

## JOB PROGRESS REPORT

State: HawaiiProject Title: Statewide Non-Game and  
Endangered Species  
Program

Project No.: W-18-R-7

Study Title: Waterbird InvestigationsJob No.: R-III-CTitle: Abundance and Distribution of Koloa  
on the Island of HawaiiPeriod Covered: July 1, 1981 to June 30, 1982

## Summary:

Koloa were released on the Island of Hawaii in an attempt to re-establish the species in portions of their former range. A total of 361 birds was liberated in the Kohala mountains (Kahua Ranch) from December 1958 to October 1979. Another 58 Hawaiian ducks were set free in the Hilo Forest Reserve on December 1, 1980. Koloa were found to be firmly established in the former area, but their status was not determined in the Hilo Forest Reserve.

Dispersal from Kahua Ranch was extensive. Breeding birds were found up to 18 miles southeast and 7.5 miles northwest of the release site. Movements in other directions were less due to habitat limitations.

No population estimate was attempted, but koloa were found to be locally common. Areas supporting the greatest number of birds were the Kehena, Lalakea-Mahiki and Honokaia-Kapoaula sections of Parker Ranch in Kohala.

Koloa were distributed from Hawi to Paauilo with sightings being made from 900 to 4,600 feet elevation. The breeding range was only slightly more restricted. Nests or broods were found from Hawi to Ahualoa, between 1,000 to 4,000 feet elevation.

## Introduction:

The Hawaiian Archipelago supports three endemic species of Anatidae. They are the koloa or Hawaiian duck (Anas wyvilliana), Laysan duck (Anas laysanensis) and nene or Hawaiian goose (Branta sandwicensis). All three species are classified as endangered and are non-migratory.

Koloa formerly inhabited all of the main Hawaiian Islands. These birds were said to be common everywhere except on Lanai and Kahoolawe prior to 1900 (Henshaw 1902, Munro 1969). A general decline in the population was noted about the turn of the last century. This reduction in numbers was less evident on Kauai than on other islands. The status of the Hawaiian duck on the Island of Hawaii changed from numerous in 1897 to comparatively scarce by

1902 (Henshaw 1902, Bryan 1915). Schwartz and Schwartz (1949) failed to find any established populations on Hawaii during their game bird survey of 1946 and 1947. These same authors listed the bird as rare in 1953 (Schwartz and Schwartz 1953). Reasons for the drastic decline of koloa are not known, but habitat destruction, indiscriminate shooting and predation are often cited as possible important factors.

Efforts have been made to protect the Hawaiian duck since 1925. A territorial regulation was passed at that time prohibiting the hunting of koloa, but shooting of migratory ducks was still allowed. The regulation probably had little effect in preserving the species because of their physical similarity to female mallards and pintails. Duck hunting was temporarily banned in 1939 and 1940 and then permanently closed in 1942 (Swedberg 1969). Taking wild waterfowl has been prohibited since then.

Captive-reared koloa have been released on various islands in recent years. These ducks are presently established on Kauai, Oahu, and Hawaii. The population size on Kauai was estimated at 3,000 birds in 1967 (Swedberg 1967). No estimates are available for the other two islands, but their populations are not as great.

Objectives:

1. To locate and map wetlands utilized by koloa on the Island of Hawaii.
2. To compare the relative abundance of birds by area and habitat type.
3. To determine the geographic distribution and breeding range of koloa on Hawaii.

Procedures:

Considerable time was spent obtaining and reviewing all available reports and publications on koloa. Field notes dating back to 1970 were also reviewed and pertinent data extracted. An extensive collection of waterfowl articles was then gathered to aid in other phases of this investigation. Planning activities included the designing of field forms and development of a wetland habitat classification system. Koloa growth and development stages were documented by photographing captive ducklings once each week from hatching to 8 weeks of age.

Information on the distribution of koloa and location of breeding sites was obtained from interviews with various ranchers, State and County Water Department personnel, taro farmers, State and Federal Wildlife employees and sugar plantation ditch supervisors. Surveys were also conducted throughout the

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Kohala Mountains and adjacent ranch lands to substantiate observations made by others and to locate and map wetlands utilized by koloa. Dispersal was defined as movement from the release point to a breeding site. The geographic range of the species was determined by delineating the area where birds were known to occur based on repeated field observations. This did not include areas of unsubstantiated or occasional sightings.

#### Findings:

##### Captive Propagation and Release

A program to re-establish koloa on the Island of Hawaii began in the mid 1950's. Breeding stock for this project was initially obtained from birds wild-caught on Kauai. The flock was later supplemented with a few ducks from zoological collections. Captive koloa were installed in pens at the Pohakuloa Endangered Species Facility and propagated under the direction of A. F. Lee. The first record of young being produced at the facility was in 1957. Limited releases of adults and juveniles were made in 1958 and 1959 at Kahua Ranch (4,000 feet elevation) in the Kohala Mountains (Swedberg 1959). No additional introductions were made again until 1968. From then on, birds were set free on a more regular basis at the same location. A final release was made on October 25, 1979. The total number of ducks liberated during this period was 361 (Table 1). Paton (1981) incorrectly listed this number as 416 birds. Hawaii Division of Forestry and Wildlife Job Progress Reports W-5-R-20, W-15-1 to 5, and W-18-R-1 to 5 documents each release and describe the procedures used.

Once it was recognized that koloa were firmly established in the Kohala Mountains, another area was selected for re-introduction attempts. The Hilo Forest Reserve was thought to be a suitable location and a release pen was constructed near the Wailuku River (3,650 feet elevation). This site is 14 miles west of the town of Hilo and 45 miles southeast of Kahua Ranch (Fig. 1). A total of 48 koloa (32 drakes and 26 hens) was placed in the pen on December 1, 1980. These birds had all left the enclosure by January 4, 1981. No other releases were made.

The status of koloa at the Hilo Forest Reserve is not known at the present time. Reports from pig hunters indicate that some birds survived the release and were utilizing streams in the forest. Field surveys are planned for this area during the next segment.

##### Dispersal from the Release Site

It is difficult to know how much dispersal from Kahua Ranch occurred unless it is assumed that no residual koloa population was present when the first birds were set free. If this assumption is true, then the re-introduction program was extremely successful with breeding birds becoming established at considerable distances from the point of release.

Free flying adults and two broods of young were sighted at Kahua Ranch only 7 months after the first birds were liberated. No positive records of dispersal from this area were obtained until 10 years later; however, S. Shima flushed two adults from a stream in the Kohala Watershed on October 30, 1968 (Swedberg 1969). This location is approximately 8 miles southeast of the release site. I saw two more koloa in the same area on April 9, 1970. Additional range expansion in the same direction was verified in 1981 when breeding pairs were found at Ahualoa. This is a distance of about 18 miles from Kahua Ranch. Evidence indicates that koloa were nesting on the plateau east of Waipio Valley (Lalakea) since 1972 (G. Rapozo, pers. comm.) and at Ahualoa beginning about 1977 (C Stevens, pers. comm.). Adults were utilizing ponds at Paauilo from at least 1978 (W. Slater, pers. comm.), although no breeding has been reported in this area.

Movements up to 3 miles northwest of the release site occurred by 1971. Birds were breeding in the Kehena area at that time (Kosaka 1972). Broods were found above Kapaau in 1977 (Kosaka and Saito, 1977). This area is located near the northern tip of the island and is 7.5 miles from the release point. Further dispersal to the north is limited by coastal boundaries.

A more or less unbroken band of suitable koloa habitat extends from the Kohala Mountains to the Hilo Watershed. It is likely that Hawaiian ducks will continue to expand their range throughout this area if they haven't already done so. In fact, one adult and a brood of five ducklings was reported at Keanakolu in June 1982 (D. Kaniho, pers. comm.). This area is about midway between the Hilo Forest Reserve release site and the eastern edge of the confirmed breeding range. The point of origin for the Keanakolu birds cannot be determined with any degree of certainty, however. Ducks could have dispersed from either of the two release sites after December 2, 1980. Movements of up to 26 miles from the point of release have been observed on Oahu (Giffin and Saito, 1980).

Homing behavior was noted in released birds. Four different individuals (two drakes and two hens) returned to the Pohakuloa Endangered Species Facility where they were hatched. This is a distance of approximately 28 miles. The time interval between leaving the release pen at Kahua Ranch and reaching Pohakuloa varied from 24 to 86 days (A.F. Lee, pers. comm.).

#### Abundance

A koloa population estimate was not attempted during the study segment. This work must await the development of a suitable census techniques and be based on results of behavior and movement studies. Some indication of relative abundance was obtained, however, from limited field surveys.

Koloa should probably be classified as locally common in the Kohala Mountains. They were not numerous anywhere, but appeared to be present in most areas with suitable habitat. Unlike migratory waterfowl, these ducks were seldom seen in large flocks. Singles or pairs were most often encountered.

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Three key koloa areas were identified within the species range. These were the Kehena, Lalakea-Mahiki and Honokaia-Kapoaula sections of Parker Ranch. All three areas are grazed by cattle and contain numerous stock ponds, streams and ditches. The greatest number of koloa observed at Kehena was 25. These birds were flushed from a single pond (July 31, 1980). This is also the largest group encountered to date. Up to 16 koloa were sighted at Lalakea-Mahiki on a single day (May 12, 1982). Only nine individuals were found in the Honokaia-Kapoaula area, but sightings were frequently made by Parker Ranch cowboys.

Little data on duck abundance were obtained from riparian habitats. Three koloa were flushed along a 0.6 section of Lalakea Stream and one other bird was found in a 1.2 mile long tributary. No birds were found during a 0.8 mile search of Honokaia Gulch. Running water was not present at this location, but scattered pools did provide some duck habitat. Swedberg (1967) found an average of 1.38 koloa per mile along 122 miles of upland streams and ditches on Kauai.

### Distribution

The known geographic range of koloa encompasses an area of about 106 square miles. It extends from Hawi in the north to Paauilo in the south. The width of the range was not bounded by any particular landmark and was much narrower due to restricted habitat availability. Elevational distribution of the species extended from 900 to 4,600 feet based on 130 sightings. More than half (53%) of the observations were made between 2,500 and 3,000 feet in elevation. The actual distribution of koloa in the Kohala Mountains is probably greater than indicated here. There is some evidence that birds occupy areas from sea level to the summit (5,505 feet elevation). Several sightings of koloa were reported at Pololu and Waipio Valleys, but these have not been substantiated. There also exists a vast network of suitable streams in lowland and upland forests on the northern side of the mountain. These areas are nearly inaccessible and are infrequently visited by man. They probably support a few ducks.

Koloa are occasionally seen by experienced waterfowl observers at locations outside the known range. Mature birds were reported at Puu OO (Paton, 1981), Makalawena (Swedberg 1969, Shallenberger 1977) and Puna Sugar Company settling ponds (P. Paton, pers. comm.). The source of these ducks is not known.

Information on the distribution of breeding birds was determined from sightings of nests and broods. All reports of young were used because koloa are the only species of wild duck known to breed on the island. Also, nesting sites were generally isolated and therefore not occupied by domestic waterfowl.

The koloa breeding range extended from Hawi to Ahualoa. Elevational distribution of nests and broods ranged from 1,000 to 4,000 feet (Fig. 2). A single, exceptional sighting of one adult and brood of five ducklings was reported on the northeastern side of Mauna Kea at Keanakolu (5,400 feet elevation). This observation was made by a Parker Ranch foreman in an area that is outside the known range of the species. I was unable to confirm the sighting, but feel it is valid.

#### Habitat Preference

Koloa were flushed from seeps, stock ponds, small reservoirs, ditches and mountain streams. Stock ponds and fast flowing streams appeared to harbor the greatest number of birds. Ponds were surveyed almost exclusively because of their ease of access and the need to maximize koloa contacts. Therefore, it was not possible to determine which of the two major habitat types was most important for koloa. Swedberg (1967) found that Hawaiian ducks on Kauai used upland streams all year and that they were evenly distributed along these waterways.

Ponds supporting koloa were usually less than one acre in size. They were typically situated on moderately sloping pastures and had grassy shorelines. Emergent vegetation was usually sparse. Floating-leaved plants and submergents were noted at some of the sites. Duck activity was greatest in isolated areas where ponds were clustered or near major drainage systems.

Streams utilized by koloa were shallow and bordered by pasture grasses or dense forest vegetation. Potholes and small pools in the stream bed were apparently preferred.

#### RECOMMENDATIONS:

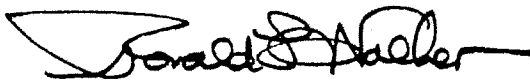
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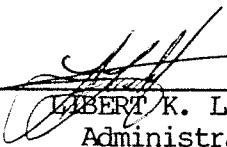


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Date: NOV 9 1982

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FINAL REPORT

State: Hawaii

Project Title: Statewide Non-Game  
Endangered Species Program

Project Nos.: W-18-R-7  
W-18-R-8

Study Title: Waterbird Investigations

Job No.: R-III-H

Job Titles: (1) Abundance, and Distribu-  
tion, of Koloa on the  
Island of Hawaii.

Period Covered:

July 1, 1981 to July 31, 1983

(2) Movements, Survival,  
Reproductive Success and  
Habitat of Koloa on the  
Island of Hawaii

Summary:

Koloa were released on the Island of Hawaii in an attempt to re-establish the species in portions of its former range. A total of 361 birds was liberated in the Kohala Mountains (Kahua Ranch) from December 1958 to October 1979. Another 58 Hawaiian ducks were set free in the Hilo Forest Reserve on December 1, 1980. Dispersal from Kahua Ranch was extensive. Birds moved up to 25 miles southeast and 7.5 miles northwest of the release site. Native ducks were found to be firmly established in windward areas on the northern half of the island. They were distributed from Hawi to Puu Oo with sightings being made from 900 to 6,400 feet elevation. The breeding range was only slightly more restricted. Nests and broods were recorded from Hawi to Keanakolu between 1,000 and 5,440 feet elevation. No population estimate was attempted, but koloa were found to be locally common. Areas supporting the greatest number of birds were Kehena, Lalakea-Mahiki and Honokaia-Kapoaula sections of Parker Ranch. Hatching dates were obtained for 18 broods. Two-thirds of the young hatched during the period April through June and one-third from July through January. The mean size of 22 broods was four ducklings. Survival of young was poor. No wild birds were instrumented with radio transmitters as planned. Therefore, little movement data were gathered. Upland ponds and streams were found to be the two habitat types used most frequently by koloa. Factors influencing the use of ponds were size, water depth, shoreline vegetation, and distribution of impoundments. Desirable elements for streams were not determined. Management strategies are presented for insuring the survival of the species.

Introduction:

The Hawaiian Archipelego supports three endemic species of Anatidae. They are the koloa or Hawaiian duck (Anas wyvilliana), Laysan duck (Anas laysanensis) and nene or Hawaiian goose (Nesochen sandvicensis). All three species are classified as endangered and are non-migratory. The Northern mallard (A. platyrhynchos) is the presumed ancestor of the koloa (Lack, 1970, Weller, 1980).

Koloa formerly inhabited all of the main Hawaiian Islands. These birds were said to be common everywhere except on Lanai and Kahoolawe prior to 1900 (Henshaw 1902, Munro 1969). A general decline in the population was noted about the turn of the last century. This reduction in numbers was less evident on Kauai than on other islands. The status of the Hawaiian duck on the Island of Hawaii changed from numerous in 1897 to comparatively scarce by 1902 (Henshaw 1902, Bryan 1915). Schwartz and Schwartz (1949) failed to find any established populations on Hawaii during their game bird survey of 1946 and 1947. These same authors listed the bird as rare in 1953 (Schwartz and Schwartz 1953). Reasons for the drastic decline of koloa are not known, but habitat destruction, indiscriminate shooting, and predation are often cited as possible important factors.

Efforts have been made to protect the Hawaiian duck since 1925. A territorial regulation was passed at the time prohibiting the hunting of koloa, but shooting of migratory ducks was still allowed. The regulation probably had little effect in preserving the species because of their physical similarity to female mallards and pintails (Anas acuta). Duck hunting was temporarily banned in 1939 and 1940 and then permanently closed in 1942 (Swedberg 1967). Taking wild waterfowl has been prohibited since then.

Captive-reared koloa have been released on various islands in recent years. Native ducks are presently established on Kauai, Oahu, and Hawaii. The population size on Kauai was estimated at 3,000 birds in 1967 (Swedberg 1967). No estimates are available for the other two islands, but their populations are not as great.

#### Objectives:

1. To locate and map wetlands utilized by koloa on the Island of Hawaii.
2. To compare the relative abundance of birds by area and habitat type.
3. To determine the geographic distribution and breeding range of koloa on Hawaii.
4. To investigate the survival and dispersal of pen-reared koloa released on the Island of Hawaii.
5. To investigate the movements, reproductive success, and habitat use of koloa inhabiting the Kohala Mountains on Hawaii.

#### Background:

This study was terminated because of man-power limitations and commitments and overriding commitments to the Alala project. No koloa were released with radio tracking transmitters and, therefore, objectives 4 and 5 were not totally met. Job No. R-III-J, "Determination of the Feasibility of Koloa Restoration on the Island of Hawaii" was cancelled. Establishment of

Koloa on Hawaii has been verified. This is a final report for the study covering the period July 1, 1981 through June 30, 1983.

#### Procedures:

Considerable time was spent obtaining and reviewing all available reports and publications on koloa. Field notes dating back to 1970 were also reviewed and pertinent data extracted. An extensive collection of waterfowl articles was then gathered to aid in other phases of this investigation. Planning activities included the designing of field forms and development of a wetland habitat classification system. Koloa growth and development stages were documented by photographing captive ducklings once each week from hatching to 8 weeks of age.

Preliminary information on the distribution of koloa and location of breeding sites was obtained from interviews with numerous ranchers, State and County Water Department personnel, taro farmers, State and Federal Wildlife employees, and sugar plantation ditch supervisors. Surveys were then conducted to substantiate sightings made by others, to locate and map wetlands utilized by the species and to determine relative abundance of ducks. Dispersal was defined as movement from the release point to a breeding site. The geographic range was delineated by mapping the area where birds were known to occur based on repeated field observation. This did not include areas of unsubstantiated or occasional sightings. Systematic searches for breeding ducks were not attempted during the study. Observations of nests and broods were obtained incidental to other activities. All sightings of young wild ducks reported by others were attributed to koloa because migratory waterfowl rarely breed in Hawaii.<sup>1/</sup> Also, nesting sites were generally isolated and, therefore, not occupied by domestic ducks.

Koloa hatching dates were established by back-dating from estimated ages. Young ducks were aged based on body size and feather development. This technique is subject to considerable error due to the extreme variability in duckling growth and feathering rates, even among members of the same brood.

Various methods of marking captive koloa were tested at the Pohakuloa Endangered Species Facility (PESF). Commercially produced urethane nasal saddles (small size), as described and evaluated by Greenwood (1977), were purchased from Max McGraw Wildlife Foundation (Dundee, ILL). These were trimmed with scissors to fit koloa and then attached to the bill with short nylon pins obtained from the same source. Standard attachment pins were slightly too long and were shimmed with a hand cut urethane washer for a tighter fit. The entire tag weighed 2 grams.

<sup>1/</sup> P. Paton (pers. comm.) observed and photographed one pair of blue-winged teal (Anas discors) with seven pre-flight young at Aimakapa Pond on June 13, 1982.

Methods of attaching radio transmitters were also tested on captive ducks at the PESF. Dummy units (12 grams) were used in all instances. Several harness configurations were evaluated using eight test birds and a control group of the same number. Breast-mounted units were held in place with polyethylene tubing (0.060 in. dia.). Unwaxed dental floss was inserted inside the tubing and used to tie the ends of neck and body loops together. All knots were glued to prevent slipping. The use of a floss core was desirable because this material will eventually decompose and allow ducks to discard their transmitters (D. Stoneburner, pers. comm.).

#### Findings:

##### Captive Propagation and Release

A program to re-establish koloa on the Island of Hawaii began in the mid-1950's. Breeding stock for this project was initially obtained from birds wild-caught on Kauai. The flock was later supplemented with a few ducks from zoological collections. Captive koloa were installed in pens at the PESF and propagated under the direction of A. F. Lee. The first record of young being produced at the facility was in 1957. Limited releases of adults and juveniles were made in 1958 and 1959 at Kahua Ranch (4,000 feet elevation) in the Kohala Mountains (Swedberg 1969). No additional introductions were made again until 1968. From then on, birds were set free on a more regular basis at the same location. A final release was made on October 25, 1979. The total number of ducks liberated during this period was 361 (Table 1). Paton (1981) incorrectly listed this number as 416 birds. Hawaii Division of Forestry and Wildlife Job Progress Reports W-5-R-20, W-15-1 to 5, and W-18-R-1 to 5 documents each release and describe the procedures used.

Once it was recognized that koloa were firmly established in the Kohala Mountains, another area was selected for re-introduction attempts. The Hilo Forest Reserve was thought to be a suitable location and a release pen was constructed near the Wailuku River (3,650 feet elevation). This site is 14 miles west of the town of Hilo and 45 miles southeast of Kahua Ranch (Fig. 1). A total of 58 koloa (32 drakes and 26 hens) was placed in the pen on December 1, 1980. These birds had all left the enclosure by January 4, 1981. No other releases were made.

##### Dispersal from the Release Site

It is difficult to know how much dispersal occurred from Kahua Ranch unless it is assumed that no residual koloa population was present when the first birds were set free. If this assumption is true, then the re-introduction program was extremely successful with breeding birds becoming established at considerable distances from the point of release.

Free flying adults and two broods of young were sighted at Kahua Ranch only 7 months after the first birds were liberated in 1958. No positive records of dispersal from this area were obtained until 10 years later;

however. S. Shima flushed two adults from a stream in the Kohala Watershed on October 30, 1968 (Swedberg 1969). This location is approximately 8 miles southeast of the release site. I saw two more koloa in the same area on April 9, 1970. Evidence indicates that koloa were nesting on the plateau east of Waipio Valley (Lalakea) since 1972 (G. Rapozo, pers. comm.) and at Ahualoa beginning about 1977 (C. Stevens, pers. comm.). Adults were utilizing ponds at Paauilo from at least 1978, although no reproduction was observed until 1983 (W. Slater, pers. comm.). This latter location is about 25 miles from the Kahua Ranch release site. Breeding birds were first reported at Keanakolu in July 1982 and confirmed in June 1983 when I found two broods at a stock-watering pond. Koloa have been observed regularly at Keanakolu since about 1981 by ranch employees (Walter Stevens, pers. comm.). The point of origin for the Keanakolu birds cannot be determined with any degree of certainty. Ducks could have dispersed from either of the two release sites after January 1981.

Dispersal up to 3 miles northwest of the Kahua Ranch release site occurred by 1971. Birds were breeding in the Kehena area at that time (Kosaka 1972). Broods were found above Kapaau in 1977 (Kosaka and Saito, 1977). This area is located near the northern tip of the island and is 7.5 miles from the release point. Further dispersal to the north is limited by coastal boundaries. Movements of up to 26 miles from the point of release have been observed on Oahu (Giffin and Saito, 1980).

### Distribution

The known geographic range of koloa encompasses portions of the north and south Kohala, Hamakua, and north and south Hilo Districts. It extends from Hawi at the northern tip of the island to the Saddle Road above Hilo. The width of the range is not delineated by any particular landmark and is fairly narrow. Elevational distribution of the species extended from 900 to 6,400 feet based on 166 sightings (figure 1). Almost three-fourths (72%) of the birds were encountered between 2,000 and 3,000 feet elevation. Perkins (1903) found koloa up to 8,000 feet elevation prior to the turn of the century.

Koloa are probably distributed throughout the entire Kohala Forest Reserve, from sea level to the mountain summit (5,505 feet elevation). Sightings are only available, however, for the western, southern, and eastern portions of the forest. There exists a vast amount of presumably suitable habitat in lowland and upland forests on the northern side of Kohala Mountain. Streams and pools in this area probably support a few Hawaiian ducks, but records are scarce. Koloa were reported at Pololu (R. Walker and C. Sproat, pers. comm.) and Waipio (L. Kaneshiro, per. comm.) valleys, but I was unable to confirm these sightings.

There is evidence that Hawaiian ducks have recently become established in portions of Hilo Forest Reserve. Sightings have only been made along the upper forest boundary, but it is likely that birds are utilizing streams and ponds in the interior. Paton (1981) observed three adult koloa at Puu Oo

(5,904 feet elevation) in October 1980 and I first encountered a single bird in the same area (5,000 feet elevation) on May 25, 1983. Flocks of up to six individuals have been sighted since then. This along with the occurrence of breeding birds at Keanakolu (5,400 feet elevation) and recent sightings (July 17, 1983) of adults at Hopuwai (6,400 feet elevation) confirm that the species is actively expanding its range.

Several extra-limited sightings of koloa have been recorded in recent years. Mature birds were observed at Opaepa Pond near Kona (Swedberg 1969, Shallenberger 1977) and at Puna Sugar Company Settling Ponds in Keaau (P. Paton, pers. comm.) The source of these ducks is not known.

Sightings of nests and broods aided in delineating the breeding range. Reproduction was observed from Hawi in North Kohala to Keanakolu on the north-east flank of Mauna Kea (Figure 2). Breeding occurred from 1,000 to 5,440 feet elevation based on 25 observations. More than half (52 percent) of the nests and young were found between 2,500 and 3,000 feet. The uppermost elevation is exceptional in that koloa were not known to breed above 4,000 feet prior to the discovery of two broods at Keanakolu. Breeding occurs from sea level to 3,550 feet elevation on Kauai, but the highest point on that island is only 5,170 feet. Over three-fourths (78 percent) of the 65 nests and broods reported by Swedberg (1967) were located below 500 feet elevation.

#### Abundance

A koloa population estimate was not attempted during the study. This work must await the development of a suitable census technique and be based on results of behavior and movement studies. Some indication of relative abundance was obtained, however, from limited field surveys.

Koloa should probably be classified as locally common in the Kohala Mountains. They were not numerous anywhere, but appeared to be present in most areas with suitable habitat. Unlike migratory waterfowl, these ducks were seldom seen in large flocks. Singles or pairs were most often encountered.

Three key koloa areas were identified within the species range. These were the Kehena, Mahiki-Lalakea, and Honokaia-Kapoaula sections of Parker Ranch. All three areas are grazed by cattle and contain numerous stock ponds, streams and ditches. The greatest number of koloa observed at Kehena was 25. These birds were flushed from a single pond on July 31, 1980. This is also the largest group encountered to date. Up to 16 koloa were sighted at Mahiki-Lalakea on a single day (May 12, 1982). Only nine individuals were found in the Honokaia-Kapoaula area, but sightings were frequently made by Parker Ranch employees.

A few observations were obtained (November 1980 to July 1983) concerning the average number of ducks present at stock ponds in the Kohala mountains. Two ponds in the Mahiki-Lalakea pastures were baited with grain (wheat and

cracked corn) to attract ducks for trapping while three others in the same area were not baited. The average number of koloa observed at baited ponds (Mahiki I and II) was 1.4 (N=35) with a range of 0 to 4. Unbaited ponds (Lalakea II, III, and IV) yielded an average of 0.6 birds (N=14) with a range of 0 to 4. The mean number of koloa per pond at Kehena (unbaited ponds) was 0.9 (N=25) with a range of 0 to 8 (Table 2). On Kauai, Swedberg (1967) reported an average of 4 koloa per reservoir. Most of these bodies of water were larger than the stock ponds surveyed on Hawaii.

Koloa population trend information is available for the Kehena area from 1971 to 1983. The total number of birds observed during surveys each year varied from one in 1971 to 25 in 1980. Releases of koloa were made almost annually at Kahua Ranch from 1968 to 1974 and then again in 1979. Increases and decreases in duck abundance followed these release periods (Figure 3).

Information on duck abundance in riparian habitats was obtained in only a few instances. Portions of Lalakea Stream were surveyed three times, covering a total distance of 3.2 linear miles. Results indicated an extremely high density of koloa in this perennial drainage system. The mean number birds flushed per mile of stream was 6.6 and ranged from 5.0 to 9.3. Birds were most abundant between 2,350 and 2,600 feet elevation. On Kauai, densities of up to 4 koloa per mile of stream were reported by Schwartz and Schwartz (1953) and Swedberg (1967) found an average of 1.4 koloa per mile along 122 miles of upland streams and ditches.

Two intermittent streams were each surveyed once. Both contained pools of water, but were not flowing. A 1.1 mile section of Hoaleipalaoa Stream (Kehena area) yielded one koloa and a 0.8 mile survey of Honokaia Gulch (Ahualoa area) yielded no birds. A flock of six koloa were observed flying up the latter stream bed, however.

### Reproduction

Endemic island waterfowl, such as the koloa, tend to show less restrictive breeding seasons than mainland birds. This presumably results from a more stable climatic regime (Weller, 1980). Perkins (1903) indicated that koloa nest at irregular times, but that the majority breed between March and June. On Kauai, Swedberg (1967) found nests or broods during all months of the year, except August, with 72% of the young occurring from December through May.

My results confirm the nesting dates reported above and also indicate that koloa do nest in August. A total of 18 broods was encountered during this study. Of these, 21 (67%) were hatched during the period April through June and 6 (33%) were hatched July through January. Months of hatching and number of broods were as follows: April - 4, May - 3, June - 5, August - 2, September - 1, October - 1, November - 1, and January - 1. In addition, Kosaka (1972, 1974) observed three broods in March, but no ages were given.

No information was obtained on the number of eggs laid by hens. However, Swedberg (1967) reported a mean clutch size of 8.3 eggs (range 2-10) for 11 nests on Kauai. The incubation period for koloa is 28 days (Swedberg 1967, A.F. Lee, pers. comm.).

Information on brood size was available in 22 instances. The number of young encountered ranged from 1 to 10 with a mean of 4.3 per hen. The actual mean was probably somewhat greater because ducklings were very secretive and some may not have been counted. Schwartz and Schwartz (1953) and Swedberg (1967) recorded brood sizes on Kauai ranging from 4 to 8 and 1 to 7, respectively. A mean brood size of 3.1 young was indicated for 50 nests by the latter author.

Survival of broods appeared to be poor. Five was the largest number known to reach the flying stage, but one or two was more usual. Dead ducklings less than 2 weeks old were found on several occasions, but the cause of death was never determined. One downy young was examined by a veterinarian soon after death. Necropsy results failed to reveal any indication of disease or predation. The bird was thought to be a victim of environmental stress.

Breeding birds were only found at stock ponds during this study. This was probably due to the fact that riparian habitats were rarely visited during the main breeding season. However, it is known that ditches and streams are frequently used for reproduction. On Kauai, half of the 50 nests and downy young report by Swedberg (1967) were found near flowing water and the other half were near ponds. The data suggests that ducks may be intentionally selecting pond sites over streams for nesting. The amount of shoreline available in the former habitat type is relatively scarce compared to that in the latter.

The koloa is similar to other dabbling ducks in that the hen incubates the eggs and the drake deserts his mate prior to the hatching of young. Departure times for males are probably similar to those exhibited by the mallard. Gilmer et al. (1977) found that 15 radio-marked mallard drakes left their hens an average of 4.1 days into incubation.

No nests were ever found even though ponds and reservoirs were sometimes searched with an experienced bird dog. On at least two occasions, new broods were located at a pond that had been searched 10 days earlier and yielded no nests. These nests were probably hidden in deep grass some distance from the water and therefore were missed by the dog. Many of the nests reported by ranchers were found on grassy slopes or ridges adjacent to ponds.

Breeding birds are prone to nest desertion if disturbed during incubation (Swedberg 1967, A.F. Lee, pers. comm.), but are reluctant to leave their young after they hatch. Hens with broods will sneak off into dense vegetation and hide at the first sign of danger. If flushed, they will usually feign injury by flopping across the water or ground or take flight and circle overhead, quacking repeatedly. When a dog chases a duck with young, the bird will often

fly slowly and close to the ground in order to lead the dog away from the ducklings.

Pre-flight young responded to humans and dogs by swimming around the pond and then sneaking into dense shoreline vegetation or by diving and swimming under water. On several occasions ducklings left the pond and were found in tall grass several hundred feet from water. Young also escaped capture from dogs by spreading their wings and submerging until only their nares were above the water surface. They would drift motionless in this position for extended periods. This ability to regulate buoyancy was only seen in young birds, but has been reported in flightless adults as well (Swedberg 1967).

#### Tagging and Radio Marking

Koloa at the PESF were fitted with numbered plastic neck bands and nasal saddles to test the acceptance of these marking devices under captive conditions. Four of the eight neck-banded birds repeatedly caught their lower mandibles under the bands. This marking system was abandoned when it was found that ducks were unable to free themselves from this situation.

Nasal saddles met with better success. These tags were applied to two males and two females on September 29, 1982. Birds were examined monthly for evidence of bill wear or weight loss. Nasal saddles were still in place at the end of this report period and the ducks exhibited no adverse effects from being marked.

Various methods of attaching transmitters were also tested in order to work out problems before birds were instrumented in the field. Most of these methods were not suitable for koloa.

Initial trials with tail, back, and neck-mounted transmitters all proved unsatisfactory. Ducks pulled out retricies with attached radio packages. A back-mounted unit was attached to one bird, but this individual removed it within a few days. Further tests with this system were not attempted because results of studies by Greenwood and Sargent (1973) indicated that back-mounted transmitters caused feather wear, skin abrasion, loss of body weight and partial aversion to swimming in captive mallards and blue-winged teal. Transmitters attached to the neck of birds in a pendant fashion restricted feeding and caused the death of one individual due to inanition. No attempt was made to instrument birds with bill-mounted transmitters, but some success has been reported using this method on dabbling and diving ducks (Swanson 1976, Perry 1981).

Breast-mounted transmitters produced none of the problems associated with other methods of attachment. Birds began losing these units after five weeks because of defects in bonding harnesses to the dummy radio packages, but three of the eight were still in place after 5 months of service. No feather wear, skin irritation or weight losses were detected in any of the treated birds. Gilmer et al. (1974) found that breast-mounted transmitters used on mallards

and wood ducks (Aix sponsa) caused little feather wear, skin abrasion or abnormal behavior.

### Baiting and Trapping

Baiting trials for attracting and trapping koloa were initiated on June 24, 1982. Cracked corn and wheat were scattered along the shoreline at two ponds on Parker Ranch (Mahiki-Lalakea area). Ducks were feeding heavily on the grain by July 16. Koloa were never actually observed taking the feed, but tracks and feathers were always found at the bait stations. Migratory waterfowl usually leave the islands by summer (Medeiros 1958) and were not observed in the area.

A portable wire trap similar to the one illustrated in Anon. (1956, Figure 19) was constructed and then installed at Mahiki I pond on November 5, 1982. Bait was placed inside the entrance and the door was left open. Ducks were going in and out of the trap to feed by November 23. However, no attempt was made to capture birds because of limited field time. The trap was dismantled on December 30.

### Movements

Little information was obtained on the movements of koloa since no wild birds were marked. However, diurnal movements of koloa between Lalakea Stream and stock ponds in pastures at Mahiki were suspected. Flights of ducks (probably koloa) were observed daily (9-12 a.m.) at Mahiki by a Parker Ranch employee. This individual reported that birds flew from Waipio toward Honokaa and that flocks of up to 18 birds participated in these flights. At the turn of the century, koloa were observed leaving the mountains at nightfall and moving to lowland rice and taro patches to feed (Perkins 1903).

Disturbance induced movements of broods were indicated by field observations, but could not be confirmed. Flightless young apparently made overland trips between adjacent ponds at Mahiki after being chased by dogs. A certain number of ducklings would be found in a pond one day, but missing the next. The exact same number (and similar sized birds) would appear a few days later at a nearby pond. The distance between two of these ponds was 0.5 mile.

Homing behavior was noted in captive-reared koloa released at Kahua Ranch. Four different individuals (two drakes and two hens) returned to the PESF where they were hatched. This is a distance of approximately 28 miles. The time interval between leaving the release pen and reaching Pohakuloa varied from 24 to 86 days (A.F. Lee, pers. comm.).

### Habitat Use

Koloa occupy both upland and lowland habitats. Perkins (1903) noted that these birds were equally at home in the mountains or on the hottest coasts. The former habitat is used much more extensively today, at least on the Island

of Hawaii. One reason is that low elevation wetlands are rapidly being drained and filled for agricultural uses and urban development. Also, the remaining low lying marshes, reservoirs and taro patches are subject to continuous human disturbance or intensive agricultural practices.

In upland habitats, koloa were flushed from seeps, stock-watering ponds, small reservoirs, ditches, and mountain streams. Stock ponds and flowing streams appeared to harbor the greatest number of birds. Ponds were surveyed almost exclusively because of their ease of access and the need to maximize koloa contacts. Therefore, it was not possible to determine which of the two major habitat types was most important for koloa. Swedberg (1967) found that over 95% of the koloa on Kauai lived along streams. He also noted that these ducks were evenly distributed along upland waterways and used them throughout the year.

Stock ponds that supported koloa were usually small with an average basin size of 10,485 sq. ft. (N=15, range 491 to 23,550 sq. ft). Lokenoen (1973) found that pond size was the habitat feature most highly correlated with duck use in North Dakota.

Water depth was indicated as an important factor in duck use. Koloa were most often found in shallow ponds (depths not determined) with gradually sloping shorelines. Deep bodies of water with steep banks were seldom used. Exposed mud flats apparently increased habitat value.

Shoreline vegetation also influenced habitat suitability. Ponds completely surrounded by tall emergents like cattail (Typha angustata) or bulrush (Scirpus spp.) were seldom used by koloa. Floating-leaved plants like water lilies (Nymphaea spp.) did not appear to discourage birds, however. Stock ponds used most frequently were typically situated on moderately sloping pastures dominated by introduced grasses like kikuyu (Pennisetum clandestinum) and pangola (Digitaria decumbens). The mean shoreline cover for 24 impoundments used by koloa consisted of 80 percent pasture grasses and two percent trees. Bare ground accounted for the remaining 18 percent. Emergent and floating-leaved vegetation covered 16 and 6 percent of the water surface, respectively, on the average. Only 32 percent of the ponds contained visible submergent vegetation.

The distribution of water impoundments is an important physical characteristic of waterfowl habitats. Lokenoen (1973) found that the use of ponds by pairs generally decreased as the distance from a pond to other water increased. Koloa activity was greatest in areas where ponds were clustered or where they were located near a perennial stream. The mean distance between ponds at Mahiki and Kehena (areas of greatest bird density) was 0.5 mile. Perennial streams were also present at both locations.

There was some evidence that breeding birds preferred ponds with ungrazed or lightly grazed shorelines over those that were heavily cropped by cattle. Tall, dense grasses probably offered good nesting and escape cover. Kirsch

(1969) found that pair numbers, nesting densities and nest success of upland nesting waterfowl in North Dakota were generally reduced by grazing.

Little information was obtained regarding the type of streams preferred by native ducks. Lalakea Stream supported the greatest koloa density of any drainage system surveyed. This may, therefore, infer optimum habitat conditions. Lalakea Stream is situated on the plateau above Waipio Valley and flows from 2,800 to 1,800 feet elevation before plunging to the valley floor. It is bordered on one side by open pasture and on the other by grazed forest. The stream channel has cut a deep gulch with banks that vary from a few feet to over 75 feet high. Water is clear, shallow, and fast-flowing. Numerous, deep potholes occur along the entire length of the rock strewn stream. The shoreline is heavily vegetated with Polygonum, ginger (Zingiber sp.), ferns, and native trees. Aquatic crustaceans and tadpoles are abundant at lower elevations, but decrease in numbers upstream. Access to the stream bed is possible at only a few points. Therefore, disturbances to ducks by dogs or humans is minimal.

#### Molting

No adult flightless koloa were encountered during this study even though a trained dog was used to search for them. Swedberg (1967) found flightless birds on Kauai in March, June, July, August, and September (nine observations). Molting in captive koloa at the PESF occurs from April through July. Age of first flight capability occurs at 9-10 weeks of age (A.F. Lee, pers. comm.).

#### Parasites and Disease

No evidence of parasites or disease was found in wild koloa except in one instance. Cestodes were retrieved from the cloacas of two young birds (approximately 40 days old) captured at Kehena. These were tentatively identified as Cloacotaenia megalops (J. Belfrage D.V.M., pers. comm.). This same parasite was also reported in koloa by Alicata (1964). Schwartz and Schwartz (1953) found two species of lice, Trinoton querquedulae and Anaticola crassicornis, infesting a single female captured on Kauai. Most of the captive koloa at the PESF have been examined for the presence of Salmonella and blood parasites. Fecal cultures and blood smears were all negative for these organisms.

#### Management Considerations and Recommendations

Koloa are currently well established on the Island of Hawaii and are expanding their range. A population increase has occurred even though factors that caused their earlier decline have not been fully identified or alleviated. Much of the success of the State's reintroduction program can probably be attributed to recent changes in habitat availability. A large number of irrigation reservoirs and stock-watering ponds have been constructed on upland farms and ranches in the past 30 years. Impetus for building these impoundments was provided by the Soil Conservation Service (SCS) and Agriculture

Stabilization and Conservation Service (ASCS) through their programs to furnish technical and financial assistance to qualified individuals. Records show that a total of 77 new ponds and reservoirs was developed on the island with ASCS funds since 1975 (L. Kunitake, pers. comm.). Most water storage basins were not built with waterfowl in mind, but many provide suitable feeding, loafing, and breeding habitat for koloa.

A number of specific management strategies should be developed to further ensure native duck survival. These include continued restrictions on hunting and development, implementation of a recovery plan, protection of nests from excessive human disturbance, control of exotic predators, avoidance of hybridization with domestic mallards, habitat protection and improvement, surveys to monitor population levels, research to provide an understanding of the species needs, and continuation of the captive breeding program.

Hunting restrictions on ducks should continue to be strictly enforced. Harvesting of native or migratory waterfowl is not feasible due to low population numbers. Limited open seasons on migratory ducks would lead to koloa losses through misidentification of species by hunters.

The development and implementation of recovery plans for endangered species is one approach for increasing their chances of survival. No such document presently exists for koloa. The U.S. Fish and Wildlife Service should be encouraged to expedite the preparation of a detailed koloa recovery plan.

Koloa are extremely wary, unlike other native waterfowl. These ducks will flush or hide at the first sign of danger. Favorite feeding areas will be abandoned and nests deserted if birds are excessively disturbed. Hens may also lead their young overland to adjacent wetlands if harassed, unnecessarily exposing their brood to predators. Disturbance can be minimized by locating new irrigation reservoirs and stock ponds away from buildings and well traveled roads and by posting known breeding areas to reduce public trespass.

Various predators prey on koloa including domestic dogs and cats, mongooses, and feral pigs. The impacts of these exotic pests is not known, but it may be substantial. Removal of predators by trapping and poisoning or exclusion by fencing is desirable in situations where birds are especially vulnerable to attack. Koloa release sites and prime breeding ponds fall into this category.

Mallards and koloa are known to interbreed and produce fertile offspring in captivity. However, only one hybrid nest has been confirmed in the wild (Kato, 1981). The threat of hybridization is a major concern on Oahu where feral mallards and koloa share the same habitat. No problem is thought to exist on the Island of Hawaii. The only real solution for preventing hybridization is to eradicate domestic mallards in areas occupied by koloa. Migratory mallards seldom visit the islands and are not known to breed here.

Habitat improvements can take many forms. Perhaps the most beneficial results can be obtained by modifying existing irrigation reservoirs and stock-watering ponds to increase their value for waterfowl. Recommended actions would include altering pond bottoms to create zones of shallow and deep water, creating sections of open shoreline in heavily vegetated marshes and fencing the shallow end of water basins where overgrazing is a regular occurrence. Protective enclosures should be irregular in shape and include high ground or a hill for nesting. The amount of land enclosed should be at least five times the water area (J. Sprague, pers. comm.). Plantings of aquatic and terrestrial food crops for ducks are also desirable.


New water impoundments developed under SCS and ASCS cost sharing programs should be designed to accommodate waterfowl. They should be located near natural wetlands or perennial streams whenever possible. Plans should specify small pond size (less than 1/2 acre), substantial areas of shallow plus deep water and grouping or clustering of basins (less than 0.5 mile apart). Bue et al. (1964) and Edminster (1964) present guidelines for developing stock ponds, dugouts and farm ponds that meet the needs of wild ducks.

Periodic surveys are needed to assess koloa population trends and to monitor the extent of range expansion. Streams and ponds on the windward side of Kohala Mountain and the interior of Hilo Forest Reserve should be searched for the presence of native ducks. Virtually nothing is known about the abundance and distribution of birds in these areas.

Continued research is vital to the success of any koloa re-introduction or management program. Information is needed regarding survival of captive-reared birds released into the wild, census techniques, home range size, daily movements, and habitat use and preference. Aerial radio tracking studies are essential to meet these research needs.

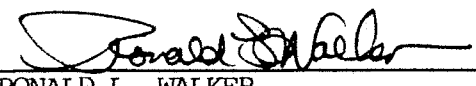
Captive propagation of Hawaiian ducks should be continued at the PESF, but only at the level necessary to maintain a small breeding flock. No further releases of birds are recommended for the Kohala Mountain area as long as the population remains stable. One additional release should be made at Hilo Watershed to augment existing stock.

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Table 1. Summary of Koloa Releases at Kahua Ranch, Island of Hawaii.

*Date	Drakes	Hens	Total	
December 12, 1958	--	--	21	
August 1, 1959	2	2	4	
December 6, 1968	30	22	52	
November 12, 1969	23	21	44	
November 6, 1970	19	23	42	
December 29, 1971	30	23	53	
November 14, 1972	29	26	55	
January 14, 1974	28	19	47	
October 25, 1979	25	18	43	
	TOTAL	186+	154+	361

\*Date birds were placed in release pen.

Table 2. Numbers of adult koloa observed at stock ponds in the Mahiki-Lalakea and Kehena study area, November 1980 to July 1983.

Mahiki I*	MAHIKI-LALAKEA AREA				KEHENA AREA						Old Kehena		
	Mahiki II*	Lalakea II	Lalakea III**	Lalakea IV	Waipuni I	Tribble	Kehena Res	Slater	Puu Manunu	Kehena I		Kehena II	Kehena VI
4	3	0	0	0	1	0	2	0	0	0	3	0	0
0	1	0	0	0	1	0	0	0	2	0	3	1	0
2	0	2	4	1	2	0	0	0	8	0	0	-	0
0	3	0	2	0	0	0	0	0	0	0	0	-	-
1	2	0	0	0	0	0	0	0	0	0	0	-	0
4	0	0	0	0	0	0	0	0	0	0	0	-	0
1	2	0	0	0	0	0	0	0	0	0	0	-	0
0	1	0	0	0	0	0	0	0	0	0	0	-	0
0	3	0	0	0	0	0	0	0	0	0	0	-	0
0	0	0	0	0	0	0	0	0	0	0	0	-	0
0	4	0	0	0	0	0	0	0	0	0	0	-	0
0	0	0	0	0	0	0	0	0	0	0	0	-	0
2	0	0	0	0	0	0	0	0	0	0	0	-	0
2	0	0	0	0	0	0	0	0	0	0	0	-	0
2	0	0	0	0	0	0	0	0	0	0	0	-	0
3	0	0	0	0	0	0	0	0	0	0	0	-	0
4	0	0	0	0	0	0	0	0	0	0	0	-	0
1	1	0	0	0	0	0	0	0	0	0	0	-	0
4	0	0	0	0	0	0	0	0	0	0	0	-	0
Average:	1.5	1.3	0.3	0.3	1.2	0.3	0.7	0	3.3	0	3	0.5	0

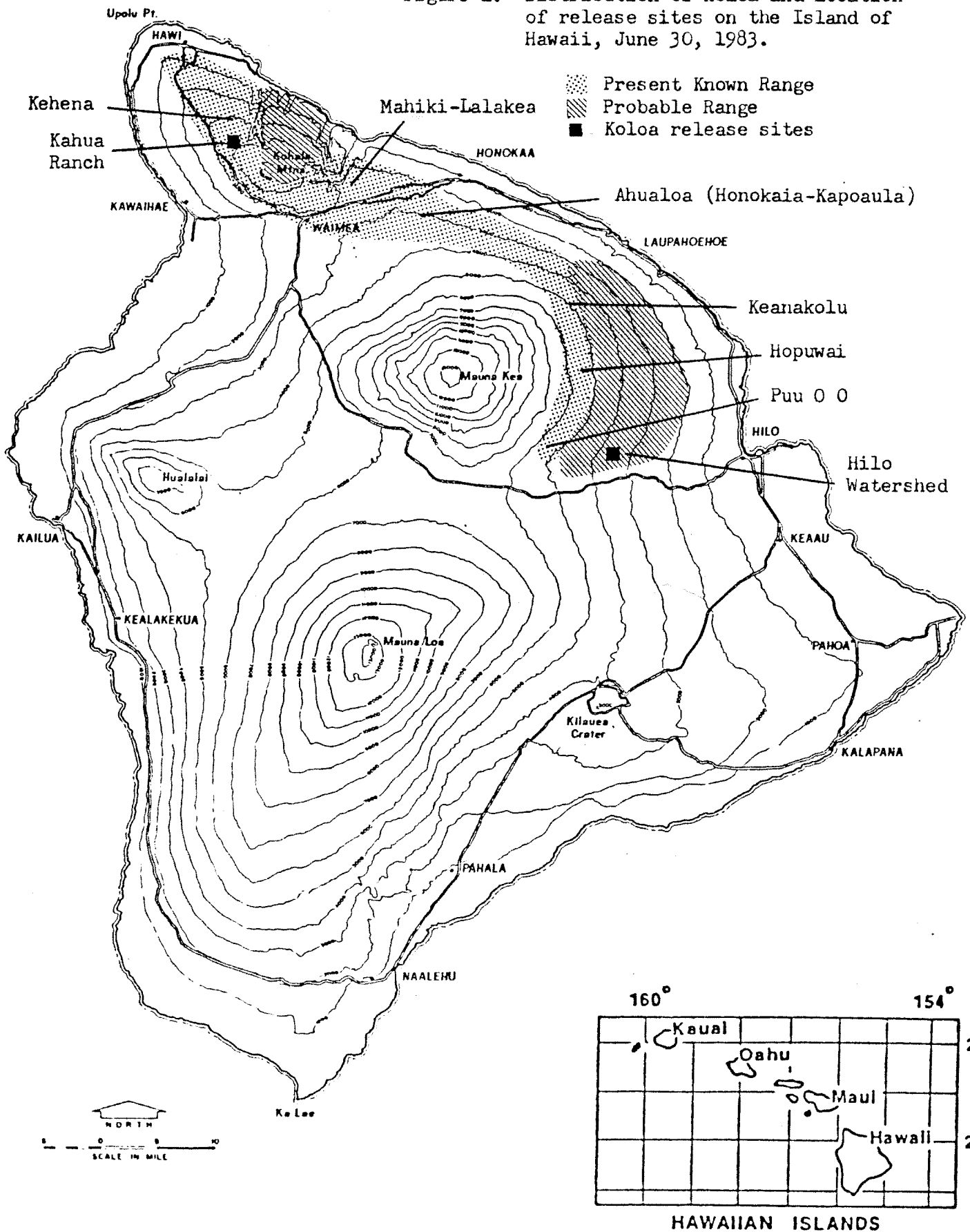
\* Baited Ponds

\*\* Twin Ponds



Ke

Figure 1. Distribution of koloa and location of release sites on the Island of Hawaii, June 30, 1983.



\* Baited Ponds  
 \*\* Twin Ponds

Figure 2. Kploa breeding areas on the Island of Hawaii, March 1971 to June 1983.

★ Breeding Areas

▲ Kahua Ranch Release Site

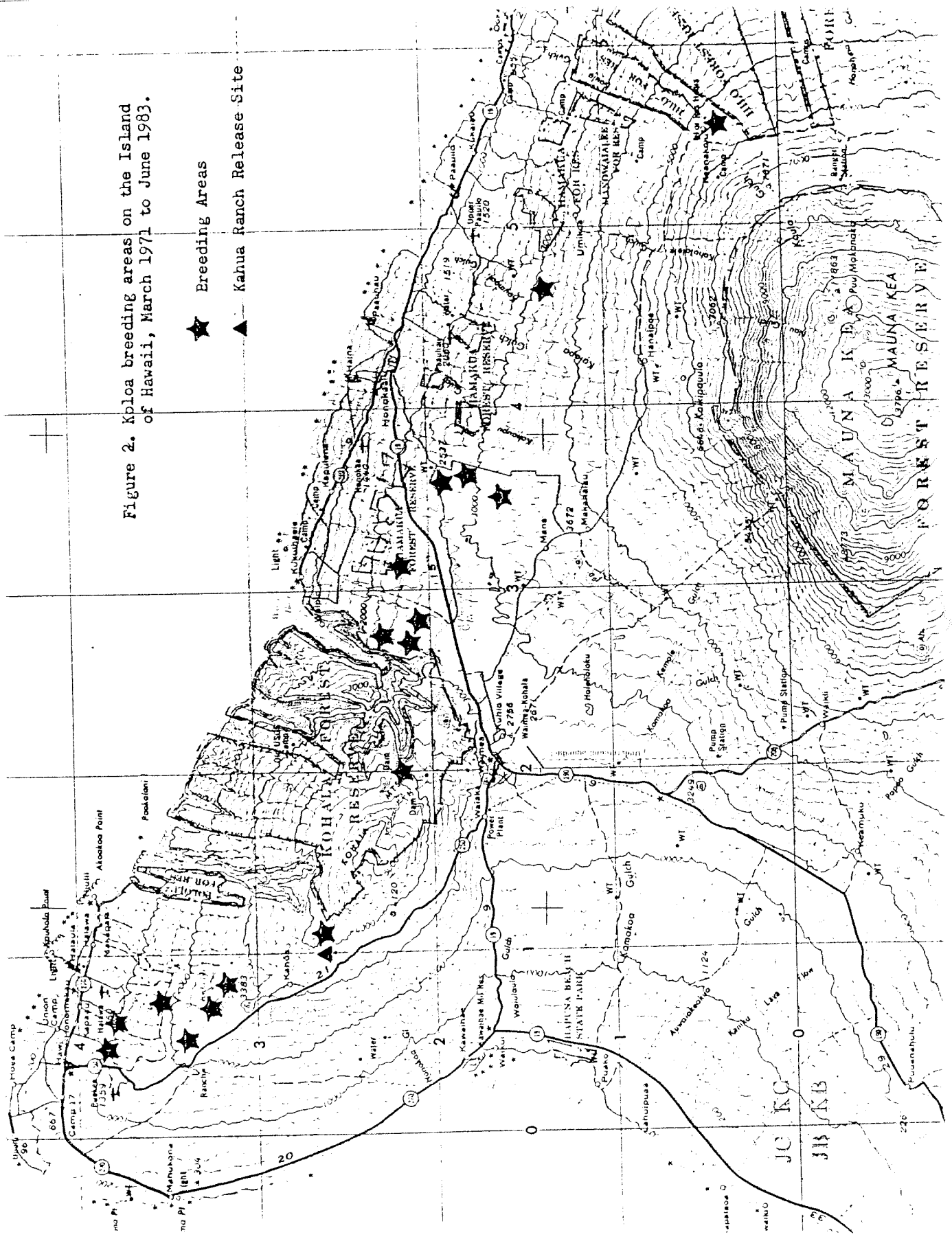
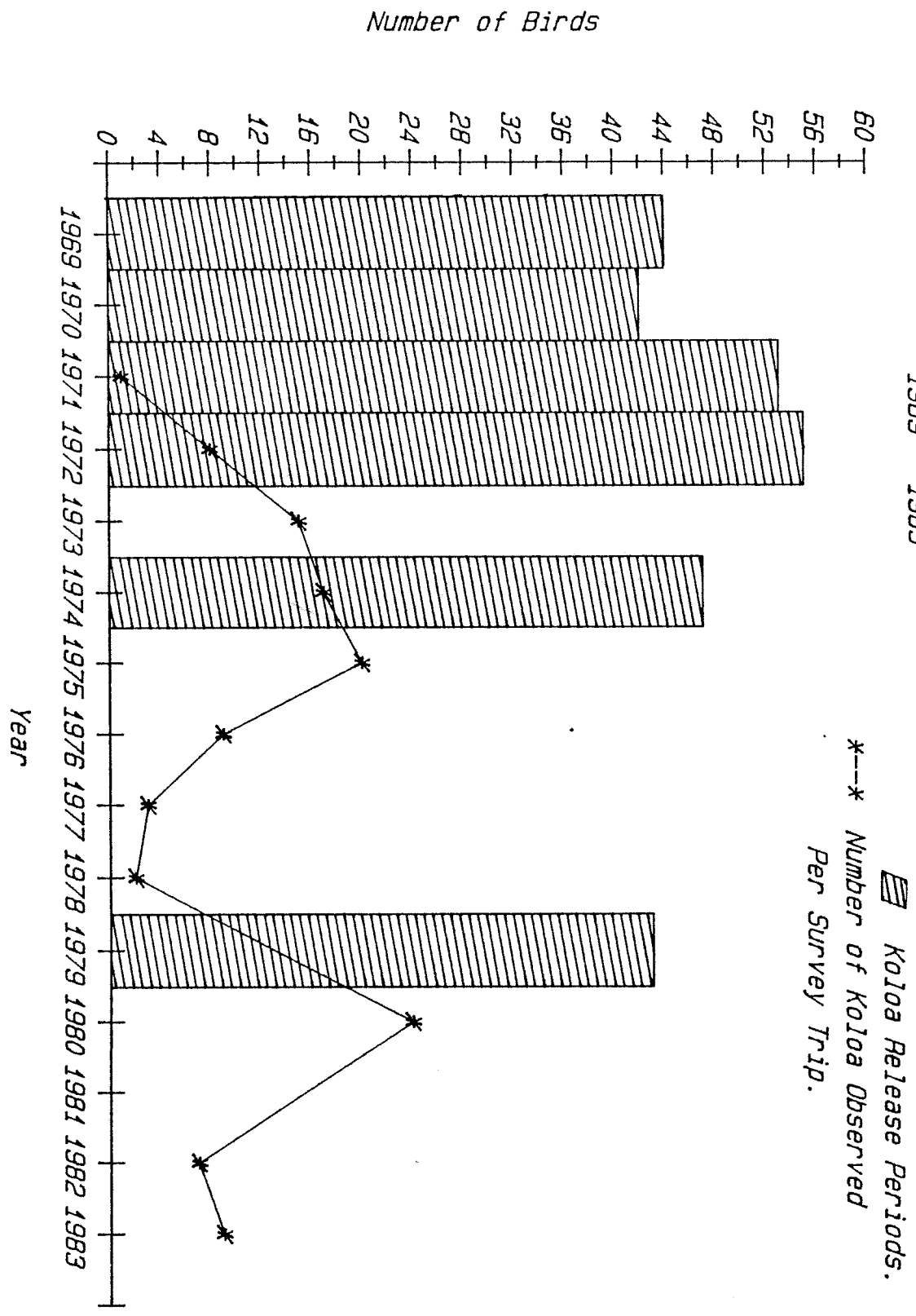


Figure 3. KOLOA POPULATION TRENDS AT KEHENA  
 CORRELATED WITH KOLOA RELEASE PERIODS  
 AT KAHUA RANCH, ISLAND OF HAWAII  
 1969 - 1983



Note: No Survey Data for 1969, 1970, 1979, and 1981

Figure 1. Distribution of koloa and location of release sites on the Island of Hawaii, June 30, 1983.

