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Avifauna of Kohala Mountain, Hawai'i

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## ABSTRACT

Censuses were conducted from 1970-1972 in the Kohala Mountain Forest, Hawai'i. Native passerines were the most commonly encountered birds, with the nectar guild of the Drepanididae having the greatest numbers of recorded individuals and being the most consistently detected birds. A number of species, known to have occurred historically in the forest, were not found during the study; however, four endangered species (koloa, 'io, Hawaii Creeper, nuku-pu'u) were recorded during count periods. The nuku-pu'u has not been reported previously from the island of Hawai'i.

Species composition was constant in the forest throughout the year. However, the nectarivorous species in the principal study area did undergo significant changes in numbers over the annual cycle. The number of nectarivorous birds recorded/hour of censusing did not change significantly in the principal study site over the annual cycle. Breeding periods, as determined from active nests and census data, were found to lengthen somewhat the presently known breeding seasons of some species in other areas of Hawaii.

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## AVIFAUNA OF KOHALA MOUNTAIN, HAWAI'I

The Kohala Mountain Forest remains one of the least known areas in the Hawaiian archipelago. A wide variety of avian species were found there during the late 1800's (Rothschild 1893-1900, Wilson and Evans 1890-1899). Palmer (in Rothschild 1893-1900:58) collected one of the few specimens of the 'ula-'ai-hawane (Ciridops anna) and Perkins (1901) reported this forest to be one of the last strongholds of the 'o'u (Psittirostra psittacea) on Hawai'i. Since 1900 there has been little ornithological work done in this region; Pratt (1967) recorded 5 native bird species in the southernmost part of the forest, but Donaghho (1971) failed to find any native birds in an expedition along the northern slope of the mountain. Berger (1975) and van Riper (1973, 1974, 1976, 1978a) reported on open-habitat birds, most of which were introduced species.

Because so little suitable habitat remains in the islands for Hawai'i's endemic birds, it is imperative to document extant forest areas which contain threatened or endangered species. From 1969-1972 I conducted censuses and recorded the breeding behavior of birds in Kohala Mountain Forest, attempting to: (1) define composition of the present avifauna; (2) measure uniformity of species composition throughout the forest; (3) quantify relative population numbers of each species; and (4) delimit aspects of the breeding seasons.

## METHODS

Study area.— The Kohala Mountain Forest is a mesic ecosystem with a mixed canopy of 'ohi'a (Metrosideros collina) and 'olapa (Cheirodendron

trigynum) trees, underlain by tree ferns (Cibotium spp.) and other subcanopy tree species of which Pelea ssp. are the most common. The vegetation of this area is most similar to that of East and West Maui, being different from any other forest on the island of Hawai'i (Rock 1913). The paucity of field work in this area has been largely due to the rugged terrain. The forest is bounded on 2 sides by the precipitous canyons of Honokane on the west and Waipio Valley on the east, and by sheer sea cliffs to the north. Only limited access is available from the south through private ranch lands.

The principal study area was a 0.25 km<sup>2</sup> quadrat at 1100 m elevation between Puu Laelae and Kohakohau Gulch (Fig. 1). Comparative census locations were the Kehena Ditch Trail, Eke, and Kawainui Stream area. In pasture areas surrounding the forest, numerous incidental sightings were noted.

Techniques.--Breeding observations were made throughout the 3 years of the study. During 1971 and 1972, 222 hours were spent censusing during 47 daily-count periods. I made most observations during the peak breeding season (February to May); however, censuses were also undertaken in an early, late, and a nonbreeding period (January, July, and November, respectively). Strip transect counts were conducted (Emlen 1971), however, unlike Emlen's technique the perpendicular distance of the bird from the observer's path of travel was not recorded.

A total of 38 daily counts was made in the principal study area in which 178 h were spent censusing. The counts were from 07:00 through 12:00 and conducted at a slow uninterrupted pace. Count periods averaged 4.7 hours, but were of unequal length because of variable weather conditions. All birds were recorded as either an aural or visual

detection, and age and sex were noted whenever possible. In order to minimize double registrations the time, location and direction of flight were recorded. No "squeaking" or other sounds were used to lure birds.

On alternate months during the peak breeding season, comparative counts were conducted in habitat of the Kohala Mountain Forest which was similar to that of the principal study area. A total of 44 hours was spent during 9 days of comparative censusing, 3 each at the Kehena Ditch, Eke, and Kawainui Stream. These counts were conducted on the day following a census in the principal study area, under similar weather conditions, and during the same time period as the previous day's census.

The numbers of each species encountered per hour of censusing were used to describe abundance levels (Rotenberry and Wiens 1974). These data were then used to define:

$$\text{relative abundance of species } i = N_i/A$$

where  $N_i$  = total number of individuals of the  $i$ th species recorded and  $A$  = total number of the most abundant species; and

$$\text{frequency of species } i = S_i/S_t$$

where  $S_i$  = number of count periods in which the  $i$ th species was observed and  $S_t$  = total number of counts; and

$$\text{incidence of species } i = N_i/S_i.$$

All statistical analyses were computed on a Burroughs 6700 using SPSS programs (Nie et al 1975). Where data were not normally distributed, transformations were used before application of statistical tests. The level of statistical significance was considered to be 0.05.

## RESULTS AND DISCUSSION

Species distribution and abundance.--A total of 13 bird species was recorded during censuses in the Kohala Mountain Forest, while 16 other species were noted during incidental observations on the mountain. Native species predominated in the forest area (Table 1), while introduced species were more common in the pasture land and introduced forests at lower elevations.

Native species.--The native raptors preferred open pasture habitat to that of the closed-canopy forest. Numerous incidental sightings of the 'io and pueo were made outside of the forest. The 'io was most frequently observed soaring over the deep valleys on the northern and northeastern edges of the forest while the pueo was most common over pasture lands. Because of releases by the Hawai'i Division of Fish and Game, the koloa has recently been returned to the Kohala Mountain Forest. The greatest concentration of koloa are presently in the Kahua Ranch (the principal Fish and Game release site), scattered throughout the smaller cattle watering holes up to the boundary of the forest near the Kehena Ditch. One pair was observed in the Hamakua Ditch during incidental sighting periods throughout 1971, but no young were seen.

The most frequently observed group of native birds during censusing was the passerines, of which the endemic Drepanididae were the most common. The 'apapane and 'amakihi were found throughout most of the forest whereas the 'i'iwi was much more localized, being found only where extensive stands of larger 'ohi'a occurred. The endangered Hawaii Creeper was observed most often in the forest between Puu Eke and the Kehena Ditch trail, being quite rare to absent in other areas of the forest. The nuku-pu'u which heretofore has not been reported from the island of



erckelii), Indian Grey Francolin (Francolinus pondicerianus).

Absent species.--Noticeably absent from the forest were the Hawaiian Thrush (Phaeornis obscurus; see also van Riper and Scott 1979), and other less common endemic species such as the 'akepa (Loxops coccinea), 'akiapola'au and 'o'u. None of the native species which historically occurred in the forest, but are now believed to be extinct, were observed. Although I did not find evidence of breeding seabirds, Kepler et al (1979) recently suggested that colonies of Manx Shearwater (Puffinus puffinus newelli) may exist in the Kohala Mountain Forest. The Kaliji Pheasant (Lophura leucomelana) which has recently undergone a great range expansion on the island of Hawaii (Pratt 1975) has apparently not yet reached the Kohala Mountain Forest.

Uniformity of species composition.--In an effort to determine if bird species were uniformly distributed over widespread but similar areas in the Kohala Mountain Forest, comparative counts were undertaken. The analyses, which were conducted on the numbers of species encountered during one day's census in the principal study area versus the number of species encountered the following day in a comparative location, showed that in all cases no significant difference in species composition existed between outlying areas and the principal study site (Eke:  $\chi^2 = 3.54$ ,  $df = 8$ ,  $P = .90$ ; Kawainui Stream:  $\chi^2 = 1.35$ ,  $df = 6$ ,  $P = .97$ ; Kehena Ditch Trail:  $\chi^2 = 1.75$ ,  $df = 6$ ,  $P = .94$ ). These results suggest that bird species composition is relatively uniform over the extant Kohala Mountain Forest area.

Species abundance.--Overall numbers of most bird species in the Kohala Mountain Forest were higher than comparable studies reported from Molokai (Scott et. al. 1977) and Oahu (Shallenberger 1978), but lower than

other forest areas on the island of Hawai'i (Conant 1981b, Scott pers. comm.). The intermediate numbers of birds recorded during this study may reflect the lowered carrying capacity of this small remnant of now nearly isolated forest. I found that the 'apapane was the most abundant bird in the Kohala Mountain Forest, followed closely by the Japanese White-eye and then the 'amakihi (Table 1). Not only was the 'apapane the most abundant bird over the annual cycle, but it also had the most months when it had the highest relative abundance (Table 2). However, the 'amakihi was the most consistently encountered species during count periods in the forest (species frequency = 0.98). The lower species frequency of the 'i'iwi was primarily a result of its absence during the nonbreeding censuses. However, even when present the 'i'iwi's relatively low species incidence value indicates that the bird was never commonly encountered.

I analyzed data from all counts conducted within the principal study area and found that numbers of 'apapane, 'amakihi, and 'i'iwi changed significantly over the annual cycle (analysis of variance;  $P \leq .05$ ; Fig. 2). These three species are all nectarivorous, and their movements in and out of the study area might well be related to changes in local nectar availability as Baldwin (1953) showed was true for another 'o'hia forest on Hawaii. Of the non-nectarivorous species which were encountered frequently enough to determine if population movements occurred, none showed significant changes in the number of birds recorded/hour over the annual cycle (Analysis of Variance;  $P \geq .05$ ; Fig. 3). These birds tended to be either insectivorous ('elepaio) or omnivorous (Red-billed Leiothrix, Japanese White-eye).

Breeding seasons.--On Kohala Mountain, I found that the native birds tended to nest earlier in the year than did the introduced species (Table

3). The 'amakihi showed a more contracted breeding period than has been reported for the population in the dry forest on Mauna Kea (Berger 1972, van Riper 1978b), but had a similar breeding period to the 'amakihi from the wet forests of Kauai (Eddinger 1970) and Hawai'i (Baldwin 1953). The 'apapane and 'i'iwi had breeding periods similar to those reported from Kauai by Eddinger (1970). I found that the 'elepaio had a slightly longer breeding season in the Kohala Mountain Forest than Eddinger (in Berger 1972) found for the bird on Kauai, and Conant (1977) found on Oahu.

The breeding seasons of all native species coincided well with immature birds observed during censuses (Table 4). 'Apapane juveniles were recorded over the longest period, but because it is not yet known the length of time that each of these species retain their juvenile plumage, the same birds may have been observed over an extended time period.

The introduced species on Kohala Mountain all exhibited breeding seasons similar to the limits set for each bird by previous workers. The Japanese White-eye breeding season was within the breeding period of an Oahu population (Guest 1973), but the Red-billed Leiothrix breeding period was later in the year than was given for this bird by Fisher and Baldwin (1947). The Common Mynah nests that I found were in the earlier part of the breeding season which Eddinger (1967) outlined for an Oahu population. All of the House Finch nests that I found during this study occurred during the same months that other nests have been reported from Hawai'i (van Riper 1976) and from Oahu (Hirai 1975). Breeding seasons for the other introduced birds found on Kohala Mountain have not yet been determined in Hawai'i.

## MANAGEMENT IMPLICATIONS

Analysis of breeding and census data from the Kohala Mountain Forest show that, while the present day avifauna is not as diverse as historical records indicate it once was, 9 native species still exist on the mountain. Four of the species (koloa, 'io, Hawaii Creeper, nuku-pu'u) identified during count periods are classified by the U.S. Fish and Wildlife Services as endangered (USDI 1966). Recent work on a number of endangered species in Hawaii has indicated that genetic fitness may be a problem in rarer species (Temple, pers. comm.; van Riper 1980; Walker, 1974). It is therefore imperative that diverse gene pools be preserved in order to insure the genetic integrity of the extant species.

Although the forest is much reduced from its original size, it does fit a number of criteria Diamond and May (1976) deem essential for a natural reserve. The forest is nearly circular in shape, which maximizes the area-to-perimeter ratio thus minimizing dispersal distances within the forest. A circular configuration also avoids a penninsular effect in which dispersal rate to outlying parts would be so low as to cause numerous local extinctions thereby diminishing the reserve's effective area. Secondly, the Kohala Mountain Forest has numerous easily accessible stepping stones of forest patches above Honokaa, which lead to the large pristine 'ohi'a forest on the northeastern flank of Mauna Kea. Over time, these forest patches would enable birds to emigrate into the Kohala Mountain Forest area. Finally, because of Hawai'i's disharmonic fauna, many forest areas (of which Kohala is one) are well below the carrying capacities of similar sized islands outlined by Diamond and May (1976) in their review of natural reserves.

The Kohala Mountain Forest area would therefore seem to lend itself

well to the reintroduction of certain species which have been extirpated from this region. Translocations of avian species have been carried out quite successfully in New Zealand (Morris 1977, Best 1980), but other than the Anseriformes, little attention has been given to this technique in Hawaii. The Hawaiian Thrush, which was once quite abundant (Perkins 1903) but has since been lost from the Kohala Mountain Forest, would seem to be a prime candidate for reintroduction. The bird still exists in high numbers on the south and southeastern part of the island (van Riper and Scott 1979), and could be easily captured and transported to the Kohala Mountain Forest.

The Kohala Mountain Forest remains today one of the more inaccessible areas on the main Hawaiian Islands, and because of this can be preserved in its present condition. Barring the introduction of new avian predators, more successful competitors, or an epizootic, the area will remain a refuge for Hawaiian birds. Therefore, steps need to be taken so as to ensure the preservation of this small, but important native Hawaiian refugium.

#### MANAGEMENT RECOMMENDATIONS

Although the Kohala Mountain Forest is not National Park Service land, it is an island of vegetation and the problems associated with extinctions are applicable to the many islands of vegetation in Hawaii Volcanoes National Park. It is recommended that:

1. National Park Service personnel keep abreast of changes in the avifaunal composition of Kohala Mountain and see if any of the changes would be applicable to changes that occur within Hawaii

Volcanoes National Park.

2. If a transplant of the Hawaiian Thrush ever does occur into the Kohala Mountain Forest area from the Mauna Loa forests, scientist and Resource Management staff at Hawaii Volcanoes National Park should become involved in the effort.

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TABLE 1  
Birds recorded in the Kohala Mountain Forest during 47 count periods from 1970-1972

Species	No. Counts in which Species was Observed	Total Birds Recorded		Relative Abundance	Species Frequency	Species Incidence
		No. Aural	No. Visual			
koloa ( <u>Anas wyvilliana</u> )	2	--	4	0.004	0.04	2.00
'io ( <u>Buteo solitarius</u> )	2	--	2	0.002	0.04	1.00
pueo ( <u>Asio flammeus</u> )	2	--	2	0.002	0.04	1.00
Red-billed Leiothrix* ( <u>Leiothrix lutea</u> )	34	191	23	0.230	0.72	6.29
Melodious Laughing Thrush* ( <u>Garrulax canorus</u> )	1	1	--	0.001	0.02	1.00
'elepaio ( <u>Chasiempis sandwichensis</u> )	44	160	172	0.360	0.94	7.55
Japanese White-eye* ( <u>Zosterops japonicus</u> )	42	613	229	0.910	0.89	20.05
House Finch* ( <u>Carpodacus mexicanus</u> )	6	22	11	0.040	0.13	5.50
'amakihi ( <u>Loxops virens</u> )	46	421	280	0.760	0.98	15.24
Hawaii Creeper ( <u>Loxops maculata</u> )	7	1	10	0.010	0.15	1.57
nuku-pu'u ( <u>Hemignathus lucidus</u> )	1	--	1	0.001	0.02	1.00
'apapane ( <u>Himatione sanguinea</u> )	45	800	323	1.000	0.96	24.96
'i'iwi ( <u>Vestiaria coccinea</u> )	33	188	93	0.300	0.70	8.52

\* Denotes introduced species

TABLE 2

Monthly relative abundance of bird species as determined from 47 count periods conducted from 1970-1972 in the Kohala Mountain Forest, Hawai'i

Species (total counted)	Month (total census hours)						
	January (172.5)	February (150.5)	March (375.5)	April (79.0)	May (215.0)	July (101.0)	November (21.0)
'amakihi (701)	1.00 (228)*	.71 (214)	.52 (157)	.37 (31)	.34 (59)	.31 (8)	.17 (4)
'apapane (1,123)	.75 (170)	1.00 (302)	.53 (162)	1.00 (83)	.96 (166)	.65 (17)	1.00 (23)
'elepaio (332)	.19 (44)	.22 (66)	.36 (109)	.28 (23)	.35 (60)	1.00 (26)	.17 (4)
'i'iwi (281)	.13 (30)	.36 (110)	.29 (89)	.23 (19)	.18 (31)	.08 (2)	-- (0)
Red-billed Leiothrix (214)	.06 (14)	.07 (21)	.26 (78)	.42 (35)	.25 (43)	.77 (20)	.13 (3)
Japanese White-eye (842)	.37 (85)	.67 (202)	1.00 (304)	.75 (62)	1.00 (173)	.58 (15)	-- (0)

( )\* = total birds counted that month

TABLE 3

Number of active nests found from 1969-1972 on Kohala Mountain, Hawai'i.\*

SPECIES /	MONTHS											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
'amakihi	4	10	14	11	8	3						
'apapane		1	3	4	2							
'i'iwi		2	5	4	1							
'elepaio		1	1	2	6	4	3	1				
Red-billed Leiothrix				1	3	3	1					
Japanese White-eye				1	3	2	1	1				
Ricebird				1	1	1				1	1	1
Common Mynah			2	4	3							
Northern Cardinal		4	4	5	2	2						
Skylark			1	1	1							
House Finch				1	4	10	7					
House Sparrow			2	4	2							

\* A nest can occupy more than a one month period.

TABLE 4

Mean percentage of juvenile birds recorded during 1,115 hours of censusing from 1970-1972 in the Kohala Mountain Forest, Hawai'i

Species (total birds counted)	Month (total hours censused)						
	January (172.5)	February (150.5)	March (375.5)	April (79.0)	May (215.0)	July (101.0)	November (21.0)
'amakihi (701)	2.0 (102)*	0.0 (67)	0.0 (59)	0.0 (11)	10.0 (31)	0 (8)	0 (2)
'apapane (1,123)	7.0 (69)	3.0 (93)	0.0 (57)	14.0 (28)	59.0 (46)	87.0 (15)	7.0 (15)
'elepaio (332)	3.0 (36)	0 (36)	0 (42)	0 (9)	16.0 (25)	5.0 (20)	75.0 (4)
'i'iwi (281)	53.0 (19)	0 (39)	0 (21)	29.0 (7)	50.0 (6)	100.0 (1)	0 (0)

( )\* = total visual observations each month

## Figure 1.

Map of a portion of Kohala Mountain, Hawai'i, showing the study area (dark hashing) and locations where comparative censuses were conducted. Elevation contours are in meters, double dashed lines are jeep roads, and light hashing denotes pasture land adjacent to the forest.

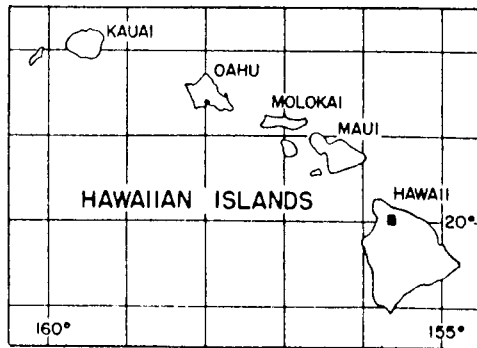
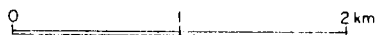
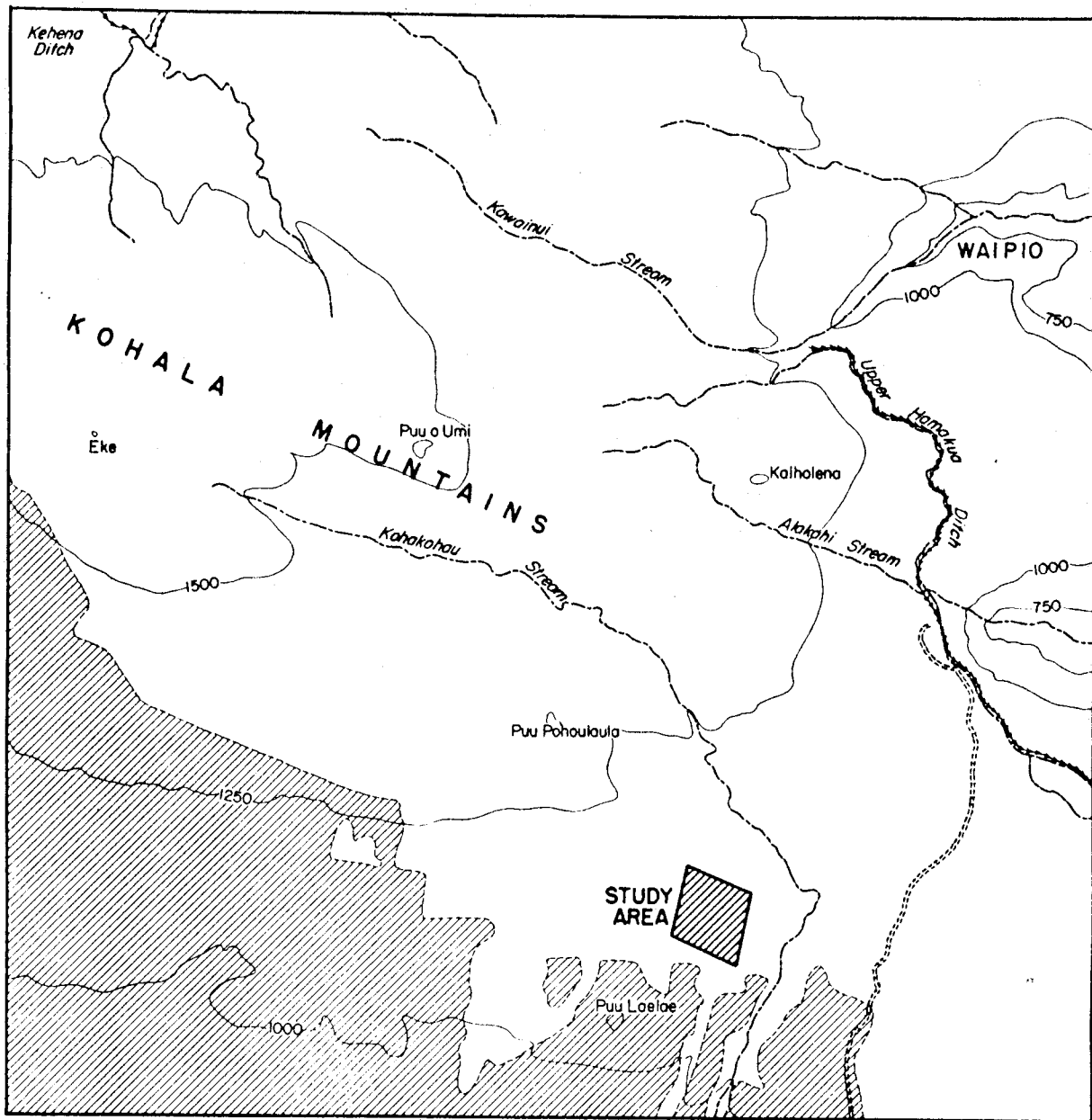
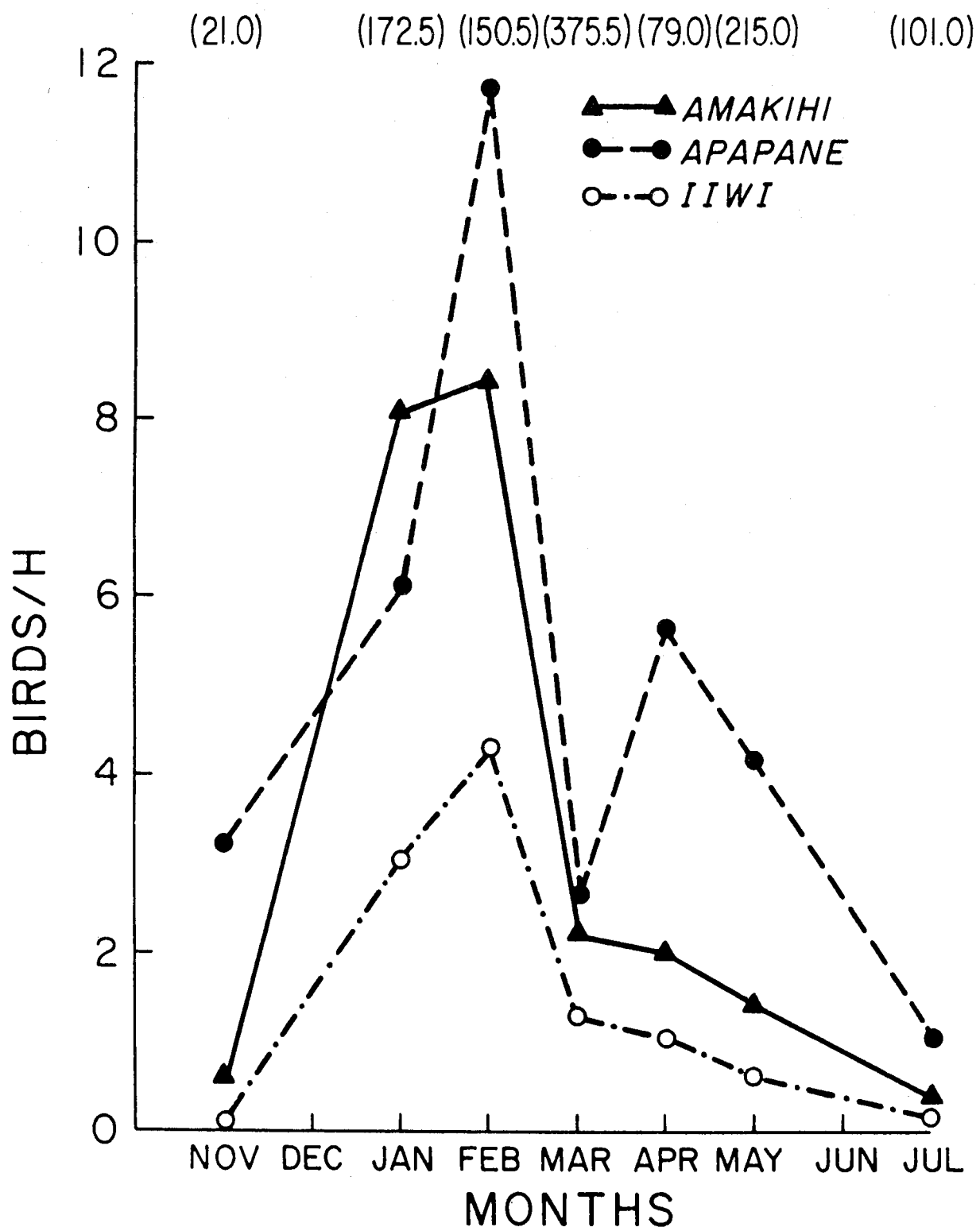




Figure 2.

Average monthly numbers of nectarivorous birds recorded during counts from 1970-1972 in the Kohala Mountain Forest, Hawai'i. Numbers at the top in parentheses are sample sizes.



## Figure 3.

Average monthly numbers of the common non-nectarivorous passerine species recorded during counts from 1970-1972 in the Kohala Mountain Forest, Hawai'i. Numbers at the top in parentheses are sample sizes.

