A SURVEY OF THE BIRDS OF KAUAI, HAWAII

By

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and

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INTRODUCTION

THE ASCERTAINMENT during the summer of this survey, in 1960, that all of the rarest native birds of Kauai—the puaiohi (small Kauai thrush), Kauai oo, Kauai akialoa, nukupuu, and ou—are still in existence, even though some had been considered to be probably extinct and others were of uncertain status, has created much international interest among ornithologists and conservationists. Delacour wrote (Greenway, 1958, Foreword): ". . . we still know nothing of the condition and status of the rarer birds of the Island of Kauai. . . ." Our new knowledge of these birds now places a real responsibility on the State of Hawaii, the United States, and all interested people to take adequate steps to assure their continued existence. It is hoped that this paper will serve both as a standard ornithological contribution and as a documented plea for the preservation of native conditions in the only remaining major virgin area of Kauai, an area unique in many ways in all of Hawaii. Recommendations toward this goal are given at the end of the paper. Some measures have been taken by the State of Hawaii to safeguard the preservation of the critical area, but the establishment of a more inviolate wilderness area for future generations is still necessary.

Near the end of the nineteenth century impressive volumes on Hawaiian birds were published by Wilson and Evans (1890-1899) and by Rothschild (1893-1900). Perkins (1903) made the first outstanding scientific studies of the Drepaniidae. Since that time a few comprehensive works on Hawaiian birds have appeared, the most notable one being by Munro (1944), and later the more up-to-date summary by Peterson (1961). Bryan's check list (1958) contains the most complete listing of occurrences of all birds, whether native or introduced.

Nevertheless, no adequate analysis of all of the birds of a single main Hawaiian island has yet been published. It is possible to compile a list of birds on any one island from available sources, but these would provide nothing on the distribution or abundance of the species beyond brief, scattered notes, despite the fact that each of the five major islands shows great diversity of habitats and ranges of different birds. Little attempt has been made to estimate the abundance of each species or to compare the abundance of native birds to that of introduced birds, although these matters should be of much

interest in Hawaii, where there has been justifiably great concern over the reduction or extinction of native birds and the role that introduced species may have played in such reduction.

The devastating effects of introduced plants and grazing mammals on the native flora of Hawaii, and hence on virtually all bird habitats, have long been recognized. However, we know of no special study correlating present distribution of birds with conditions variably changed by introduced plants and mammals. The relation of some introduced birds to inhabited or agricultural areas is often noticed, but the much greater distribution of some of these species has received less attention. Game species tend to be more carefully studied, and Schwartz and Schwartz (1949) give more detailed studies of these species than one can find for most others.

It is hoped that the present study of the birds of Kauai will satisfy some of the above deficiencies in our knowledge of Hawaiian birds. It must be recognized, however, that two observers, even though they spend almost all of their time for two and one-half months observing birds, cannot adequately survey the avifauna of an often mountainous and overgrown island of some 550 square miles. To do this would require a year-round study since there is altitudinal migration of some resident birds as well as the coming and going of migratory waterfowl and shore birds. A portion of the results of the present study, essentially a list of the rarer native forest birds that were seen, has been published (Richardson and Bowles, 1961).

Methods

The main object of our whole study was to observe native Kauai forest birds. Dozens of trips were made on the island, both by car and on foot. The most successful of these were three separate weeks spent in or near the Alakai Swamp forest area. These trips and the areas visited are indicated on Figure 1. Many lowland routes on the map were repeatedly traversed by car, but a number of the major mountain areas or canyons were accessible only by hiking, often involving considerable back-packing through rough, overgrown country. Trails, when existent, are likely to be faint and unmarked. Observation of birds is made difficult by the dense forest and by frequent rains. Hence, these areas were quite inadequately studied.

From what we could see and learn, however, the Alakai Swamp region constitutes the single remaining area for the greatest variety of native forest birds. We did not climb the great ridges between the Wainiha, Lumahai, and Hanalei Rivers. They are generally too precipitous for high stands of native forest, but they appear virgin and may support various native birds. The same may be true of the highest Makaleha Mountains in northeast Kauai, and of the upper ends of the great Hanapepe and Olokele Canyons.

Less time was spent in observing in the agricultural lowlands than in the mountains so that data obtained on some introduced birds are all too meager. For instance, we did not see Brazilian cardinals (*Paroaria cucullata*), although they have been reliably reported from around Lihue. Likewise, we apparently did not spend sufficient time in the disturbed native forest, as around Kokee, to see the varied tit (*Parus varius*) known to occur there. On the other hand, both these species may be reduced in numbers, which could account for our not seeing them.

After every trip each of us made an estimate of the number of individuals of each bird species we had seen that day. In general, the figures given in the report are averages of our estimates. Most estimates were made from observations along trails where it was relatively easy to judge distances. Estimates were obtained from some of the same regions in both early and late summer giving some idea of seasonal variation in distribution.

A limited number of birds was collected, including some introduced species and one or two specimens each of several of the rarer native species. In general it was felt that the other species were unmistakable from observation alone. The skins of the rarer species, such as the oo, puaiohi, and akialoa, have been placed in the collections of the Bernice P. Bishop Museum.

Plants that characterized habitats or that were used by birds, particularly for food, were regularly collected and each week many of them were sent to the University of Hawaii for identification. Plant and animal remains from stomachs of birds collected were saved for identification.

Acknowledgments

We should like primarily to thank the McInerny Foundation and the Samuel N. and Mary Castle Foundation, both of Honolulu, for the financial support which made this study possible. Bernice P. Bishop Museum has been our chief sponsor. Its past director, Dr. Alexander Spoehr, and present director, Dr. Roland W. Force, and staff have been extremely helpful. The Thomas Burke Memorial Washington State Museum of the University of Washington was also a key sponsor in allowing the senior author freedom to undertake the study and prepare its results. The Hawaii Division of Fish and Game was most cooperative and helpful.

The individuals who, above all others, gave continued encouragement to the project through their interest, efforts, or actual participation in the field were George C. Munro, Paul Breese, Valdemar Knudsen, and David Woodside. We are also much indebted to Charles Lamoureux, plant taxonomist of the University of Hawaii, for identifying plants we sent to him from Kauai. Many individuals and organizations on Kauai helped in such ways as permitting us to study on their lands, allowing the use of cabins, or actually serving as

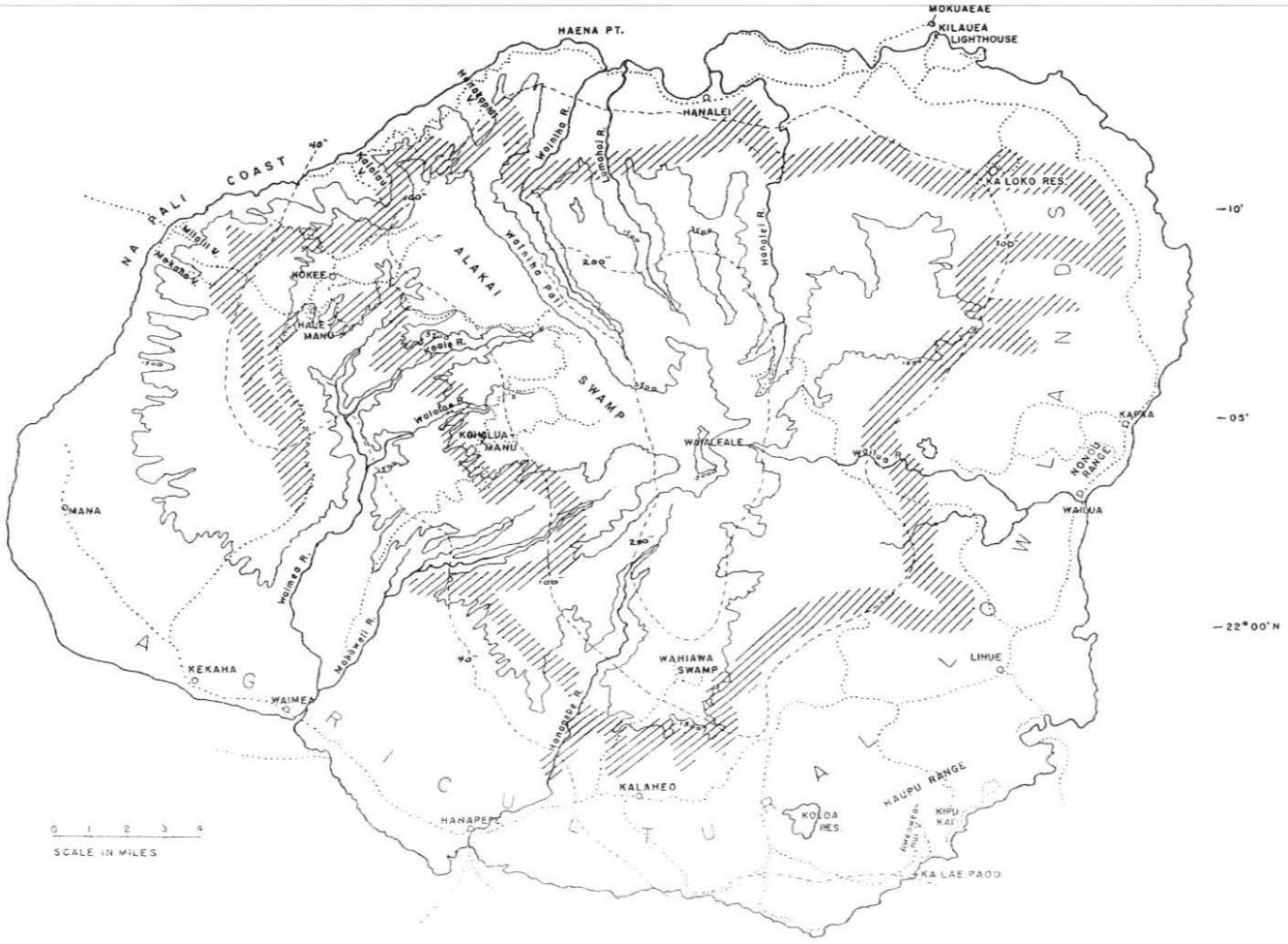
guides. Among these should be mentioned the Division of Forestry under Albert Duvall on Kauai, the United States Geological Survey, the Lihue Plantation, Jack Waterhouse, Holbrook Gooddale, Ralph Artaho, and Selwyn Robinson. Lastly, our thanks are extended to the Department of Zoology of the University of Washington for its help, especially in the preparation of this paper.

BIRD HABITATS ON KAUAI

To DESCRIBE ADEQUATELY the bird habitats and their distribution on Kauai would demand extensive study and detailed mapping, but it is possible to outline the habitats here and then give the major characteristics and distribution of some. Few of the biotic communities of North America are known to Hawaii. Evergreen forests, for instance, in Hawaii lack any native coniferous species, and arid regions show parallels with other arid regions only in scarcity of rain and vegetation, or presence of introduced xerophytes.

I. Water
   A. Sea
      1. Exposed windward shores on northeast and east with few protected bays.
      2. Relatively quiet waters on south and west, but generally no bays.
   B. Fresh
      1. Reservoirs. Fairly numerous in eastern lowland.
      2. River lagoons. Often sizable fresh-water bodies by coast.
      3. Streams. Actively flowing in mountains and lower canyons (Fig. 2).

II. Land
   A. Forest
      1. Native mixed ohia forest. Characteristic of high, wet areas such as Alakai Swamp.
      2. Native mixed koa forest. Restricted to high, relatively dry mountain area chiefly around Kokee and high lands to the south and east.
      3. Introduced forest. Many types such as of *Albizzia* in wet eastern canyons, *Eucalyptus* and *Grevillea* on scattered slopes, and guava and Java plums especially in northwest coastal canyons.
   B. Scrub
      1. Native scrub. Some arid western canyons and parts of northwest beach cliffs.


MOKUAEAE
KILAUEA LIGHTHOUSE
HAENA PT.
HANALEI
NA PALI COAST
KA LOKO RES.
ALAKAI SWAMP
KOKEE
HALE MANU
KOHALUA MANU
WAIALEALE
KAPAA
WAILUA
NONOU RANGE
MANA
KEKAHA
WAIMEA
WAHIAWA SWAMP
LIHUE
KALAHEO
HANAPEPE
HAUPU RANGE
KOLOA RES.
KIPU KAI
KALAE PADD
AGRICULTURAL LANDS
0 1 2 3 4
SCALE IN MILES
-10'
-05'
-22°00'N

2. Introduced scrub. Small to extensive growths as of lantana, blackberries, Indian rhododendron and koa haole occurring over most of island except, for example, in some high, forested areas and arid western regions.

C. Marsh

1. Scattered small areas in mountains (as in Alakai Swamp area) or lowlands. Flooded rice fields may be considered as artificial marshes.

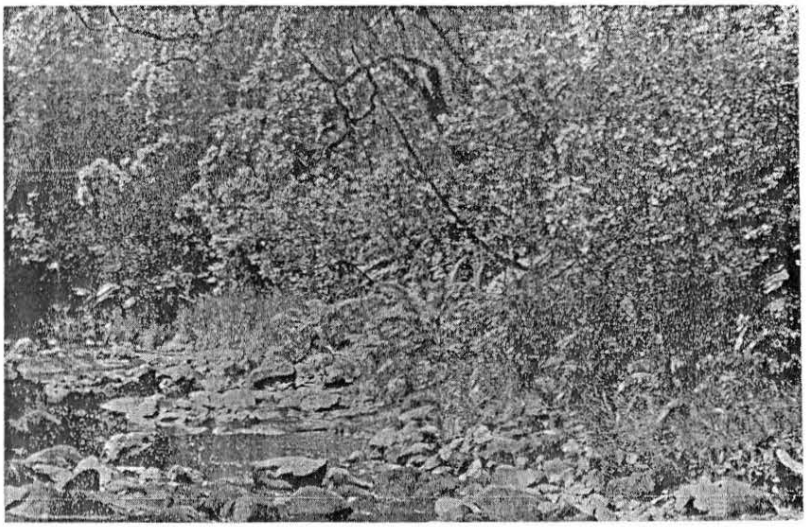


FIGURE 2.—Koaie River at about 3,750 feet in virgin mixed ohia forest. Hawaiian ducks passed along this stream as did golden plover. Ricebirds entered the area along the stream feeding on grass seeds at its edges.

D. Crops or plantings

1. Sugar cane.
2. Pineapple.
3. Pasture.
4. Gardens and house plantings.

E. Cliffs

1. Extensive palis or cliffs along west coast especially and along inland canyons (Fig. 3).

F. Beaches—Coastal. Generally lacking on streams or reservoirs.

FIGURE 1.—Map of Kauai. Trips taken by the authors (including the starts and ends of sea trips) are shown with dotted lines; selected contours with solid lines; and selected isohyets with broken lines. Certain forest cabins are indicated by an ×. The approximate lower edge of Kauai's forested area, although often with various introduced plants, is shown by the band of parallel lines.

The extent and distribution of many of the above habitats is indicated on Figure 1, but a description of certain ones is important in relation to bird distribution.

Native Mixed Ohia Forest

This habitat held all of the native forest birds, some species being found there exclusively. Introduced birds were at a minimum in numbers and variety, but included the following: jungle fowl; white-eye; ricebird; and Chinese thrush. Other foreign species, including the mynah, lace-necked dove, hill robin, linnet, and cardinal, penetrate the edges of this habitat.

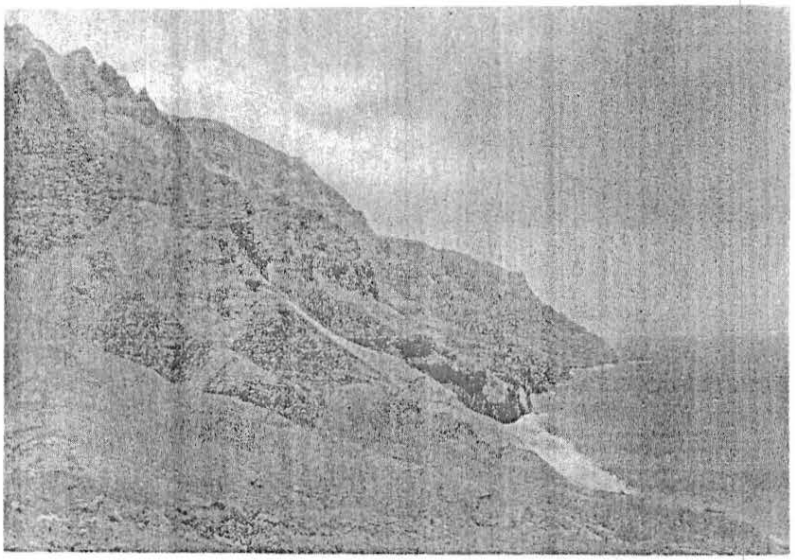


Figure 3.—Na Pali coast, including beach of Kalalau Valley, from the northeast. White-capped noddies nest in sea caves, such as those just beyond the beach, and white-tailed tropic birds in the high cliffs.

The vegetation of this forest type consists of dense to slightly scattered trees, generally under 30 feet high. Ohia (*Metrosideros collina*) is the dominant species, but others, especially lapalapa (*Cheirodendron kauaiense*), also occur (Figs. 4 and 5). The lower vegetation is profuse and of great variety. The large shrubs or small trees include several species of *Pelea,* several lobeliads, kanawao (*Broussaisia arguta*), tree ferns (*Cibotium* sp.), mountain naupaka (*Scaevola glabra*), and mamake (*Pipterus ruber*). Still lower vegetation includes such common species as pukeawe (*Styphelia tameiameiae*), peperomia (*Peperomia* sp.), uluhe (*Dicronopteris linearis*) and other ferns, and several grasses.

FIGURE 4.—Dense virgin ohia forest at about 4,250 feet some 2½ miles northeast of Kaholuamanu. A large-leafed lapalapa tree is visible in the center and a pukiawe bush at the lower right. Relatively few birds, native or introduced, were found in such dense, high-altitude ohia forest.

FIGURE 5.—Mixed ohia forest at 3,750 feet near Koaie River Cabin. Large ohia trees (to over 50 feet) and tree ferns are chiefly visible, but a great variety of native plants are present. The maximum number of native forest birds, including the oo in this immediate vicinity, were found in this habitat.

FIGURE 6.—Open, grazed area by the Waialae River Cabin at about 3,500 feet, with ohia trees at the sides and dark fire trees in the center background.

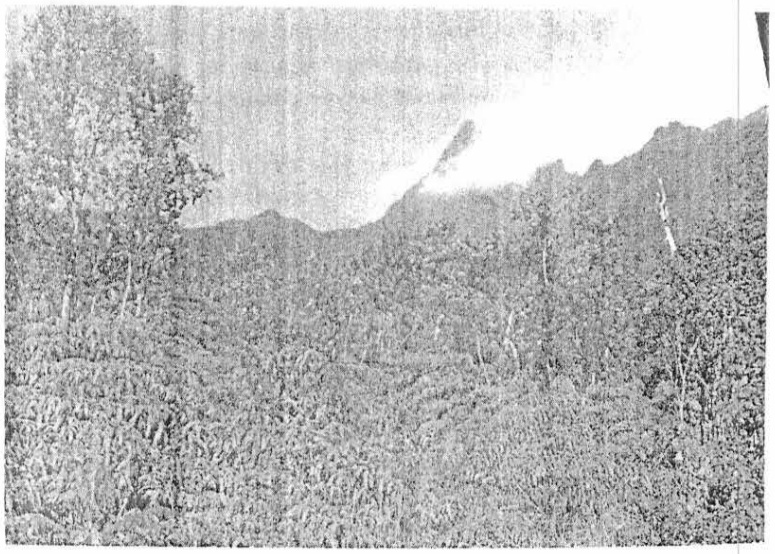


FIGURE 7.—Uluhe fern surrounding scattered ohia trees near upper North Fork of Wailua River at about 2,000 feet. The peak in the background is Pohakupili.

Although this mixed ohia forest represents an almost pure native flora, various introduced plants are invading its margins and a strong and continuing program will be necessary to preserve the native forest. The fire tree (*Myrica faya*), for example, was introduced in the upper Waialae Canyon in about 1940 and is spreading at an alarming rate (Fig. 6). This tree crowds out all native plants and, since nothing grows under it, creates the increasing dangers of rapid runoff. Groves of *Cryptomeria japonica* present similar dangers, although this species does not appear to spread itself. Blackberries are invading the native forest where cattle and horses graze, as around Kaholuamanu. In many parts of Kauai the native ohia forest, apparently opened up by grazing, is being rapidly choked out and replaced by thousands of acres of the uluhe fern (Fig. 7).

The large Alakai Swamp area, prominent on maps of Kauai, in reality is almost entirely covered with native mixed ohia forest. Most of the area has an average annual rainfall of only 100–150 inches. In the less-forested westernmost part, as one approaches Mount Waialeale, the annual rainfall jumps to over 400 inches (see Fig. 2).

Native Mixed Koa Forest

This extensive forest type contained large numbers of native and introduced birds. There were fewer species of the former, but more of the latter than in the ohia forest. The native forest birds found were the elepaio, apapane, iiwi, anianiau, amakihi, akikiki, and akepa; the introduced species were those listed for the ohia forest and for its margins. The white-eye was by far the most abundant species, but the apapane, although about half as common, still was abundant and second only to the white-eye.

The koa (*Acacia koa*) is the largest and most dominant tree of this forest, the biggest being over 50 feet high (Fig. 8). Ohia trees are scattered throughout most of the koa forest and they, too, acquire huge size. A few species of introduced trees are present, the karaka (*Corynocarpus laevigata*) having become widespread in regions. The native pukiawe is probably the most common species of the understory; but in many areas, various introduced species, such as the Himalayan blackberry (*Rubus*) and lantana (*Lantana camara*), are all too common.

Since its introduction in about 1940, the blackberry has rapidly spread along roads and trails and often back into the forest, choking out almost all other vegetation and undoubtedly preventing any tree reproduction (Fig. 9). Wild cattle roamed the koa forests for decades and were probably more responsible than horses, pigs, or other influences for opening the forest floor and thus making it vulnerable to invasion by such introduced species as blackberry or lantana.

FIGURE 8.—Koa forest near Halemanu. Much of the understory here is pukiawe. The rainfall in this region is approximately 50 inches a year and the elevation 3,250 feet.

FIGURE 9.—Ohia trees in foreground with extensive growth of blackberry filling valley beyond. This picture was taken near Kaholuamanu at some 3,500 feet.

Introduced Forest

There are extensive plantings or naturally reproducing areas of numerous foreign trees on Kauai, but in general these trees harbor no native and few introduced birds. Groves of huge *Albizzia moluccana,* such as that southwest of Ka Loko Reservoir, seemed to attract Chinese thrushes and the larger collared thrush. Elepaio were seen in Java plum trees (*Eugenia cumini*) in Hanakoa Valley where this tree has become common. The guava (*Psidium guajava*), forming low thickets or fair-sized trees, has taken over great areas, for instance in Kalalau and Hanakapiai Valleys (Fig. 10), and seems to be of little value to birds, although the fruit is eaten by white-eyes. The silky or silver oak (*Grevillea robusta*) is very widespread on the dry southwestern slopes of Kauai. Its use, if any, by birds was not determined.

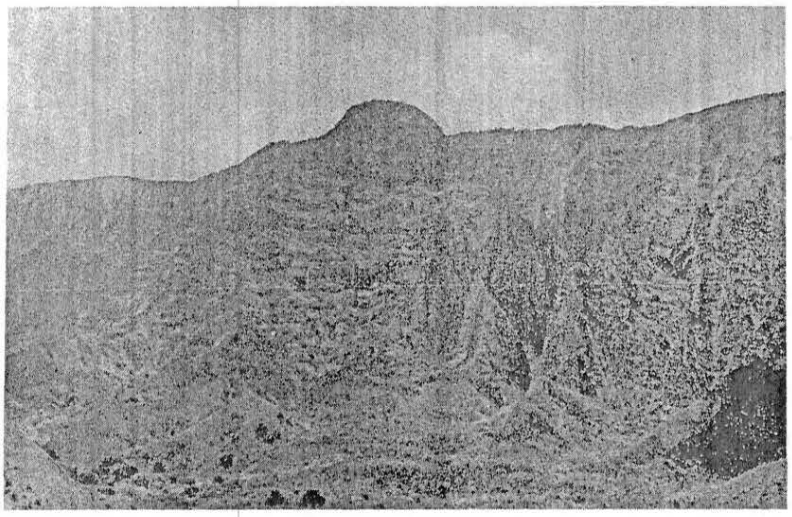


Figure 10.—Kalalau Valley with pali rising some 4,000 feet in background. The lower slopes and valley floor are covered with guava and other introduced plants (the dark spots are mango trees), and are devoid of native birds.

Native Scrub

Almost no native vegetation is to be found in the lowlands of Kauai; but in some isolated west-coast canyons, such as Makaha (Fig. 11), naio (*Myoporum sandwicense*) is abundant. The fruit of this shrub provides the main food of the chukar partridges. Another native bush—the beach naupaka (*Scaevola frutescens*)—forms low thickets in spots, chiefly on the north and northwest coasts (Fig. 12). Wedge-tailed shearwaters sometimes make use of this cover for their burrows.

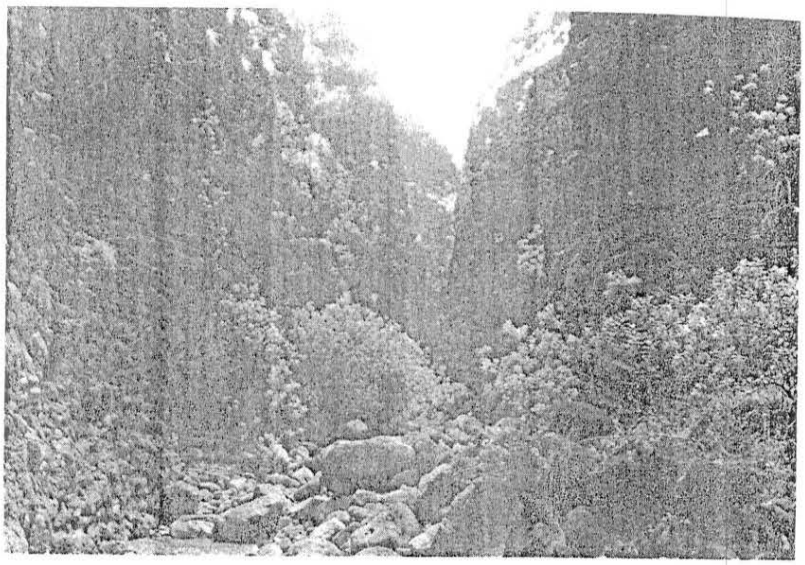


FIGURE 11.—Makaha Valley on the arid west end of Kauai. The fruits of the native shrub naio (*Myoporum*), plants of which are seen at the right, appeared to form the chief food of chukar partridges.

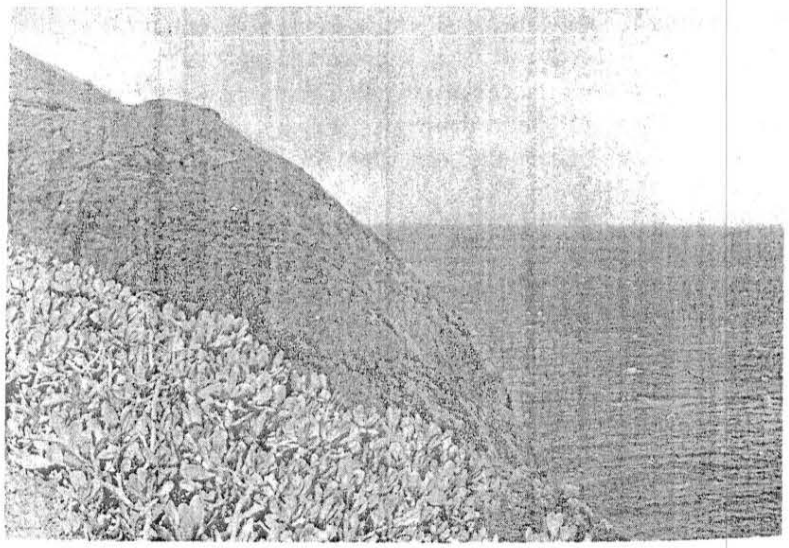


FIGURE 12.—The native beach naupaka (*Scaevola*) forms some thickets chiefly on the steep slopes of the Na Pali coast, as shown here, and the north coast of Kauai. A few wedge-tailed shearwaters nest under its cover.

Introduced Scrub

Many foreign species of shrubs or low trees are widespread on Kauai. Some, for example the blackberry or lantana, have been mentioned in connection with native forest. Of these two, the lantana has taken over many slopes, some of them very rocky and dry, as those around Kipu Kai, and far from forests. Various other imported species form dense, often nearly pure, stands. The Indian rhododendron (*Melastoma malabathricum*) has spread in dense stands in the region of Kilohana Crater and well up into neighboring mountain canyons. Koa haole (*Leucaena glauca*) forms particularly large stands on dry southern slopes where it is heavily grazed by cattle, but its seeds are apparently important to California quail. The kiawe or mesquite (*Prosopis chilensis*) is common along the dry southern coast of Kauai, where it forms large trees or low thickets. It is variously used by introduced birds, including the mockingbird, for food and cover.

Marsh

True marsh lands are few and quite restricted on Kauai. In the lowlands they are confined to small areas with nonnative aquatic plants bordering some reservoirs or river lagoons, and are used at times by coots, gallinules, stilts, night herons, and ducks. In the mountains, the Alakai Swamp area, shown on existing topographic maps as a region of at least 10 square miles between the elevation of 3,750 and 5,000 feet, is actually almost all native forest with only local marshy spots, as toward its southeast end. This swamp, although misnamed, is of the utmost ornithological importance because the dominant native mixed ohia forest of this region is the chief, and in some cases the only, remaining habitat of the rarest native birds of Kauai—the oo, puaiohi, akialoa, nukupuu, and ou.

The Wahiawa swamp, located at 2,100 feet in elevation some three miles north of Kalaheo, represents an unusual native marsh area, although less than a square mile in extent. Interesting plants, such as the insectivorous sundew (*Drosera*) and native tree lobeliads, abound; but birds were very scarce, at least on August 22, the day of our visit. Golden plover, which may originally have brought the sundew seeds from North America on their feet, occur in such native marsh areas but apparently few other birds.

Flooded rice fields, particularly extensive in the lower Hanalei River valley, constitute agricultural marshy habitats important as feeding grounds to several birds, but perhaps especially to the stilts. Introduced terrestrial species, such as ricebirds, are a problem at times in this same marshy habitat when the grain ripens.

Crops or Plantings

Sugar cane and, to a lesser extent, pineapple cover huge lowland areas of Kauai, the former covering 47,000 acres and the latter 5,700 acres, based on a 1956 estimate (Harland Bartholomew and Associates, 1957). Little observing of birds was done in these agricultural areas, but it was noted that native birds were completely lacking and that a few introduced species occurred infrequently. The birds seen most often in sugar cane, feeding along the numerous roads in between cane, were the lace-necked and barred doves. Ricebirds and mynahs were not uncommon around the cane fields.

Pastures or open grazing lands, while all man-made and rarely used by any resident native birds, are frequented by various introduced and migratory species (Fig. 13). Ricebirds, western meadowlarks, and ring-necked pheasants

Figure 13.—Pasture lands near Ka Loko Reservoir. Ricebirds, meadowlarks, linnets, and ring-necked pheasants were among the characteristic birds in this region. The tree at the right is a *Pandanus*.

would be examples of the introduced birds; and golden plovers and ruddy turnstones examples of the migratory. Golf courses, or large lawn areas, were attractive to plovers and mynahs. Grazing areas on Kauai were estimated at 119,000 acres in 1956 (Harland Bartholomew and Associates, 1957), over one-third the total area of Kauai, but much of this grazing acreage must have included forested or rather barren areas.

Gardens, trees, or other vegetation around houses constitute an important habitat, if the term may be so used, for numerous introduced birds. White-eyes and mynahs are probably the most numerous of such species; but cardinals, barred doves, linnets, house sparrows, and shama thrushes should also be mentioned.

ANNOTATED LIST OF BIRDS

IT IS POSSIBLE to divide the birds of Kauai into groups according to, for instance, their resident or migratory status; but since the native and introduced species differ in biological position and interest, it seems best to treat these two groups in separate, phylogenetically arranged lists. The 1957 American Ornithologists' Union *Check-List of North American Birds* is used for nomenclature as far as possible, but is supplemented by Peterson (1961), Amadon (1950), and Bryan (1958).

NATIVE SPECIES

As an introduction to the some 39 regularly and naturally occurring species of birds on Kauai, we may group them ecologically as follows:

Permanent residents (22 species)	Sea birds—3 Waterfowl—1 Marsh and shore birds—4 Birds of prey—1 Forest birds—13 (Passerines)
Summer or winter residents, or transients (17+ species)	Sea birds—10+ Waterfowl—4+ Shore birds—3

It is not possible to give an absolute total of the sea birds of Kauai since most of them occur offshore at various distances and do not breed on the island. Those species seen within two miles of shore are included in the above figures. Undoubtedly more than four species of ducks visit Kauai in the winter, but data are lacking. Rare or accidental occurrences of migrants are not considered although a number of such records are known (see Bryan, 1958), for example, an emperor goose in 1940 and red phalaropes in 1941 (Munro, 1944), a greater scaup in 1961 (King, 1961), and a sharp-tailed sandpiper (Bryan and Greenway, 1944).

In the following species accounts, all dates are for 1960, unless otherwise noted.

Puffinus pacificus cuneatus. Wedge-Tailed Shearwater, Uau Kani.

Breeds in fair numbers (275+) on Mokuaeae Island off Kilauea Lighthouse; small numbers along cliffs and slopes between Kilauea Lighthouse and Mokolea Point, slopes by Ka Lae Paoo south of Kipu Kai, and steep slopes on Na Pali coast just west of Hanakoa Valley. Probably present from March on, with eggs and young from June to November.

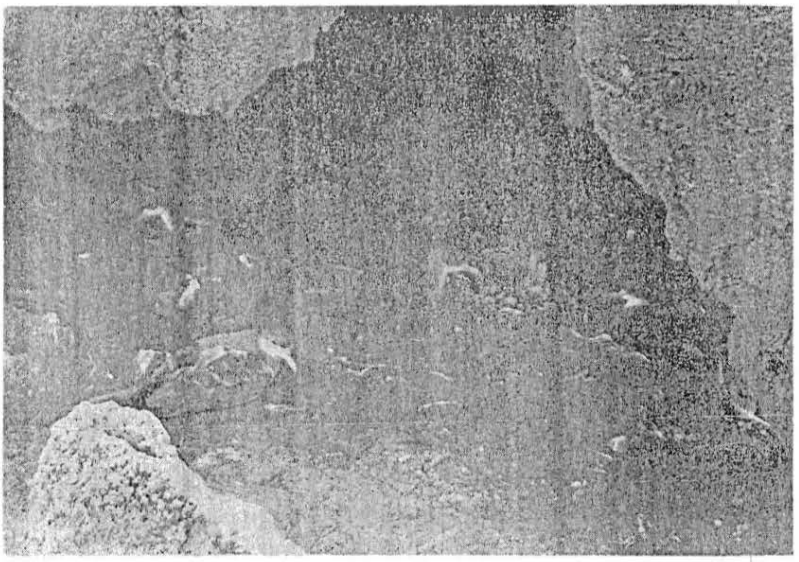


FIGURE 14.—Wedge-tailed shearwaters on Mokuaeae Island, July 12, 1960. Three nests in this small cave illustrated an unusual situation for this species which usually nests in separate burrows.

This shearwater has its strongest colony on Mokuaeae Island where it is probably rarely bothered (Fig. 14). By the lighthouse opposite the island it breeds successfully in burrows, even directly under nesting red-footed boobies. On the steep slopes to the east of here it is severely suffering from predation. On July 11, we saw three dogs excitedly working over a part of these slopes. The next day, while searching nearby Mokolea Point, we found at least 75 wedge-tailed shearwaters, a large proportion of the colony, which in recent weeks had been pulled from their burrows and killed, perhaps by dogs.

The shearwater colony south of Kipu Kai near Ka Lae Paoo is on private property sometimes grazed over by cattle; and although the colony is

in fair shape (we estimated roughly 100–150 active burrows), it is widely scattered with numerous empty burrows and some evidence of predation. A probable reflection of many years' predation was the fact that all burrows seen were well in or under rocks, even though the soil is suitable for burrowing in the area. An interesting feature of the colony is that burrows occur even up to 700 feet elevation, perhaps a record for this species. Within at least the last 20 years another shearwater colony existed on a point in the bay of Kipu Kai, but no birds could be found there now.

Probably very few wedge-tailed shearwaters breed on the remote steep slopes of the Na Pali coast. The one bird with egg found on June 22 in a patch of *Scaevola* some 200 feet above the ocean was the only one we came across during intermittent searches along this coast.

This shearwater was frequently seen offshore. For instance, on a 25-mile boat trip from near Waimea to Milolii Valley on July 27, we saw some 600 to 700.

Puffinus puffinus newelli. Manx (Newell's) Shearwater, Ao.

Occurs in moderate numbers, probably nightly in the summer, along much of east coast. Probably heard along Na Pali coast.

Four of these shearwaters were found dead along the main eastern, coastal highway, probably from flying into overhead power or telephone lines. One specimen was found dead on the beach near Kapaa. On a number of nights, one to six Manx shearwaters were observed just before dark, flying high overhead along the coast near Kapaa or heading inland toward the mountains. Altogether, these bits of evidence indicate a fair-sized breeding population of this species on Kauai, presumably back in the mountains; but we found no certain clues to its whereabouts.

Three Manx shearwaters were seen in the daytime over the open sea three or four miles off southwestern Kauai, and six were seen on a trip to Lehua on August 10. A report from Carl A. Miller of Honolulu, of what seem certain records of this shearwater, tells of seeing some 95 individuals over waters between Oahu and Kauai, and up to 150 miles northwest of Kauai, in August, September, and early October of 1960. Kauai remains the most likely breeding island of this population in Hawaii.

Bulweria bulwerii. Bulwer's Petrel, Ou ('Ou).

Occurs in small numbers offshore. Does not breed on Kauai or adjacent Mokuaeae Island.

We saw only six of these petrels on our trip off western Kauai on July 29; but 25 or more were seen on our trip to Lehua on August 10. Mokuaeae appears very suitable for the species, but careful search did not reveal its

presence there. Apparently the nearest breeding grounds are Lehua Island 15 miles to the west of Kauai.

Oceanodroma castro cryptoleucura. Harcourt's (Hawaiian Storm) Petrel, Oeoe.

Occasional offshore. Breeding grounds unknown. One seen off western Kauai, July 29; eight seen on trip to Lehua, August 10.

Phaethon rubricauda rothschildi. Red-Tailed Tropic Bird, Koae Ula.

Casual along the shores. Two seen off Milolii Valley, July 27. Abundant on Lehua, nearest breeding ground of this species.

Phaethon lepturus dorotheae. White-Tailed Tropic Bird, Koae.

Common resident throughout most mountainous parts of island, especially in canyons of Na Pali coast.

We found this species chiefly associated with sizable cliffs—in canyons such as Hanapepe, Waimea, and Kalalau, or in such isolated mountainous areas as the Haupu and Nonou (Sleeping Giant) ranges. It appeared to be nesting both in very dry cliffs like those near Kipu Kai, or in such moist, vegetated cliffs as are near Haena. At least 35 individuals were seen at one time in Kalalau Valley on June 30. The total population on Kauai may well be several thousand.

Sula leucogaster plotus. Brown Booby.

Casual along shores. Two seen off the shore of Kalalau Valley, June 22, and one off westernmost Kauai, July 29. The species breeds in numbers on Lehua, 15 miles westward.

Sula sula rubripes. Red-Footed Booby, A.

Breeds in numbers at Kilauea Lighthouse and a few on nearby Mokuaeae. Seen occasionally along shores.

The thriving, apparently undisturbed colony of this species at Kilauea Lighthouse was estimated on June 20 to consist of 60–75 pairs of adults with about 50–60 young (from recently hatched to half grown) and some eggs (Fig. 15). Nests are built on low lantana and *Euphorbia celastroides* bushes. Branches of these shrubs and also of Christmasberry (*Schinus terebinthifolius*) and *Scaevola* are used in nest construction. Richard Walker, Chairman of the Department of Botany of the University of Washington, reports that on April 1, 1961, many birds were present and on nests apparently with eggs. On September 4, 1961, Bowles (1962) found far fewer adults than in June, 1960, three or four downy young, and six birds in brown plumage. Three nests on Mokuaeae occupied three of the five or six suitable bushes present, yet dozens of boobies use the island as a resting spot.

The lighthouse attendant stated with certainty that the breeding boobies arrive regularly in February each year and leave in November. If this is true, it is in interesting contrast to the red-footed booby colonies present on Oahu where some breeding is done the year round (Richardson, 1957).

Fregata minor palmerstoni. Great Frigate Bird, Iwa.

Occurs regularly in small numbers along coasts. Rests, but does not breed on Mokuaeae Island.

The greatest number of frigate birds was seen around Mokuaeae (25 on July 13), their numbers here probably correlated with kleptobiosis on the red-footed booby colony near Kilauea Lighthouse.

FIGURE 15.—Mokuaeae, Kauai's only offshore islet, with part of the Kilauea Lighthouse red-footed booby colony in the foreground. Over 50 young boobies, up to half grown, and a few eggs were present in the colony on June 20, 1960, the time of this photograph.

Nycticorax nycticorax hoactli. Black-Crowned Night Heron, Aukuu.

Resident in small numbers chiefly along streams or reservoirs near coast, but occasionally along streams in mountains to over 3,300 feet.

At least 20 of these herons were seen during the summer, and a more thorough search along streams would undoubtedly have disclosed many more. On August 25, on numerous rocks projecting from the swift stream in Hanakapiai Valley, we found piles of from 4 to 12 shells (½–1½ inches) of the

grained neritina (*Neritina granosa*), a limpet-like gastropod mollusk. The shells were neatly cleaned out, the large opercula frequently lying beside them. These mollusks were apparently being eaten by the night herons, one of which was seen. Each shell had a large hole pecked in its outer surface, presumably made by the heron when it caught and detached the mollusk from under rocks in the 1–2-feet-deep, rushing water.

Of three herons seen in the uppermost Hanalei River (some 10 miles inland at an elevation of 1,350 feet), one appeared immature, suggesting that breeding may have taken place earlier in this region.

Anas platyrhynchos wyvilliana. Mallard (Hawaiian Duck), Koloa.

Resident in small numbers along streams or on reservoirs near the coast, but especially along the least-frequented streams to about 4,000 feet into the mountains.

At least 26 individuals of this distinctive race of mallard—or what may best be considered a unique species of duck—were seen during the summer. They were in widely scattered localities ranging from streams in such high, wet, forested canyons as the upper Hanalei Valley south of Keanaawi Ridge, to small coastal streams in quite arid canyons such as Milolii. Of six birds seen in Milolii Canyon on July 27, one had molted most of its flight feathers and was unable to fly. It was living in a deep rocky pool by a waterfall and, when we tried to catch it, successfully sought refuge by diving under a projecting rocky ledge.

Our only nesting record of the koloa was from the upper Hanalei Valley (at about 2,000 feet) where, on July 8, we found a nest with six apparently well-incubated eggs. The adult was not flushed from the nest until nearly stepped on. The nest was on a forested bank covered with the day flower or honohono (*Commelina diffusa*) and ferns, and was about 20 feet from and over 10 feet above a main stream. The nest was made of dry ferns, grass, and moss, but no down was noted. There was a strong odor from excrement next to the nest. Similar droppings, collected from rocks in the stream where ducks were observed, were made up largely of plant remains, mostly or entirely of green filamentous algae, and particles of one or two large insects.

A half-grown Hawaiian duck was seen in an irrigation ditch southwest of Ka Loko Reservoir on August 24. This and the above record of eggs suggest a rather late breeding season for this species.

Anas platyrhynchos platyrhynchos. Mallard.
Anas acuta. Pintail, Koloa Mapu.
Anas discors. Blue-Winged Teal. (Pearsall, 1946.)
Spatula clypeata. Shoveler, Koloa Moha.

The species listed above, plus occasional others, are known to occur, or have occurred, on Kauai in the fall or winter, but published records of them

are scarce. The number of migratory ducks on Kauai has apparently been much reduced since the large marshes near Mana on the west end of the island were drained in 1923.

Gallinula chloropus sandvicensis. Common (Hawaiian) Gallinule, Alae Ula.
Uncommon resident on bodies of fresh water near coast.

One gallinule was seen in the lower Hanalei Valley and two in the small slough at Kipu Kai. Holbrook Gooddale reported seeing moderate numbers of this species in reservoirs near Kipu.

Fulica americana alai. American (Hawaiian) Coot, Alae Keokeo.
Fairly common resident on bodies of fresh water.

We saw at least 48 coots during the summer, the greatest concentration being 38 birds seen on June 20 at the inlet of the Wainiha River. Perhaps the most unusual occurrence was of one bird on Kawaikoi Stream at about 3,300 feet on June 29.

Pluvialis dominica fulva. American Golden Plover, Kolea.
Regular migrant and winter resident, some staying all summer but not breeding.

We saw small numbers (a total of 45 or so) of this species throughout the summer at such places as the Lihue Airport and Wailua Golf Course. On June 17 more than 25 plovers, possibly some still migrants, were seen at the airport. Six plovers were seen on July 25 in Aweoweonui Valley. On August 17 we saw two plovers in the uppermost canyon of the Koaie River above 4,000 feet. Almost all birds seen during the summer were in winter plumage, but a few had partial breeding plumage.

Arenaria interpres interpres. Ruddy Turnstone, Akekeke.
Regular migrant and winter resident, some staying all summer but not breeding.

Three turnstones were seen near Kapaa during the last half of July. These birds may have been returning migrants, although this early a date makes it seem unlikely.

Heteroscelus incanum. Wandering Tattler, Ulili.
Regular migrant and winter resident, some staying all summer but not breeding.

At least 11 tattlers were seen during the summer from late June through August. Most of these—for instance, three at Kalalau Valley on June 22—were seen on open sandy beaches. Others were seen on rocky shores, their typical habitat on the Pacific Coast. Two were seen, surprisingly, on mountain streams.

Himantopus himantopus knudseni. Hawaiian Stilt, Aeo.

Resident in small numbers on a few scattered, lowland marshy areas.

We saw stilts in only two areas: in the slough at Kipu Kai on July 15 (four birds), and in the flooded rice fields of the lower Hanalei Valley on July 13 (seven birds). King (1961) reports seeing 10 at a pond five miles west of Kekaha, March 4, 1961. Bowles (1962) reports seeing about 12 in the lower Hanalei Valley on September 4, 1961. As Schwartz and Schwartz suggest (1949, p. 126), a very helpful step to preserve the stilt on Kauai would be to create suitable shallow-water areas, as around the Koloa Reservoir. The stilt is the only nonpasserine endemic full species of bird on Kauai, and special interest can thus be attached to its preservation.

Sterna lunata. Gray-Backed Tern, Pakalakala.

Occurs in small numbers offshore. Does not breed on or near Kauai; its nearest breeding grounds probably on Kaula.

Twelve of these terns were seen during a boat trip off the western end of Kauai on July 27 and 29. Ten were seen on our trip to Lehua, but none were on or near the island, although it appears to offer a very suitable breeding ground.

Sterna fuscata oahuensis. Sooty Tern, Ewaewa.

Occurs irregularly offshore, the nearest breeding site probably being Kaula.

Six of these terns were seen on a trip around the west end of Kauai on July 27 and 29.

Anoüs stolidus pileatus. Noddy Tern, Noio Koha.

Occurs in fair numbers off or sometimes close to shore, but the nearest breeding ground is apparently Kaula.

Six of these terns were seen near the Na Pali coast off Hanakoa Valley on June 22, and at least 24 off the south end of this coast on July 27 and 29.

Anoüs tenuirostris melanogenys. White-Capped Noddy (Hawaiian Tern), Noio.

Resident in moderate numbers along Na Pali coast, breeding in caves, as at Kalalau.

This tern breeds in at least two caves near Kalalau Valley: the "wet cave" with its body of fresh water at the west end of the beach; and the ocean cave through the point beyond. On June 22 there were at least 18 terns in these caves, a few having either eggs or small young, suggesting a spring-summer breeding season typical of this species on other Hawaiian islands.

Asio flammeus sandwichensis. Short-Eared Owl, Pueo.

Resident over whole island, occurring most frequently in the mountains.

At least 35 owls were seen during the summer, as many as 5 in one day such as happened in the Kokee region on June 30. As the only predatory bird on Kauai, they seemed to fill the niche of both hawks and owls of continental regions. This was indicated by their nocturnal and diurnal hunting, their frequent high soaring as well as low flying, and by their occurrence more often over forested areas with few openings than over agricultural or grazing lands.

Little was learned of the breeding habits of the pueo on Kauai, but on August 4 near the upper Waialae River, an apparently full-grown young owl, not quite able to fly, was found. This record suggests a spring and summer breeding season.

No observations of feeding were made, but six pellets gathered at several widespread points contained the remains of three Hawaiian rats and one house mouse.

An incident occurred on the side of the dirt road on top of the pali high above Kalalau Valley on June 30 which may be of interest. An owl flew down to the roadside, stood a minute or so, then squatted, thrusting the head forward, and fluffed and squirmed in the dirt for three separate periods. A shallow depression about an inch deep was left in the dry but not really dusty soil in which the owl had apparently taken a typical "dust bath."

Owls, perched in trees in the daytime, were seen on two occasions being "mobbed" by numerous small birds. Roger Tory Peterson, noted avian author and artist, observed one of these incidents and noted that both native apapane and introduced white-eyes were participating.

Phaeornis obscura myadestina. Hawaiian (Kauai) Thrush, Omao, Kamao.

Resident and fairly common in some areas, in or near the Alakai Swamp native forest region.

This thrush was seen in 1941 by Munro (1944, p. 77) and heard by H. S. Baldwin (1960, p. 2), but our records now make certain its existence in moderate numbers. We are not able to estimate closely the number of individuals seen or heard since a very clear view is necessary to distinguish it from *P. palmeri* and also we were not sure that we could differentiate between the songs of the two species. Nevertheless, on August 16 we definitely saw 12 omao between the upper Koaie River (about 3,750 feet) and Kawaiiki Ridge (about 4,250 feet) to the southeast, and estimated hearing at least 15. On August 15 we estimated hearing 10 or more omao near the upper Kohua Ridge within a mile of the Wainiha Pali. More thrushes, presumably of both native species, were heard July 19–22 in these regions, and also on August 3–5 in the

upper Waialae River (about 3,750 feet) to about two miles east along the high forest country leading toward Mt. Waialeale. Since on one day (August 16) we were sure that we had seen or heard more than 28 omao in a round trip over some four miles of trail, we feel there must be at least some hundreds, if not a few thousands, of these thrushes living in the Alakai Swamp native forest area.

There are indications in this species of considerable deviation from a spring breeding cycle. There was much singing at times in both mid-July and mid-August, and the testes of the male we collected on August 16 were highly developed (13 millimeters long, gray). Another condition suggesting a very prolonged breeding season was the occurrence of full-grown, completely independent, immature thrushes in August.

Since neither the old nor the newer bird books give clear accounts of the distinguishing features of Kauai's two native thrushes, we may point out here that the omao lacks the white eye-ring, has a markedly shorter and wider beak, and is definitely a larger bird than the small Kauai thrush. The song of the omao seemed usually to be a series of flute-like double notes, but it was sometimes more like that of the Chinese thrush, although shorter and repeated.

The stomach contents of the Hawaiian thrush collected August 16 consisted chiefly of lapalapa berries and their seeds, but there were a few small seeds (about 2.5 millimeters) of another species and parts of a large heteropteran insect.

Phaeornis palmeri. Small Kauai Thrush, Puaiohi.

Resident and fairly common in some areas of the Alakai Swamp forest region.

This thrush, one of the four endemic full species of birds of Kauai, was listed as probably extinct by Amadon (1950, p. 256) but reported seen by Donaghho in 1940 (1941, p. 52). We were able to prove its existence by collecting two specimens, and then, through careful observation, to be sure of seeing at least 15 individuals. All were seen between the uppermost Koaie River region and Kawaiiki Ridge to the southeast. The two specimens were collected in the canyon of the Koaie River. This, as well as our observations, indicated that the species tended to occur in the high wooded canyons or valleys more often than did *P. obscura*. Nevertheless, both species occurred together on the nearby forested slopes and ridges.

The food of the two birds collected on July 19 was chiefly the fruit of the lapalapa (*Cheirodendron* sp.), and the gizzards and intestines were stained purple by the juice of these berries. The gizzards also contained parts of at least 10 insects of several species.

A prolonged nesting cycle similar to that of the omao was suggested in this species because one specimen had large testes (7 millimeters, gray) while the other, foraging independently, was in the vermiculated immature plumage.

Chasiempis sandwichensis sclateri. Elepaio.

Common, widespread, resident chiefly in native forests.

This well-marked race of elepaio with its colorful red-brown males is the most widespread native passerine on Kauai. It occurs from the predominantly koa forest, such as that southwest of Kokee, to the low, sparse ohia forest, in swampy areas some 4,500 feet high, west of Mt. Waialeale. The lowest elevation at which we saw elepaio was in Hanakoa Valley at 450 feet where they were in a mixed forest of chiefly Java plum, coffee (*Coffea* sp.), and kukui (*Aleurites moluccana*). They were also seen in a mixed forest with introduced *Albizzia* and guava near Ka Loko Reservoir.

The abundance of elepaio is roughly indicated by our estimation of having seen some 275 individuals during the summer. Estimates often ran to over 10 per mile of trail, and the species was so dependably present in native forests that one can assume the total population on Kauai is at least several thousand.

Little information was obtained on the breeding of the elepaio. Immature birds seen with parents in late June and the lack of singing throughout the summer indicated an earlier nesting season. However, a freshly made, empty nest, apparently of an elepaio, was found in a lapalapa tree about six feet above ground near the upper Koaie River on July 21. On June 21 in Hanakoa Valley, a male was seen fluttering its wings and courtship-feeding an elepaio which was apparently a female. Near here on June 24, a fledged but partially downy elepaio was seen. The testes of a male found August 19 were moderately large (2.5 millimeters).

Elepaio were seen looking for food in ohia blossoms and foliage, and in coffee leaves. One was seen to fly from a tree branch to catch a form of grasshopper about an inch long. On another occasion two birds were seen feeding among rocks on the edge of the upper Koaie River.

Moho braccatus. Kauai Oo, Oo Aa.

Uncommon resident in some areas of undisturbed native forest of the Alakai Swamp region.

This unique Kauai species, probably the only one surviving of four Hawaiian oo, was reported seen in 1936 and 1940 by Donaghho (1941). It may well have been seen or heard by others, too, during the last half century, but we were able to establish its current existence by collecting a specimen on July 21 (probably the first since 1897) and by closely observing or hearing at least 12 other individuals. The localities where the birds were observed were near the upper Koaie River above about 3,750 feet, and in the forested high country connecting with Kawaiiki Ridge (at about 4,250 feet) a mile and a half to the south, an area roughly paralleling and closely approaching the Wainiha Pali. Birds were seen on both of our trips to this area on July 21

and August 16–18, but none were seen or heard in the seemingly suitable virgin forest area from the upper Waialae Stream (Palikea Cabin) to two miles or so east toward Mt. Waialeale. Perhaps sharply increased rainfall as one approaches the Mt. Waialeale region, closer proximity to effects of grazing, or the presence of occasional horses or cattle made this region less desirable. At least four observers have failed to find oo in the upper Koaie region in 1961 and 1962, but Bowles (1962) reports seeing one and hearing several others there on September 3, 1961.

The oo seemed to prefer a rather thick forest habitat, and more were seen or heard in the high canyons than on the nearby forested ridges. Birds were seen foraging in both ohia and lapalapa trees and one was seen eating lapalapa berries. Inspection of the stomach and gizzard contents of the specimen collected near the upper Koaie Stream Cabin showed the following: remains of one large and two or more small spiders; assorted parts of ten or more insects, including beetles and a hemipteran; remains of at least one large insect larva; and three small snails.

Curiosity, or concern was shown by oo, and they came several times, even from over 100 yards away, to imitations of their calls. The calls, although variable, were typically loud, mellow whistles. "Whip-poor-wéeo" was most often heard, not too fast and descending at the end. Loud pairs of notes, "afi-o," were also heard, in addition to slurred, liquid, double notes. All birds seen appeared to be adults. The one collected July 21 was an adult male with testes apparently in postbreeding condition and only two millimeters long. The tail of this bird was short and incomplete, for several molted feathers were being replaced. This suggests an early breeding season with postnuptial molt starting perhaps in late spring. The bird was in good condition, having a fair amount of fat.

Loxops virens stejnegeri. Amakihi.

Moderately common resident of native forest areas above approximately 1,500 feet.

A conservative estimate of 60 amakihi were seen during the summer, the birds being about equally common in the koa and ohia forest, as around Kokee, and the upper ohia forests. Like the elepaio, the amakihi seems able to tolerate some vegetational or other human disturbances of the native forest, and its total numbers may actually be as great as the elepaio since it frequents higher trees and does not come readily in response to squeaks.

Amakihi were seen to forage in both koa and ohia trees, and one was seen apparently getting nectar from a banana blossom. As in the case of apapane, much foraging by amakihi was noted in ohia foliage as well as in blossoms. They were not heard to sing after late June, nor were any other signs of breeding noted during the summer.

Loxops parva. Anianiau or Lesser Amakihi.

Moderately common resident of native forest areas above approximately 1,500 feet.

This endemic species of Kauai is apparently more common than the amakihi, for an estimated 104 anianiau were seen during the summer, and the likelihood of seeing the two species (based on their habits) seemed comparable. Ten or more anianiau were definitely seen during each of several different days along five to seven miles of trail.

The range of this species, both altitudinally and with respect to forest type, seemed to be approximately that of the amakihi, and the two species were often seen foraging together. Breeding also appeared to be completed in the anianiau for we heard no singing during the summer and saw little evidence of pairing or territories. However, on June 30 three birds were seen together; one, apparently immature, was fluttering its wings and being fed. The testis of a male collected July 21 was small (about 1 millimeter).

Anianiau were seen several times to forage, like creepers, along bark and dead twigs of trees, once feeding in the dying curled leaves of a small native tree (*Coprosma*?), and once feeding in an introduced passion flower (*Passiflora* sp.). Examination of fragments from two stomachs showed parts of a number of insects, including several small beetles, several insect larvae, and a spider. One stomach also contained several small seeds, a small rock, and parts of feathers.

Loxops maculata bairdi. Creeper, Akikiki.

Abundant resident in some regions of native forest in or near the Alakai Swamp area.

A small group of birds of this species was seen in the disturbed, native forest near the Mohihi River about four miles east of Kokee; but on our three trips into the essentially undisturbed forests at higher elevations (above 3,750 feet) to the east of this, we estimated seeing at least 375 individuals. No less than 50 were seen on several different days along only three or four miles of trail, so their total population, although somewhat sporadic, must be in the thousands.

Creepers were almost always seen in loose flocks which seemed to be traveling through the forests. Probably these flocks were postbreeding groups; one bird collected July 19 was in juvenal plumage. Akikiki were frequently seen to feed along trunks and branches much in the manner of nuthatches. Their squat stance with widespread lower legs was similar, as was their habit of prying off pieces of bark or pecking in cracks or holes for animal food.

Loxops coccinea caeruleirostris. Akepa.

Moderately common resident, widely scattered in the higher ohia forests and, to some extent, in the mixed koa forest.

Akepa were occasionally sighted either individually or in small groups; a

total of 26 were seen for certain. On July 22, for example, we saw a group of five foraging in ohia trees just above the Wainiha Pali east of Kohua Ridge. Because of its superficial similarity to the amakihi and anianiau, the species could not always be differentiated. Probably akepa are at least a bit more common than our observations indicate. King (1961) reports seeing 24 akepa March 3 and 4, 1961, in the uppermost Koaie River region.

Akepa were typically seen foraging in the foliage or outer branches of ohia trees. Fragments in the stomach of the one bird collected included a homopteran and several other insects.

Hemignathus procerus. Kauai Akialoa.

Rare resident of the undisturbed native forest of the Alakai Swamp region.

Only two individuals of this unique species were seen, both in high (4,000 feet), forested ridge country within a mile southeast of the upper Koaie River Cabin. However, there are grounds for hoping that a small population still exists, for Munro (1944, p. 116) reports that akialoa were seen in 1941, and Knudsen (unpublished) seems certain to have seen a group of the birds in 1957.

The specimen collected July 20 was a female apparently in postbreeding condition. Among its stomach contents were: parts of four or more large beetles, probably carabids; parts of three or more large beetle larvae, probably a wood-boring species; two large black, hooked mandibles of beetle or spider; and one sprouting seed.

The akialoa seen on July 19 by David Woodside was actively foraging on the moss, lichen, and fern-covered trunk of a large ohia.

Hemignathus lucidus hanapepe. Nukupuu.

Rare resident of the undisturbed native forest of the Alakai Swamp region.

We caught a fleeting glimpse of only two individuals of this species on August 16 in the high, forested ridge region of the upper Koaie River drainage near where the akialoa were seen. One of the birds appeared to be begging for food, and was probably an immature individual or a female. King (1961) reports seeing two nukupuu in this same region on March 4, 1961. It can only be hoped that, on the basis of these two observations for this century, a population of nukupuu still exists on Kauai.

Psittirostra psittacea. Ou ('O'u).

Rare resident of the undisturbed native forest of the Alakai Swamp region.

Two ou were seen by Woodside on July 21 near the high (about 4,250 feet) eastern end of the Kawaiiki Ridge country, and one or more by the authors on August 17 in the canyon of the Koaie River at over 4,000 feet and

just west of the Wainiha Pali. Donaghho (1941, p. 52) reported seeing several, and King (1961) reports seeing one on March 4, 1961, in the above general region. These several records constitute fair evidence for a continuing small population of this species on Kauai.

Himatione sanguinea sanguinea. Apapane.

Abundant resident in native ohia or koa forests. Less common in disturbed forest down to about 1,500 feet.

We estimated seeing at least 750 apapane during the summer, indicating that this species is, strikingly, the most abundant native bird of Kauai. It was so dependably present throughout the native forest areas, even where introduced plants and birds were numerous, that an estimate of its total population based on the extent of native forests and average trail-counts seems valid:

Apapane seen along 1 mile of trail, 1 acre wide	30+
Apapane heard along 1 mile of trail, 1 acre wide	60+
Apapane per square mile	2,250+
Square miles of suitable habitat	100+
Estimated total population	225,000+

Such a population figure, admittedly based on rough estimates, is, we think, conservative. For one thing, the area of suitable habitat may be almost double the above figure. There can be no question of the apapane's successful adaptation to changed conditions, including, presumably, introduced avian diseases, in its native forests.

The breeding season of the apapane was apparently over by the start of summer, and only juvenal and adult birds were seen during the summer. As further indication of such a season, Ord (1962) reports a great amount of singing of apapane, iiwi, and elepaio on April 20, 1962, in the upper Koaie River region. We saw at least 15 birds in the brown juvenal plumage accompanied by parents, June 27-30 around Kokee. A brown juvenal bird with red sides was seen on July 6. Apapane were singing in fair numbers in late June around Kokee, but were heard to sing little thereafter. An exception was a fair amount of singing heard August 18 near the Mohihi River Cabin.

Apapane, as well as amakihi and anianiau, were seen to feed in the uncommon yellow or orange ohia blossoms as well as in typical red ones.

Vestiaria coccinea. Iiwi.

Moderately common resident of ohia or koa forests, generally above 2,750 feet.

Iiwi appeared to range about as widely as apapane, often occurring with or near them but never in such large numbers. We estimated seeing at least

134 iiwi during the summer. An average of about five were seen per mile of trail, and about this number were heard but not seen. Judging that perhaps 75 square miles of suitable habitat exist, we crudely estimate that there are at least 18,500 iiwi on Kauai.

No sign of breeding activity was seen, but we saw juvenal birds in a variety of intermediate plumages throughout the summer. In late June one juvenal was seen that had large red-brown patches on each side of the breast, and another had a rosy-brown head and neck, and red shoulder patches.

Introduced Species

All of the approximately 25 species of foreign birds that have become established on Kauai are permanent residents. It is not possible to give an exact total of species because of the uncertainty of the establishment of some (see Bryan, 1958, for records of unsuccessful introductions), but we feel our search was extensive enough to give a fairly accurate figure. All of the species are land birds, including forest and game species, 7 being gallinaceous, 3 columbiforms, and 14 passerines. Many of the dates of introductions are taken from Caum (1933).

Bubulcus ibis. Cattle Egret.

Recent introduction (43 birds in 1959) which appears to be establishing itself.

Six cattle egrets were seen July 15 at Kipu Kai, about three miles from their point of liberation in July of 1959, feeding around cattle in a marshy pasture. One other was seen August 1 near Makaweli.

Lophortyx californicus. California Quail.

Scattered resident along the south and southwest coast and into the adjacent arid hills and canyons. Introduced in 1929.

We saw this bird only once, just above Kekaha. Schwartz and Schwartz (1949, p. 48) give details on its occurrence and habits.

Gallus gallus. Jungle Fowl.

Resident, sometimes common, as in the Kokee region, in scattered mountain areas.

Schwartz and Schwartz (1949, p. 102) show widespread areas for this species, but we saw it only from the Kokee region and up into the Alakai Swamp forest. Perhaps it is gone from some previous areas, but it is certainly common —very likely overly so—in the drier koa forests around Kokee. It occurs on up into the pure native forest toward Mt. Waialeale for we heard it, even at about 4,000 feet. On August 19 we encountered two hens with chicks 2–4 days old about a mile west of Halemanu.

Phasianus colchicus. Ring-Necked Pheasant.

Widespread in small numbers, except in highest forested regions.

We saw occasional pheasants from as high as Kaholuamanu (3,650 feet) to almost sea level near Kalalau Valley. If green pheasants (*Phasianus versicolor*) or hybrids occurred in the Kokee region, as indicated by Schwartz and Schwartz (1949, p. 28), we did not distinguish them.

Syrmaticus reevesii. Reeve's Pheasant.

First introduced in August, 1958, in mountains near Kokee.

We saw four of these pheasants, appearing to be immature, about three miles east of Kokee on July 22.

Alectoris graeca. Chukar Partridge.

Apparently well established, at least in the Makaha Valley region of the Na Pali coast.

These partridges were heard and their feathers and a great many of their droppings were seen in Makaha Valley on July 28. This valley is actually a very precipitous rocky canyon with a small stream in its upper part and good water holes, around which chukars had obviously spent much time, almost down to the ocean. This is an arid region of Kauai and the slopes appeared quite brown and lifeless in July. There were scattered bushes of naio (*Myoporum*), and the fruit of this plant was apparently serving as the chief food of the chukars for its seeds formed the major part of their droppings. It is interesting that, according to Woodside, this same fruit is an important food of chukars on other Hawaiian islands. Other remnants detectable in the droppings were seeds of three other plants, especially of *Bidens* sp., and small leaves.

Pavo cristatus. Pea Fowl.

A very old (1860) introduction to Kauai, but now resident only in small numbers at Kipu Kai and Kalalau Valley.

We did not see or hear pea fowl at Kalalau, although they have been reported there in recent years; but we did see several at Kipu Kai, including a brood of approximately 12 small young. Little native vegetation exists in the two areas where this species occurs.

Meleagris gallopavo. Turkey.

Introduced at least at Kipu Kai where we saw two well-grown immature birds.

Columba livia. Rock Dove, Pigeon.

Established as a wild bird in a few areas.

Although Schwartz and Schwartz (1949, p. 101) give details on the habits and habitat of the pigeon, they do not include Kauai in its range. However, we saw pigeons several times in wild cliff areas, including Hanapepe Valley and the Nonou range, in which regions they appeared to be well established.

Streptopelia chinensis. Spotted, Lace-Necked, or Chinese Dove.

Common resident over most of island.

We saw probably a few hundred of these doves during the summer. A note that might be added to Schwartz and Schwartz's (1949, p. 68) rather detailed discussion of the species is our repeatedly having seen small numbers of these doves well up into completely or nearly virgin forests of the Alakai Swamp region. Here they seemed most often to make use of the bare ground afforded by narrow trails and were most common along the Kohua Ridge trail where we saw 15 or more along about four miles on August 18. Their droppings indicated they were eating the berries of ukiuki (*Dianella* sp.) which was common on the sides of the trail, often overhanging it. Another feeding note is that twice we saw them feeding on the ocean beach near Hanalei.

Geopelia striata striata. Barred Dove.

Common resident of lowlands.

This dove is much more common than the spotted dove and many hundreds were seen, especially around yards and agricultural areas. The numerous dirt roads of cane fields were an important feeding ground. Although none were seen in the higher or wilder parts of Kauai, we saw three individuals on Mokuaeae Island (and several on Lehua), indicating some preference of the species for isolated, barren localities.

Parus varius. Varied or Japanese Tit.

Uncommon locally in Kokee region. Introduced in 1890.

This species has been seen by various observers in the past, but we did not happen to find it, perhaps because of insufficient searching around habitation.

Garrulax canorus. Chinese Thrush, Hwa-mei.

Common resident over whole island. Introduced probably about 1920.

Our estimate of seeing or hearing at least 135 of these "thrushes" (actually babbling thrushes) does not give an adequate idea of their widespread abundance. The species was present from the coast to the highest forests (over 4,500 feet), and from humid, forested valleys to dry, barren canyons of the southern Na Pali coast. It seemed equally at home in many introduced plant thickets (as lantana, *Melastoma,* and blackberry) and forests (as *Albizzia*), and dense, native forest of the Alakai Swamp region. Its numbers became smaller, however, in the high, forested area, perhaps in relation to increasing amounts of rainfall.

Apparently, the breeding season of the Chinese thrush covers many months, for of two birds collected July 8, one was a juvenal but the other an adult male with black, somewhat enlarged (4 millimeters) testes. The stomach contents

of this latter bird consisted of several hundred seeds and fleshy parts of some fruit, a few seeds of two other species of plants, and remains of three or more insects, one an ant.

Garrulax albogularis. Collared or White-Throated Laughing-Thrush.

Uncommon resident of a few lowland areas.

The existence of this babbling thrush on Kauai should be verified by a collected specimen. The above species was introduced on Kauai as early as 1919. It was reported seen recently near Lihue by Warner (1959, p. 9). We fleetingly saw and repeatedly heard several birds, presumably of this species, in the *Albizzia* forest near Ka Loko Reservoir.

Leiothrix lutea. Red-Billed Leiothrix, Pekin Nightingale.

Uncommon resident in widespread localities. Introduced in 1918 (from San Francisco) and in 1928 from the Orient.

In curious contrast to its great abundance on Oahu and Hawaii, this species is generally very hard to find on Kauai. We saw nine or more in two groups in late July and early August above 3,750 feet on the outskirts of the Alakai Swamp native forest. Bruce Richardson, son of the senior author, reported seeing fair numbers of the species in Kalalau Valley in early September.

Mimus polyglottos. Mockingbird.

Uncommon locally near southern coast.

On July 25 we saw four mockingbirds in Aweoweonui Valley just southwest of Kipu Kai. The birds seemed much at home in dry thickets here including those of mesquite. Another mockingbird was seen August 20 at Barking Sands, some 25 miles west of Kipu Kai. H. S. Baldwin (1960) records the possible sighting of a mockingbird near Lihue. We have heard an unconfirmed report of the liberation of this species on Kauai, but lacking verification of this we think it is quite possible that mockingbirds have naturally spread from Oahu, where they have been established for many years, to Kauai. Prevailing easterly winds could have helped in the crossing of the 80 miles of ocean between the two islands.

Copsychus malabaricus. Shama, Shama Thrush.

Moderately common resident locally, usually in inhabited lowland areas. Introduced in 1931.

During the summer we saw 10 or more of these thrushes at widespread points including Haena, Lihue, and Waimea. They were noted to occur in a mixed *Albizzia* forest, a casuarina grove, and kiawe (mesquite) thicket, thus showing much adaptability to habitats varying widely in vegetation and aridity.

An independent juvenal bird was seen as early as mid-July foraging on

lawns and ground. The plumage of this bird, except for its adult-type white rump, whitish belly, and black-and-white tail, was all light orange-brown. One shama thrush was observed eating flying termites emerging at dusk. A characteristic habit of repeatedly raising the tail rapidly then slowly lowering it was observed many times in shama thrushes.

Acridotheres tristis. Indian Mynah.

Abundant throughout lowlands and in scattered localities in the mountains.

No consistent attempt was made to estimate the numbers of mynahs, but from even casual observations the total mynah population would run to many thousands. Their greatest concentrations were in lowland agricultural areas and around habitations, but over 100 were present in the vicinity of Kokee. Their nearest distribution to the higher, virgin forest was in the upper Waialae River region, where at least 35 were seen roosting in the fire trees behind the Waialae Cabin (3,650 feet) on August 4. A few mynahs were seen in valleys of the west coast, however remote and arid (for instance, six birds seen in Milolii).

Miscellaneous notes on mynah food habits include the following: Birds were seen several times perched on the backs of horses and cows, apparently using these as vantage points. They were seen to eat papayas, rose apples (*Eugenia jambos*), figs, and a large centipede (the latter was in a road, perhaps already dead). All these would seem to be indications of their very adaptable food habits.

Zosterops japonica. Japanese White-Eye, Mejiro.

Widespread and abundant resident.

There can be no question that the white-eye is by far the most abundant bird, native or introduced, on Kauai. We estimated their numbers only part—perhaps half—of the time, but reached a conservative total of 1,233 white-eyes seen. Considering the commonness of the species in almost all habitats, native or introduced, there must be hundreds of thousands.

White-eyes were present even in the highest areas of virgin forest; but here, at least, they were outnumbered by some of the native species. On three successive days, for instance, in the upper Koaie River region, we saw about 5, 4, and 4 white-eyes, but 45, 50, and 30 apapane, and 50, 25, and 25 akikiki. Fewer white-eyes were seen here than six native species. It can be hoped that the higher, wetter forest areas, with few or no introduced plants, are not optimum for white-eyes, and that this bird will not become a severe competitor with the native birds whose last stronghold is here.

Apparently most breeding was completed well before late June. Of a number of nests seen, all but one appeared abandoned. The one nest in use contained three small (2–4 days old) young on June 20.

White-eyes were seen several times feeding on guavas and on or in ohia blossoms and foliage, even seeking out isolated examples of the latter tree in areas of extensive nonnative plants. They were also seen to eat rose apples, peaches, mulberries, papaya, and mountain apples.

Lonchura punctulata. Ricebird.

Widespread, although localized, abundant resident.

We estimated seeing over 500 of these birds during the summer and feel that this number indicates a total population of some thousands, especially since we spent little time looking for the species in agricultural and grasslands where it could be expected to be most common. Ricebirds were seen under extremely diverse conditions, as along the uppermost Koaie River (3,750 feet) and in dry Milolii Canyon near sea level. They were common usually in high-grass clumps along roads or by clearings in the Kokee region, and also in the grasses beside the innumerable roads of sugar cane fields. Ricebirds appear to occur in virgin forest areas rarely, except along open stream beds.

We most often saw them feeding in high, perennial grass, but also saw them in large rushes (*Scirpus* sp.) apparently getting seeds. Ricebirds were noted in plum trees probably eating the fruit. In the rice fields just west of Wailua, the birds are a continuing problem.

Passer domesticus. House Sparrow.

Uncommon resident in some settled areas.

This species was seen in small numbers around the Lihue Airport and in yards near Kapaa; but in general, it seems surprisingly scarce on Kauai.

Sturnella neglecta. Western Meadowlark.

Scattered resident of lowland pastures.

We observed some 15 of these birds, most of them in pastures either just south of Kapaa or just east of Ka Loko Reservoir; a range from low, dry grass next to the seashore to verdant, upland (750 feet) pasture. Bryan (1958) lists the meadowlark as introduced to Kauai in 1931.

Richmondena cardinalis. Cardinal.

Resident in small numbers over most of island. Introduced in 1929.

We counted at least 52 of these cardinals during the summer, finding them in virgin forest near the Alakai Swamp (about 4,000 feet, above Kaholuamanu on trail to Mt. Waialeale) and in the very dry regions of the Na Pali coast. They lived in our yard at Kapaa, but seemed equally at home in the koa forest at Kokee. No notes were obtained on breeding or feeding habits of the cardinal, but birds in juvenal plumage seen as early as June 22 indicated early spring nesting.

Paroaria cristata. Red-Crested or Brazilian Cardinal.

Uncommon resident of southeastern or southern lowlands.

We did not see this cardinal, but consider the occasional records of it as quite valid. H. S. Baldwin (1960) probably saw it near Lihue. The species was liberated near Lihue about 1928, was apparently more common in some years than in others, but is now scarce.

Carpodacus mexicanus. House Finch, Linnet.

Locally common resident at widespread points.

We estimated seeing over 80 house finches during the summer. Although the species was common in certain lowland pasture and inhabited regions, it was also common in the mixed koa and ohia forests of the Kokee region and on the remote, dry Na Pali coast. However, we did not find them in the high, virgin, forested areas, the closest approach being a few seen near the Waialae Cabin (about 3,650 feet).

One breeding record obtained was the finding of a few-days-old bird fallen from a cliff nest at the entrance to the "dry cave" on the beach at Kalalau Valley on June 23. A single feeding note was of house finches eating rose apples.

ANALYSIS OF DISTRIBUTION

THE MOST CONSPICUOUS correlation between the distribution of the birds of Kauai and their habitats, and one which is repeatedly apparent in the foregoing species accounts, is that introduced species are very widely distributed throughout the agricultural or other nonnative plant areas and often in all or much of the areas of native vegetation; whereas most native, resident bird species are confined to dominantly native plant areas or exclusively to essentially virgin forests. Apart from native migrants and the nine native, resident, nonpasserine species (including the sea birds, marsh or shore birds, and the owl), not a single record of the 13 native passerines was obtained in the extensive northern, eastern, and southern lowlands of Kauai (making up approximately two-fifths of the area of the island). The only exception to the absence of native passerines in the lowlands, devoid as they almost completely are of native vegetation, was the occurrence of the elepaio in the largely introduced forest of the lower Hanakoa Valley.

Table 1 attempts to show more graphically the above relationship between native and nonnative birds and habitats. The placing of species in the different columns was not always clear cut. For instance, at least one (the creeper) given as restricted to virgin forests gets down into the edges of the mixed forest, and it is likely that others may do so occasionally, as for instance in the winter. Again, the native species put in the nonnative habitat column were the coot, gallinule, and stilt; but aquatic habitats are not readily comparable to terrestrial ones, and we might, with justification, put them in the "native and nonnative habitats" column, assuming that bodies of water have retained some basic native conditions. Migratory waterfowl were not included in the chart partly because of the difficulty of classifying the fresh-water habitat on a native or nonnative basis. Under the introduced birds, perhaps a separate column should have been set up for the Japanese tit and Reeve's pheasant (if established), species which occur only in the mixed native forest.

One striking point brought out by Table 1 is that all of the rarer native passerines appear to be rather closely restricted to the virgin mixed ohia forest. The creeper is the only species of the seven which is abundant, and is, perhaps, the only one to spread down somewhat into the less virgin mixed forests. The

TABLE 1

DISTRIBUTION OF BIRDS RELATIVE TO NATIVE OR NONNATIVE HABITATS
(Excluding Sea Birds)

SPECIES	NATIVE HABITATS ONLY		BOTH NATIVE AND NONNATIVE HABITATS	NONNATIVE HABITATS
	Virgin Mixed Ohia Forest	Virgin Ohia and Mixed Koa Forest		
Native nonpasserines			4	3
Native passerines	7	6		
Introduced nonpasserines			5	6
Introduced passerines			8	6

thrushes (although a report of one species occurring in lower mixed koa forest may well be valid), oo, akialoa, nukupuu, and ou are at once the rarest native birds and the ones with the most restricted distributions. All of their ranges are known to have been more extensive originally, so one may judge that these species are the least adaptable or most sensitive to habitat changes.

At the opposite extreme are the 12 introduced species, passerines and others, that are found only in nonnative habitats. Passerine examples here would be the collared and shama thrushes, mockingbird, and house sparrow. It is interesting that none of these species has achieved anything like the abundance of the introduced passerines that take advantage of both native and nonnative habitats—for instance, the Chinese thrush, mynah, white-eye, and ricebird. The type or extent of use of the native habitat varies with each of these latter species. The ricebird, for example, often escapes into native forest when frightened away from feeding on introduced grasses along mountain roads; or the white-eye, overwhelmingly the most abundant and widespread of all species, thrives in virgin forest and adopts feeding habits much like those of native birds.

FACTORS RESULTING IN PRESENT BIRD DISTRIBUTION

There is an apparent close primary relationship between most species of birds on Kauai and the vegetation of their habitats, a relationship which must be accompanied by important correlations with food, nesting, and other habits. The major factors which have changed and are changing the flora of Kauai are:

1. Clearing and planting areas for agricultural use, especially sugar cane, pineapple, and pasture grasses.

2. Introduction of plants for various reasons (as presumably esthetic, for shade, fruit, and so on) and their subsequent spreading. Examples—*Melastoma, Rhodomyrtus,* blackberry, guava, Java plum.

3. Accidental establishment and spread of weed or pest species, such as lantana, Jamaica vervain, and Spanish clover.

4. Destruction of native flora by introduced grazing and browsing mammals—cattle, goats, horses, and pigs.

5. Disturbance of virgin conditions, as by man-made roads or clearings, so that exotic plants are able to spread and establish themselves.

6. Spread of nonnative plants by biological transport of seeds by introduced birds and mammals.

7. Destruction of native flora by disease or fire.

We shall not attempt to discuss each of these factors, nor would it be possible to adequately chronicle the history of many plant species in many regions, but some additional points may be made with regard to certain influences.

The exotic plants which most readily become established and dominant in areas of native vegetation appear to be the principal factor in the reduction of habitats of most of the species of native forest birds. The uluhe fern (*Dicronopteris linearis*), although probably naturally occurring in the Hawaiian Islands, has taken over many extensive lower mountain slopes (see Fig. 7). It has come into areas where overgrazing or other factors have opened up the native forest, often becoming so thick that it precludes regeneration of key native species, such as ohia, for instance. The blackberry (*Rubus,* apparently at least two species) was purposely introduced to Kauai in the Kokee region in about the 1930's, and although it provides fruit for introduced birds and man, its ability to become established and spread, choking out almost all else, constitutes a major threat to the native flora and birds. Extensive areas of blackberry now exist throughout the mixed koa and ohia forest and at the edges of the virgin forest, as near Kaholuamanu (see Fig. 9). Patches of *Rubus* are becoming established at disturbed spots in the virgin forest, for example, at the Koaie Cabin, but neither this plant nor other introduced species appear able to get started in the virgin forest unless disturbance (such as overgrazing or clearing) makes it possible. The intentional introduction of foreign trees, especially self-spreading species like the fire tree (*Myrica faya*) already known to be a serious threat on Hawaii, will effectively eliminate native flora and fauna.

Grazing and browsing mammals, especially goats, have already had a considerable part in the elimination of most of the native flora from the sides and upper edges of major canyons, such as Waimea, and their branches, and from the canyons and slopes of the Na Pali coast (Fig. 16). Most of these areas are now essentially barren, supporting no native and few other birds, and allowing excessive runoff and erosion. Goats are now encroaching on native forest,

especially along available roads or trails such as the road started toward Haena from Kalalau Lookout or along the Kohua Ridge trail even up to about 3,750 feet. Cattle and, secondarily, horses have probably been primarily responsible for opening up lowland valleys and upland forests, thus initiating changes in the native flora. Livestock still penetrate deeply into the virgin forest on Robinson property above Kaholuamanu, and uncontrolled cattle have been allowed to remain for years on some state land, for example, Hanakoa Valley and the Forest Reserve above Ka Loko Reservoir.

Pigs are widespread over Kauai and were seen in the dry, introduced scrub of Kipu Kai, the mixed koa forest, as that of the Kokee region, and the most

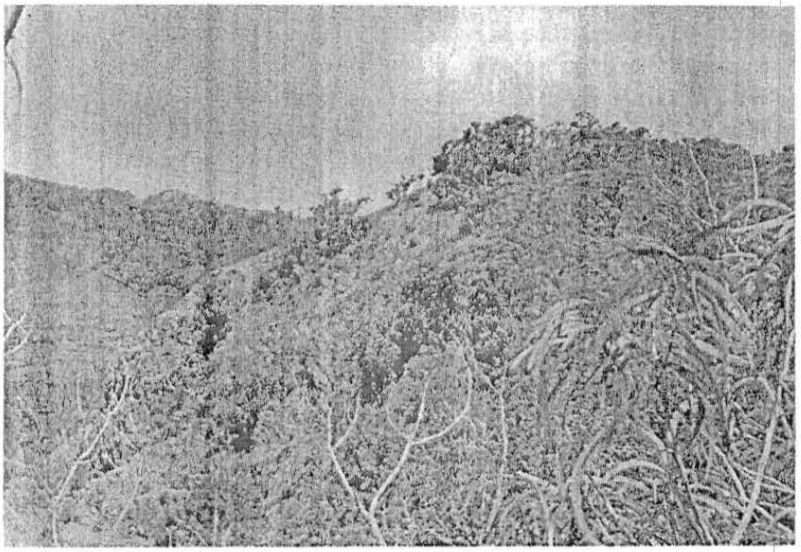


FIGURE 16.—Head of Waimea Canyon near Halemanu showing overgrazing by goats encroaching into koa and ohia forest. Goats were abundant on the rocky, open canyon slopes starting at the left.

virgin areas of mixed ohia forest, as in the upper Koaie River. Even in the latter forest, pigs, in spite of their extensive rooting, do not seem to bring about the marked vegetation changes caused by other ungulates. Pigs were seen to have destroyed tree ferns to eat the fleshy inner trunks, but otherwise the animals appeared to work under the native forest canopy without destroying it.

The introduction of some 10 black-tailed deer from Oregon into the forest of the Kokee region in the summer of 1961 seems an ill-considered and unnecessary step. This forest-inhabiting variety of mule deer, lacking predators and being largely inaccessible to hunters, could multiply dangerously.

Past and Present Distribution of Native Birds

Although detailed early records are few, there is no doubt that most of the resident native passerines of Kauai once had much wider ranges coincident with more extensive areas of native flora. Possibly some native species now move down to lower, nonnative habitats during the fall and winter, but we doubt that such altitudinal migration occurs to an appreciable extent and do not find evidence of it from other Hawaiian islands where native birds have been observed throughout the year. P. A. Baldwin (1953) found considerable shifting, some of it altitudinal, of populations of certain drepaniids on Hawaii, but the shifts were within native habitats.

On Kauai the seasonal shifting of native passerines that does occur appears to be within the high forested areas encompassing the Alakai Swamp region and the general Kokee region north and northeast of Waimea Canyon. All but the rarest of the native passerines share these forests, although there is much change in flora and climate from the wet ohia forest to the relatively dry, disturbed, dominantly koa forest. Some reports indicate that at least one species of native thrush and the creeper occur, perhaps seasonally, in the Kokee region, although they are found for the most part in the higher, more virgin, areas.

The records of ornithologists in the late 19th and early 20th centuries indicate that certain species—for instance, the oo, akialoa, nukupuu, and both thrushes—then had ranges down to near sea level, as on the north side of Kauai. These species are now absent even on the edges of disturbed native forest, as at Kaholuamanu and the Waialae Stream Forestry Cabin, close to the virgin Alakai Swamp area.

In contrast to native passerines, now quite restricted in their ranges, are the following native species: elepaio, amakihi, anianiau, akepa, apapane, and iiwi. All of these species, although undoubtedly occupying smaller ranges than they did before changes in or destruction of native forests, apparently still occur over perhaps a third of Kauai, or more than 175 square miles. They occur in extensive areas of much-changed native forest, as for example near growths of blackberries, introduced acacias, or karaka (*Corynocarpus*) in the Kokee region; near growths of guava as in the Ka Loko Reservoir area; or in such areas as the upper Wailua River drainage, where the fern *Dicronopteris* has supplanted much of the native plant cover. Perhaps the continued occurrence of numbers of koa or ohia trees in these regions is sufficient to enable these native birds to survive, or even to prosper, as in the case of the apapane particularly.

CONCLUSIONS AND RECOMMENDATIONS

ALTHOUGH THE BIRD HABITATS on Kauai have been greatly reduced or altered, especially during the past century, fewer and less marked changes are now taking place; hence, most species of birds now present may be expected to maintain their numbers and distribution under existing conditions. It might be a serious mistake, and entirely unnecessary, to introduce more birds to Kauai. Diseases cannot be completely guarded against nor can one always be sure that introduced species will not invade the critically small remaining virgin areas. The recently introduced cattle egret may spread in the lowlands without harm, but Reeve's pheasants now introduced into forests near Kokee (where we do not think hunting of them will be allowed even if they become numerous) could spread in this high country and possibly destroy something of such balances as now exist between native or nonnative fauna and flora. Some introduced birds, for instance the white-eye and Chinese thrush, have penetrated the most remote virgin Alakai Swamp areas and undoubtedly have been there now for many years; but other species, such as the mynah and leiothrix, have not gone beyond the fringes of virgin areas where introduced plants stop.

THE FUTURE OF NATIVE PASSERINES OF KAUAI

Even the rarest native passerines have now been exposed for several decades to the competition and possible diseases of a number of introduced birds; and some foreign mammals, invertebrates, and plants are present even in the most remote areas. Nevertheless, all of Kauai's native birds presumably have some ability to adapt themselves to at least a partially changed ecology and thus have survived; and there is every reason to hope that they will continue to do so—even if in small numbers—provided present conditions can be maintained. It is probably too late to reclaim native habitats, except where they are not too greatly disturbed; but it is entirely feasible to prevent appreciable change of the virgin Alakai Swamp forest region if certain steps are taken and regulations established or continued. With this in mind we have strongly recommended to the State of Hawaii Department of Agriculture and Conservation that approximately that portion of the Na Pali-Kona Forest Reserve

labeled and indicated on the United States Geological Survey topographic map of the Island of Kauai as Alakai Swamp be proclaimed a native forest sanctuary subject to the following regulations:

1. Permit no roads or clearings. Habitats are very rapidly changed by such development, introduced plants taking over very soon.
2. Keep horse trails to a minimum, but improve, mark, and extend foot trails. This would exclude not only most horses and their potential overgrazing, but also such people as are unlikely to truly appreciate the native area.
3. Allow no buildings except those already present, for instance, the United States Geological Survey huts. The erection of small trail shelters might be permissible if done without clearing the forest.
4. Allow no introduction of nonnative plants (including trees), birds or mammals (including game species). Ideally this regulation should apply to all of Kauai for one can rarely be sure that introduced species will not eventually spread to remote areas.
5. Regulate pig or other hunting, as judged best by the Division of Fish and Game from their studies.
6. Eliminate such introduced plants as are now in or near the area (for instance, a patch of blackberries at the Koaie Cabin and the fire trees around the Waialae Cabin).
7. Establish a continuing, small-scale program of rat, wild cat, and wild dog control. Rat poison put in selected spots, as under the four existing cabins of the area, could be a main part of this program.
8. Establish or maintain such fences as are necessary to prevent entrance of grazing animals. Stock on adjacent private property is currently being controlled in this way. Fences across the lower parts of certain ridges would prevent further invasion by goats.
9. Carefully restrict saddle- or pack-horse grazing.
10. Prohibit mining or other activities that could disturb the native flora and fauna.
11. Follow, in addition, regulations already set up for Forest Reserve areas.

If Kauai's chief native forest area can be protected and even somewhat improved by the above program, and if other and larger regions of disturbed native habitats can be partially protected or improved, especially by the control of certain introduced plants such as blackberries, the island should sustain and even increase its relatively rich native passerine avifauna for many years to come. Some harmony seems to have been achieved between native and introduced passerines where their ranges overlap, and this balance should continue if further introductions are avoided.

The Future of Native Nonpasserines of Kauai

Different problems present themselves if one attempts to assess the future of native nonpasserine species of birds in Kauai. One of the greatest problems here is the elimination or reduction of suitable marsh or pond areas for the resident coot, gallinule, and stilt, and for migrating or wintering waterfowl of various species. Care must be taken to preserve what suitable areas are left for these birds and also to restore additional marshy areas and give added protection to the resident species, all of which are now reduced to dangerously small populations. It is true that because of reservoirs there are now more bodies of water on Kauai than were originally present; but although these reservoirs provide resting places for waterfowl, the depth and fluctuating water level make them poor from the standpoint of both food production and suitable, stable nesting sites. Restoration of part of the once extensive marshes near Mana on westernmost Kauai should be undertaken and could be of the greatest benefit to the marsh birds and waterfowl.

The Hawaiian duck, the only resident anserine, poses different problems since it is now chiefly a bird of inland and mountain streams. The greatest remaining population, perhaps 300 individuals (Delacour, 1956), is on Kauai, and a carefully worked-out plan to better understand its needs for survival and increase should be initiated. Poaching of this duck by humans appears to be an important factor in its decrease, which could be alleviated by additional protection and publicity.

Of the five species of sea birds known to breed on Kauai, the wedge-tailed shearwater seems to be suffering the most from changed conditions, especially since it nests on accessible, open stretches of coast. Warden protection during the breeding season of May to November should at once be given the Kilauea-Mokolea and Ka Lae Paoo colonies. It should be determined whether feral dogs are indeed the serious predator on the shearwaters, and steps taken accordingly. The search should be continued to find and protect the breeding grounds of the Manx shearwater because our observations indicate that this species is still breeding in moderate numbers, very likely only on Kauai. The same may well be said of Harcourt's petrel even though we were not able to shed any light on its continued breeding on Kauai.

SUMMARIZING STATEMENT

A THREE-MONTHS' STUDY on Kauai during the summer of 1960, plus more recent brief trips and a review of the findings of other observers, has shown that all of the native species of birds, including rare endemic forms, still survive on the island. Numerous species of introduced birds flourish on Kauai, especially in man-made or modified habitats; but even where some foreign species are common in native habitats, native birds are surviving, some in remarkable abundance.

Kauai now becomes unique among the Hawaiian Islands in the continued existence of its native birds, and all possible efforts, state or national, should be made to insure the continuance or improvement of present habitat conditions which have enabled the survival of native species. The preservation of the fascinating, complex native flora of Kauai with its many endemic species is no less important and, indeed, essential to the existence of the birds. Ornithologists and other biologists have been and will increasingly be attracted to Kauai from many countries, emphasizing the responsibility of preservation of the island's all-too-limited virgin areas.

The present study, essentially a survey and review, is far from adequate in many respects. Much more should be learned of the distribution and habitat relationships of many birds on Kauai. Distribution as influenced by certain physical factors—rainfall, temperatures, and elevation—is poorly understood, as are seasonal changes in distribution. Contributions to the understanding of the breeding, feeding, and other habits of both native and introduced birds were quite fragmentary in the present study. These and a host of other ornithological and ecological subjects await investigation on Kauai in the years to come.

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