FLAMMULATED OWL MIGRATION IN THE SOUTHWESTERN UNITED STATES

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The Flammulated Owl (*Otus flammeolus*) is a small insectivorous species that breeds in montane habitats of western North America from British Columbia south to Guatemala. As is the case in certain other small owls, e.g., Scops Owls (*O. scops*) and the Elf Owl (*Micrathene whitneyi*), Flammulated Owls appear to be migratory, at least in the northern portion of their range. In Arizona the species appears to be absent from breeding areas from mid-October through late March (Jacot 1931, Phillips 1942, Phillips et al. 1964), and the same applies to the non-breeding season in New Mexico (Hubbard 1970). This information plus scattered records of non-breeding birds out of the breeding habitat are the main basis for considering the species to be migratory. Johnson's (1963) speculation that the species might overwinter on or near the breeding grounds in a state of torpor has not been supported by data from experiments by Banks (1964) and J. D. Ligon (pers. comm.) which reveal these owls possess no ability to undergo periodic torpidity.

Records of probable migrant Flammulated Owls in the Southwest are reviewed here with emphasis placed on captures at 2 sites of intensive nocturnal netting in New Mexico and Arizona. We also incorporate other data including food availability at one capture site that may affect the migration of these owls.

METHODS AND MATERIALS

New Mexico—From 1967 through 1973, McKnight maintained a series of 12 m, 4-shelf mist nets (maximum of 5) from early April through May and during August, September, and October at Cedar Crest, on the east side of the Sandia Mountains, in north-central New Mexico. Nets were strung across and adjacent to a permanent stream at an elevation of 2040 m. The dense riparian vegetation along the stream consisted of Fremont cottonwood (*Populus fremontii*), willows (*Salix* spp.), junipers (*Juniperus* spp.) and scattered shrubs including honeysuckle (*Lonicera* sp.) and snowberry (*Symphoricarpos* sp.). The arroyo coursed through pinyon pine (*Pinus edulis*)-juniper woodland that contained scattered Gambel oaks (*Quercus gambelii*) (Fig. 1). Nets were operated 161 nights in the spring and 162 nights in the fall during the 7-year period.

Temperatures for the migratory period were obtained with maximum-minimum thermometers placed near the capture site.

Arizona—From early April to mid-May and again from mid-August through mid-November of 1969 through 1973, two 12 m, 4-shelf mist nets were manned by Balda in a ponderosa pine (*Pinus ponderosa*) forest in Flagstaff, Arizona (2510 m). Although it was an urban setting, the nets were on the periphery of a 305 ha tract of relatively un-

FIG. 1. View showing woodland and riparian vegetation at the Cedar Crest, New Mexico capture site.

disturbed forest (Fig. 2). Each year the nets were placed in the same position and at the same height (ca. 1–2.5 m above the ground). The nets were adjacent to a grove of 17 Gambel oaks, and examined nightly at 23:00 and again at 06:00 for nocturnal birds. The nets were operated 232 nights in the spring and 421 nights in the autumn during the 5-year period.

Temperatures for the migratory period were obtained from the National Weather Service office located about 13 km from the capture site and at an elevation of 2500 m.

To determine the food base available to this small insectivorous owl during migration, Johnson operated a black light (ultraviolet) trap at night to collect night-flying insects from 14 September to 25 October 1973 and again during March, April, and May, 1974. The black light was approximately 1.5 m off the ground and was operated in the general area of the mist nets. Although the variation in size of insects collected was continuous, most of those captured were noctuid moths and what we classified as large (14–32 mm body length). Medium (12–13 mm body length) and small (8–11 mm body length) insects were also captured but in far fewer numbers than the large insects.

RESULTS

New Mexico—Twenty Flammulated Owls were captured between 16 April and 16 May during the 7 years of trapping. One owl was recaptured for a total of 21 captures within this time span (Fig. 3). Ten of these owls were captured in 1967 and their dates of capture span the entire 31-day period.

FIG. 2. View showing the habitat where Flammulated Owls were captured at Flagstaff, Arizona.

Far fewer owls were captured in subsequent years and this is reflected by the shorter duration of the capture period: 7 days in 1968 and 4 days in 1973. The mean capture date for the 21 owls was 6 May. All owls were captured in the lower shelves of the nets suggesting that the owls were either hawking

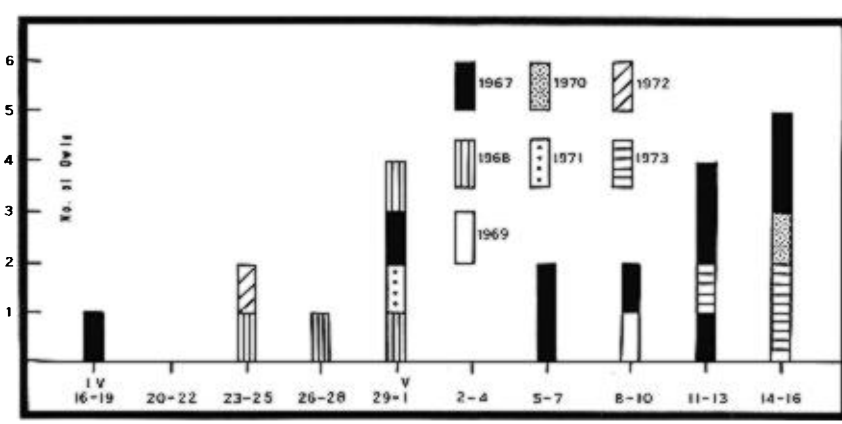

FIG. 3. Dates and number of owls captured in April and May in north-central New Mexico.

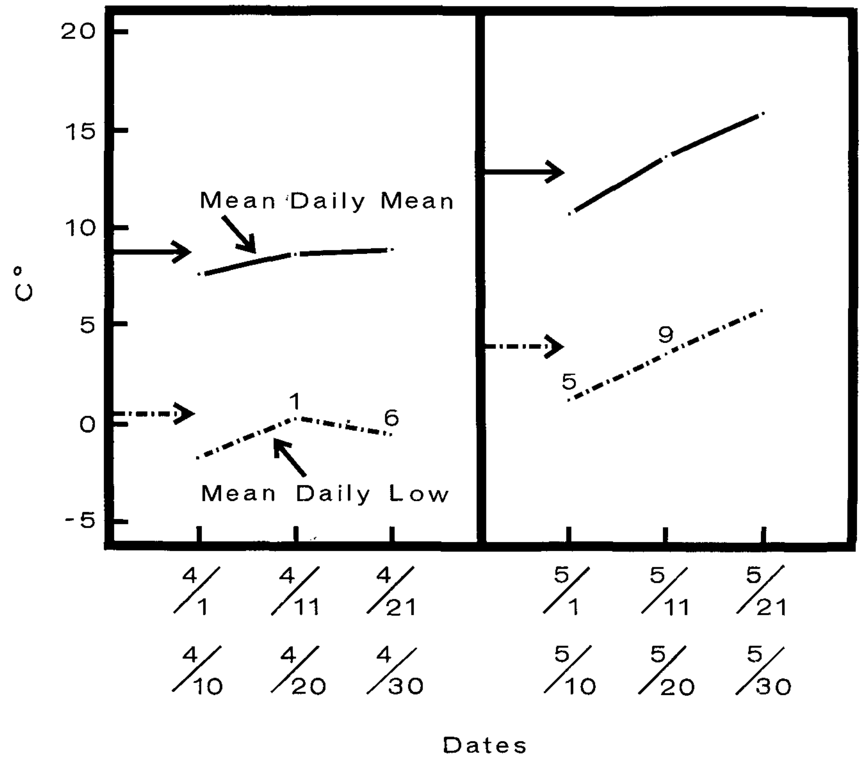

FIG. 4. Mean daily mean and mean daily low temperatures for April and May for 6 years at Cedar Crest, New Mexico. Numbers on graph indicate owls captured per time interval. Arrows indicate temperature means for capture dates.

insects near the ground or water or were drinking from the stream. It is possible, however, that the owls struggled out of the upper shelves and got caught in the lower ones.

During April and May temperatures at Cedar Crest, New Mexico were cool but gradually warming. The mean daily low for April during the 7 years of netting was –1°C and ranged from –3°C to 4°C. In May the mean daily low was 4°C and ranged from –2°C to 7°C. During nights on which owls were captured in April the mean daily low averaged –1°C and the mean daily temperature 9°C. On May capture dates the mean daily low averaged 4°C and mean daily temperature 13°C (Fig. 4). The range of nighttime lows on capture dates varied from a –3°C on 30 April 1967 and 29 April 1968 to a high of 12°C on 10 May 1967.

No Flammulated Owls were netted at this location during the autumn trap-

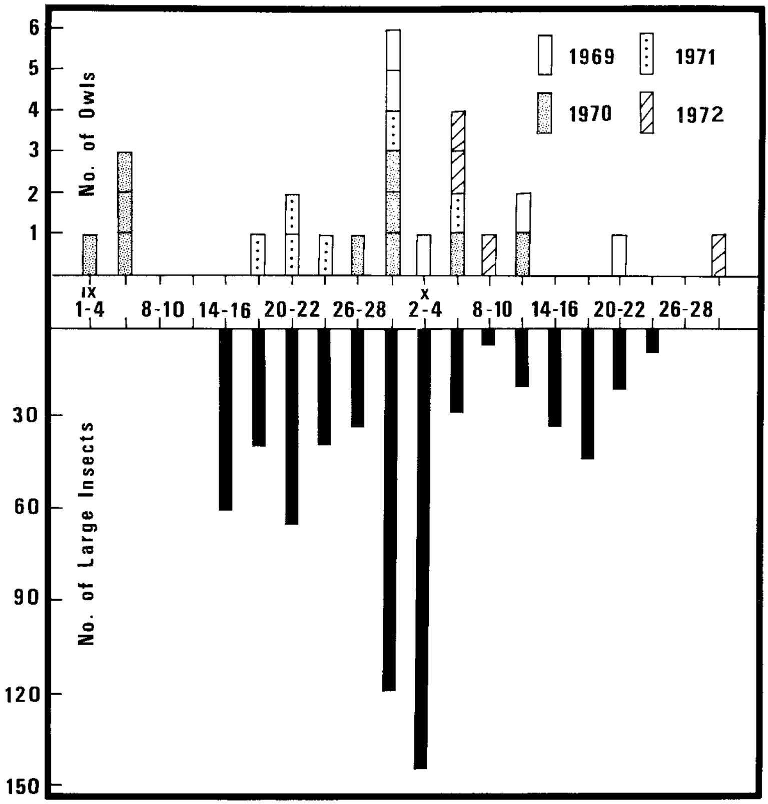

FIG. 5. Dates and number of owls and insects captured in September and October in north-central Arizona.

ping periods during any of the 7 years. No owls were captured in the spring of 1974.

Arizona—Twenty-two Flammulated Owls were captured in mist nets in Flagstaff between 1 September and 21 October during 5 years of trapping (Fig. 5). In addition, 2 birds were observed on day roosts during this period at the feeding station of G. F. Foster and another was captured by hand in a half-starved condition in a snow storm on 31 October 1972. These 3 birds are included in this analysis as the areas where they were seen or captured were checked daily and any owls present on other occasions would have been detected. Twenty-five birds form the sample for our analysis.

From these data we conclude the fall migration period (as indicated by captures) in Flagstaff, Arizona lasts about 61 days. This 61-day span was

TABLE 1

SIZE DISTRIBUTION OF NOCTURNAL INSECTS CAPTURED DURING THE SPRING AND AUTUMN SAMPLING PERIODS

	Size Class		
	Small (%)	Medium (%)	Large (%)
Spring	75 (16)	20 (4)	370 (80)
Autumn	22 (0.01)	9 (0.004)	2033 (99)

not equalled in any one year, but in 1970 when 10 owls were caught the duration was 42 days, in 1971 when 6 owls were captured or observed the dates spanned 17 days, and in 1972 the 4 owls spanned 27 capture days. The mean capture date was 29 September. The mean date of occurrence of 9 known males was 25 September and for 9 known females, 29 September. These specimens are now in the Vertebrate Museum of Northern Arizona University. These means are not significantly different (t-test, $P > .05$). All owls caught in the nets were in the lower 2 shelves and thus must have been migrating or capturing insects at heights of 1.5 m or less above the ground or had slipped down from the upper shelves of the net. At this location no Flammulated Owls were captured during spring netting operations in any year, nor were owls captured in the fall of 1973.

Insects belonging to the orders Neuroptera (lacewings), Hymenoptera (bees and wasps), Trichoptera (caddisflies), Coleoptera (beetles), and Lepidoptera (moths) were collected in the black light trap during the 2 sampling periods. Johnson collected 2064 insects in the fall sample and 465 in the spring sample. Ten families were present in the fall sample whereas the spring sample contained only 5 families. Over 99% of the insects in the 2 samples were Lepidoptera and, of these, 94% were in the family Noctuidae (millers, noctuids). The family Noctuidae is the largest in the order. Its members are mostly nocturnal and the majority of moths normally attracted to light at night are noctuids. Moths in the families Arctiidae (tiger moths), Geometridae (measuring-worms), Pterophoridae (plume moths), and Pyralidae (snout moths) were captured as well, but in far fewer numbers.

The mean number of insects captured per night was only 14.09 in the spring compared to a mean of 49.14 insects per night in the fall (Fig. 5). This difference represents a 71% increase in insects between spring and fall. The large noctuid moths made up 75% of the spring sample compared to 98% of the fall sample. Because noctuid moths are larger than most members of the other families represented in the samples, the biomass of nocturnal flying insects available to the owls was most likely much greater than the

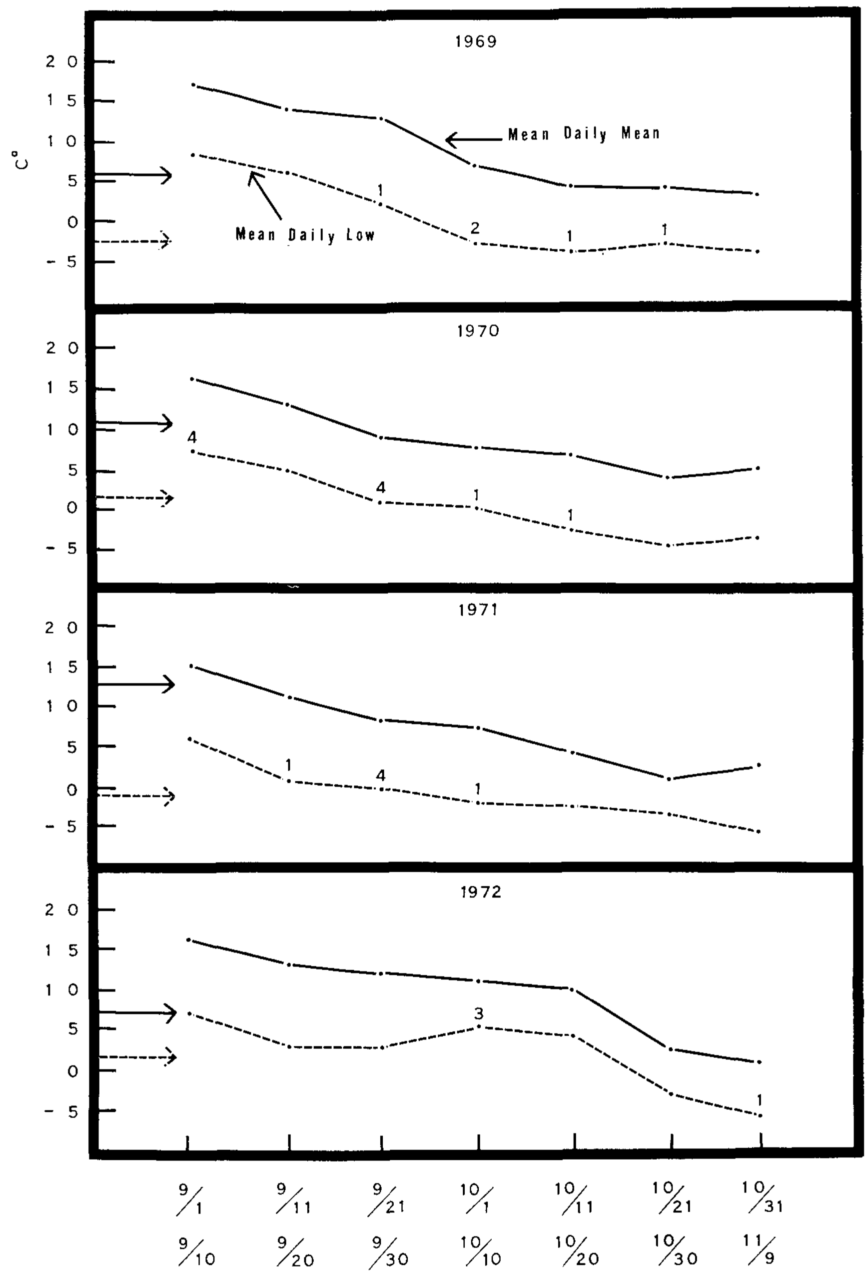

FIG. 6. Mean daily mean and mean daily low temperatures for September and October in north-central Arizona. Caption same as Fig. 4.

actual densities indicated. The distribution of insects differed significantly among size classes for the 2 sampling periods (χ^2, $p < .001$) (Table 1). A noticeable peak in the density of large fall flying moths occurred in late September and early October (Fig. 5).

During the autumnal migratory period temperatures at Flagstaff, Arizona were gradually declining and nighttime lows below 0°C were not uncommon (Fig. 6). During the nights on which owls were captured the mean daily low temperature combined for all 4 years was 0°C and yearly averages of mean daily lows varied from a low –3°C in 1969 to a high of 2°C in 1970 and 1971. The range of nighttime lows on capture dates varied from a high of 8°C on 1 September 1970 to a low of –13°C on 12 October 1969.

In the fall of 1973, no owls were captured but insects were sampled (Fig. 5) and temperatures analyzed to see if they differed greatly from those of the preceding 4 years. Casual inspection of the data indicates temperatures in 1973 were well within the range experienced in the other 4 years. The mean daily low temperature for the 42-day insect sampling period was 2°C and ranged from 6°C to –7°C. The mean daily low temperature for 29 September through 4 October when densities of large insects increased precipitously (Fig. 5) was 0°C. These temperatures match well with those experienced by the owls.

DISCUSSION

The duration of migration through the Southwest for this small owl seems to follow that of many migratory birds, that is, a short duration of passage each spring indicating a relatively rapid movement northward and a longer duration of passage in the fall indicating a more leisurely passage of birds. In spring 1967 when 10 owls were netted, the capture dates spanned 31 days. The longest span of migration (as indicated by capture dates) in the fall was 42 days for the same number of owls. In years when 4 owls were captured during each season, the spring duration was 4 days and the fall duration 27 days. Thus it appears that owls are present for an extended period each fall at the higher elevations when compared to spring records at lower elevations. This may be in part due to the geographic location of the Arizona site, as it is possible that the captures early in September were merely birds exhibiting post-breeding dispersal or birds moving down from the San Francisco Peaks whereas birds captured later were those that had already migrated some distance southward.

The time of arrival in the coniferous forest in spring appears to closely coincide with, but is slightly later than our spring capture period (Table 2). Marshall's 26 March record from the Catalina Mountains in southern Arizona is considerably earlier than others from Nevada, Arizona, or New Mexico.

TABLE 2

EARLY SPRING RECORDS OF FLAMMULATED OWLS IN CONIFEROUS FORESTS OF THE SOUTHWEST

Observer	Date	Location	Source
J. T. Marshall, Jr.	3/26/53	Catalina Mts., Ariz.	Phillips et al. 1964
J. T. Marshall, Jr.	4/10/50	Catalina Mts., Ariz.	Phillips et al. 1964
J. P. Hubbard	4/20/60	Pinos Altos Mts., N. M.	J. P. Hubbard, pers. comm.
J. S. Findley	4/27/64	Sandia Mts., N. M.	MSWB*
E. B. Hibben	4/29/67	Magdalena Mts., N. M.	Hibben 1967
R. H. Wauer	5/ 7/64	Springdale, Utah	Wauer 1966
R. H. Wauer	5/ 8/64	Zion National Park, Utah	Wauer 1966
P. R. Snider and D. DeLollis	5/14/67	N of Glenwood, N. M.	pers. comm. J. P. Hubbard
B. C. McKnight	5/24/67	Eagle Peak, Tularosa Mts., N. M.	pers. observ. B. C. McKnight

* Museum of Southwestern Biology, Univ. of New Mexico.

Scattered records (casual observations for the most part) suggest that the earliest owls normally reach the coniferous forest between 10 April and 24 May, a range of 44 days. Also, lowland spring records reported in the literature range from 13 April to 20 May, a range of 38 days. These intervals are only slightly longer than our spring capture duration from one location but far shorter than the fall capture duration (61 days) from one site. The latest spring record reported in the literature for the entire Southwest (Banks and Hanson 1970) is only 4 days later than our latest spring capture from New Mexico.

The migratory movements of the Flammulated Owl in the Southwest as depicted by our mist netting captures generally support the view of Marshall (1967): "*Otus flammeolus* (Kaup) is migratory, with some showing up in the lowlands in spring, fewer in fall . . ." Marshall (1939) reported Flammulated Owls on territories earlier in the breeding season at lower elevations. This suggests that these owls may arrive from lower elevations and gradually take up breeding territories at higher elevations. Ligon (1968a) reports a similar pattern for the insectivorous Elf Owl. Swarth (1904) reports on 15 specimens ranging in date from 22 April to 12 May in dense impenetrable thickets in the Huachuca Mountains, Arizona and in the willows along the San Pedro River, Arizona. Other spring records from the Southwest of owls

TABLE 3

SPRING RECORDS OF FLAMMULATED OWLS IN HABITATS BELOW USUAL NESTING ELEVATIONS IN THE SOUTHWEST

Date Observed	Location	Source
4/ 7/56	Paul Spur, Cochise Co., Ariz.	Phillips et al. 1964
4/13/35	S slope of Blue Mts., Ariz.	Jenks and Stevenson 1937
4/20/74	7.2 km WSW, Hot Well, Texas	pers. comm. J. Darling
4/22/02	Huachuca Mts., Ariz.	Swarth 1904
4/27/55	N of Roswell, N.M.	Ligon, J. S. 1961
4/29/57	Tucson, Ariz.	Phillips et al. 1964
4/29/59	Castle Dome Mts., Yuma Co., Ariz.	Phillips et al. 1964
5/ 3/18	Catalina Mts., Ariz.	Phillips et al. 1964
5/ 5/02	San Pedro River, Ariz.	Swarth 1904
5/ 6/35	Valley Ranch near Silver City, N.M.	CNHM* J. P. Hubbard, pers. comm.
5/ 6/71	Oasis St. Park, near Portales, N.M.	Hubbard 1971
5/ 7/51	Benson, Cochise Co., Ariz.	Phillips et al. 1964
5/ 8/30	South Twin River, Nev.	Linsdale 1936
5/14/69	16 km W of Magdalena, N.M.	Ligon, J. D. 1969
5/15/67	Cave Creek, Chiricahua Mts., Ariz.	Ligon, J. D. 1968b
5/20/62	Mohave Desert, 35 km NW Las Vegas, Nev.	Banks and Hansen 1970

* Cincinnati Nat. History Museum

at elevations below the normal breeding habitat are listed in Table 3. From our data we tentatively conclude that many Flammulated Owls migrate northward each spring in habitats below the ponderosa pine forest in elevation, and southward in autumn at higher elevations. Thus, this elusive owl appears to select different habitats along its migratory route in spring and autumn. We emphasize the change in migratory habitat by some individuals in contrast to change in migratory route as it is possible to move northward and southward through Arizona and New Mexico within rather narrow longitudinal "belts" but yet select very different habitats. For example, 15 km east of the Arizona trapping site one encounters pinyon-juniper woodland and grassland. A shift of only 5 km to the west in New Mexico would place one in coniferous forest. Thus, many of the owls appear to be demonstrating differential habitat selection in fall and spring. Our data are certainly not complete in this regard but justify consideration, especially in light of the scattered and minimal evidence available on the subject to date.

The picture for autumnal migration by Flammulated Owls, however, is not quite as clearly altitudinally-restricted as in spring, as some birds do turn up in the lowlands. C. H. Merriam (1890) collected one on 13 September 1889 below the south rim of the Grand Canyon (but this could have been in coniferous forest) and Emlen (1936) collected one at an elevation of 15 m at Davis, California, on 31 October 1935. Phillips et al. (1964) list 2 fall records from below the ponderosa pine forest, one from southern Navajo County on 2 September 1949, and one from the South Rim of the Grand Canyon on 11 October 1963. Hubbard (1972) reported on one owl collected at El Paso, Texas on 14 October 1933. We know of no other autumn lowland records from the Southwest. Flammulated Owls found in their usual nesting habitat in the autumn (September and October) would not normally be thought of as migrants or attract attention. Because coniferous forest has a disjunct distribution in the Southwest and distance between forests are in some cases great, it is not surprising some migrating owls do not reach suitable coniferous forest habitats after a long nocturnal flight. Flammulated Owls outside their normal range have only been reported in fall. Sutton (1960) reported a single owl from Lubbock, Texas in early November 1950 and Woolfenden (1970) reported one collected in November 1953 from Shelby Co., Alabama. These rather late records outside the usual migratory range may indicate some birds become disoriented on long autumnal migratory flights.

The reasons for the possible shift in migratory habitat are probably complex, but seasonal and habitat differences in food availability are probably important proximal factors.

All contemporary authors agree that the Flammulated Owl is exclusively insectivorous (Earhart and Johnson 1970, Ross 1969, Johnson 1965, Marshall 1939) and feeds by aerial hawking and picking insects in trees and on the ground. Ross (1969) found most of the arthropods he examined from 46 Flammulated Owl stomachs to be 15 mm or more in length. Our fall insect samples also had a preponderance of large insects that were within the size range of known foods of this owl and consisted of moths which are a common food type for this bird. Our insect data probably are an accurate reflection of the food base available to migrating owls.

The fact that Flammulated Owls seemingly migrate northward at lower elevations each spring correlates with the absence of an ample supply of insect food in the coniferous forest at this time. By the time birds arrive on the breeding grounds in the coniferous forest an ample supply of insects is present. If the birds delayed migration until food became abundant in the coniferous forest, they would likely arrive on the breeding grounds later and consequently initiate nesting later than is now possible. Perrins (1970) has pointed out a number of reasons why breeding as early as is possible is advantageous. Data to support this hypothesis are meager, however, except for the lack of spring records at the Arizona trapping site. Table 2 indicates at least a portion of the birds reach the coniferous forest as early as owls were captured on migration in New Mexico.

Most naturalists know that the time to visit the Southwest for maximum numbers and diversity of insects is in late August and September. This is not only true in the ponderosa pine forest (this study) but also in communities at lower elevations.

Is there a dramatic difference in insect abundance in the fall between ponderosa pine forest and habitats at lower elevations? It is our impression that there are more nocturnal insects at lower elevations in the fall and that this difference is also reflected in biomass as the very large Sphinx moths (Sphingidae) emerge in numbers in the fall at lower elevations in a pattern similar to that of the noctuids at higher elevations. Earhart and Johnson (1970) suggest that size dimorphism is minimal in insectivorous owls because they "feed on a food source which consists of items of relatively small size which exist as numerous fragments in the environment." Large moths are far more common in the fall than in the spring in the coniferous forest and if a large moth can be captured with only a slightly greater output of energy compared to energy expended for a small moth, then eating large moths is more economical.

Flammulated Owls may also be more efficient at finding and capturing prey items in their usual nesting habitat than in other habitats. This is a logical assumption if energy needs are high during the breeding season because of demanding reproductive functions such as courtship, egg laying, and parental care (Lack 1966). Thus, if large insects are found in adequate numbers at all elevations in the fall, the breeding habitat (coniferous forest) may offer the owl the most efficient opportunity for exploiting the food resource, and other habitats may be used only as a secondary choice, if coniferous forests are not reached during migration. We can find no factors (moisture, food, temperature, possible competition) which suggest these owls are forced to avoid migrating each fall through areas below their normal breeding habitat.

This explanation then allows us to reason that the lower temperatures (Figs. 4, 6) in the autumnal migrating habitat which may cause an increase in energy use are off-set by a higher level of energy intake. This higher level of energy intake may also allow these birds to fly from one mountain range to the next without stops in the intervening lowlands.

SUMMARY

Captures of Flammulated Owls in mist nets from one site each in New Mexico and Arizona for periods of 7 and 5 years form the basis for this report. Owls were captured only in the spring at the New Mexico site at a lower elevation than the Arizona site where owls were only captured in the fall. Insects sampled in the ponderosa pine forest site in Arizona show that large moths are much more abundant in the fall than in the spring. The owls appear to select different migratory habitats in fall than spring. The major reason for the habitat shift appears to be an ample supply of large, nocturnal insects at higher elevations in the fall allowing the bird to efficiently exploit a migratory habitat similar to its breeding habitat.

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