the species investigated, nocturnal restlessness of captives begins at the time of natural migration, and that the autumnal restlessness often continues into the winter. The increased activity of the owls did not continue.

Group B (N=5) did not exhibit a peak in nocturnal restlessness (Fig. 1). This may have resulted from their illness. They were absent from the testing situation during the period when Group A (N=5) reached its peak in restlessness. If timing of the peak in restlessness of Group A is indicative of that of the species, then a peak could not be expected in the activity of Group B because they were not tested during that time. Increased nocturnal activity as shown by Group A possibly is evidence that the Elf Owl is migratory.

Orientation

The owls were able to face either direction on a perch. Therefore, any given hop recorded by the event recorder could mean the bird was facing the direction of that perch or the one directly opposite it. However, there is some evidence that the owls did spend the majority of the time facing outward from the cage. Beneath most of the perches there were two accumulations of excrement. The ones indicating that the bird was facing outward were invariably larger than the piles indicating that the birds were facing the center of the cage. In the majority of the perches, the former were two to three times as large as the latter.

The Elf Owl is a nocturnal species. If nocturnal restlessness is used as a measurement of migratory restlessness, basic circadian activity is also being measured. It is possible that the apparent choice of north is a result of this basic nocturnal activity. However, this seems unlikely since the underlying circadian activity should remain relatively equal in all directions. Also, orientation toward north occurred primarily during increased restlessness.

Group A (N=5) showed a preference for north which was significant at the 0.05 level. Three of the five individuals (R/W, B/B, O/Y) showed an obvious preference for this direction. The preference for north by the fourth bird (O/B) was masked statistically by its avoidance of west. The fifth bird showed no preference. Orientation occurred during the time of greatest restlessness.

The choice of north by these owls is confusing. Autumnal migration would be assumed to be in a southerly direction. Since this group is composed entirely of young birds removed from the nest, the choice of direction could not be learned from the adult birds. Neither is it likely that it was a result of cues from the cages. The owls were placed in different cages often enough to prevent them from learning direction in this way.

Although it may appear from the graphs that south or west is chosen in the later period, there is little statistical validation of this.

Some populations of Mallard are known to orient to the northwest at all times upon release (Bellrose, 1958; Matthews, 1961). Common Terns have been found to consistently orient southeast (Goldsmith and Griffen, 1956). Continual orientation in a given direction immediately upon release without regard to season is known as "nonsense" orientation. If Elf Owls are migratory, this may well be the type of initial orientation they possess.

Fat Deposition

The increase in total body weight of all ten captive birds and the observation that there was actually subcutaneous fat are indications that the owls were depositing fat. Fat deposition usually occurs just after molt and prior to migratory restlessness (Wolfson, 1945; Engels, 1962). Fat deposition does not necessarily occur before migration (Odum, 1960). There is usually no marked variation of body weight in resident species and races (Wolfson, 1945, 1954). However, the fat that the captive owls acquired may not be related to migration at all. While premigratory fat deposition occurs suddenly, the weight of the owls increased over several months at a steady rate.

The maximum weight gain occurred after the birds were no longer being tested, implying that lack of handling may have contributed to the gain. Some of the owls had been held in captivity for over a month preceding the experimental period, and yet no great decrease in weight was noted upon their being handled. It is unfortunate that there are no weight data for the wild birds during the period following testing (15 October to 1 November), when the captive birds reached their maximum weights. However, this is the time when they became increasingly scarce in the wild, and it is presumed that migration had taken or was taking place at that time. If owls are not to fully deposit fat until the middle of migration, then the late weight gain of the captive birds would be expected.

In January, 1968, the captive owls still had retained the majority of this fat deposition. In general they appeared obese and the weights were comparable to those of the last few weeks of October. Retention of fat deposition by captive individuals throughout the winter has been found in other species (Weise, 1956, Engels, 1962). Engels noted that only molt decreased the amount of winter fat. Dyson (pers. comm.) has found the same type of weight gain in Elf Owls at the Arizona-Sonora Desert Museum. Those owls were kept outdoors and fed on live moths in the cages. The conditions under which the owls at the Desert Museum and mine were kept were not the same. Therefore, the linear weight gain of my birds was not entirely a result of my handling techniques. It might even be inherent to the species. The weight gain cannot be the result of maturation since many of the juvenile owls weighed more than the adults in late July. In addition, the three adult captive birds showed the same type of weight gain as did the juveniles.

Molt

Molt in the captive birds was not normal. Not only was it incomplete, but the duration of molt for the captive birds far exceeded that of the wild owls. While wild birds had molted remiges and rectrices by the end of September, the captive birds had only begun molting of primaries. Replacement of primaries was not complete in the captive adult owls until spring, 1968. Secondaries and rectrices never were replaced in these birds. Both wild and captive owls I studied were molting in August. Ligon (1968) found his captive Elf Owls began molting in early September.

Behavior of Wild Birds

From the end of July through September the wild owls became increasingly hard to find. Also, they became more difficult to observe even if they were found. Few were netted at this time. The occurrence of this behavior coincides to some extent with the increase in activity of the captive birds. The third week of August probably is the time when the Elf Owl begins migration for southern Mexico.

The increasing secretiveness of the owls from the end of July through mid-September may be indicative that the birds are preparing to migrate. In August when they were in heavy molt it might have been to their advantage to be quiet. The lack of vocalization may have been the result of an initial secretiveness followed by a decrease in individuals which were present. The reduced number of birds netted in the study area tends to support this. The Elf Owls' behavior is similar to the behavior of Gambel's Sparrows as they begin to migrate (DeWolfe, 1967).

The period of increasing elusiveness and eventual disappearance of the wild owls includes within it the period of increased activity of the captive birds.

Gain in weight and molt provided completely inconclusive information regarding migration. However, some captive Elf Owls tended to exhibit two of the well known phenomena associated with migration, *Zugunruhe* and orientation. Therefore, there is a more substantial basis for considering this species migratory.

APPENDIX A

The back tags were constructed from either dark blue or white Armor Tite vinyl-coated nylon. Automobile reflector tape was used for the pattern. The pattern included a cross, double dots, single vertical lines, double vertical lines, diamonds and crescent moons. This was to prevent confusion of numbers or letters. A harness for the tag was made from 1/8 inch oval sewing elastic and was attached to the tag to form two lateral loops. The finished measurements of the tags were 3/4 inch by 1-1/2 inches.

Note: The designs are visible when the owls are perched. However, with the type of head movement characteristic of owls, the back tag is a disadvantage to the bird. The tags which had been on through the summer were well worn along the upper edge, unlike those left on doves. The elastic was frayed at the junction with the tag, and the skin covering the wing was raw, sometimes to the bone, from the rough elastic.

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