

NENE REINTRODUCTION PROGRAM AND RESEARCH
IN HAWAIIAN NATIONAL PARKS

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The reduction of range and numbers of Nene (Branta sandvicensis), the Hawaiian Goose, within historic times has been an international concern of conservationists since P. H. Baldwin published the results of his literature and field survey 33 years ago (Baldwin 1945). At that time the wild population was estimated at about 50 individuals, but by 1951 only 30 were thought to exist in the wild (Smith 1952). A portion of this remnant population was breeding immediately adjacent to Hawaii Volcanoes National Park (HAVO) at high elevation--about 1980 m (6500 ft) (Elder & Woodside 1958). Nene have historically occupied high and low elevation habitats within HAVO (Baldwin 1945). However, traditional lowland nesting grounds have never been positively identified within the Park. The existence of Nene on Maui within Haleakala National Park (HALE) is less well documented than in HAVO, but the species was believed to have been breeding within Haleakala Crater prior to 1890 (Henshaw 1902; Perkins 1903).

Long before the need for conservation measures became apparent, Nene had been bred in captivity. The first record of successful captive propagation of the species was in 1834 when Lord Stanley, Earl of Derby, reared one gosling out of a clutch of four eggs laid at Knowsley, England (Stanley 1834). Young Nene were soon distributed to other private collections and zoos throughout Europe and eventually became fairly common in captivity (Delacour 1954). However, Nene had become rare in European collections after 1900 (Blaauw 1904) and finally disappeared when the last specimen, a 42-year old gander, vanished during the German invasion of France in 1940 (Delacour 1954).

The Hawaii Board of Agriculture and Forestry (now Department of Land and Natural Resources) began a captive breeding program in 1927 at the territorial Game Farm, Mokapu, O'ahu, having received a pair of Nene from Mr. Leighton Hind of Pu'u Waawaa Ranch (Smith 1952). Mr. Hind and Mr. Herbert Shipman of Hilo, who had been maintaining and breeding Nene since 1918, contributed additional birds to the territorial program and by 1935

the captive flock had grown to 42. In 1935, the flock was disbanded, and the birds were distributed to various individuals who were to continue captive propagation efforts. However, within 15 years, all but one had died, vanished, or had been released to the wild (Smith 1952).

The Board of Agriculture and Forestry began a new captive propagation project in 1949 at Pohakuloa which has eliminated the immediate threat of extinction and bolstered the number of Nene living in the wild through the release of captive-reared birds (DLNR 1966, 1968, 1970, 1974, 1974a). That the present population can increase or remain stable without additional annual releases has yet to be determined.

In fulfilling its mission to protect, manage, and restore native wildlife presently or historically found within Park boundaries, the National Park Service (NPS) began Nene propagation and release programs in HAVO and HALE in 1972. The goals of the HAVO program are to reestablish breeding populations in suitable low and mid-elevation habitats, to maintain and manage habitat at all elevations, and to control or reduce factors which are inimical to Nene survival. At HALE the objectives are similar, but the habitat available is restricted to high elevations. Research begun in 1976 is being integrated with NPS propagation-release programs to guide management decisions and to answer basic questions regarding Nene life history and ecology. Since I have been more directly involved in the HAVO research and management program, I will confine my remarks to this park.

The primary justification for directing propagation and release efforts at low and mid-elevations in HAVO has its basis in the observations of the naturalists of the 1890's. H. W. Henshaw (1902) commented on the lowland breeding range of Nene as follows:

It has been stated and seems to be the general impression that the nene rears its young in the uplands where it is found in summer, but such is not the fact. The greater number, probably all, leave the upper grounds beginning early in the fall, and resort to lower altitudes, from about 1,200 feet downwards. There are barren lava flats near the sea in Puna, Kona, Kau and Kohala, rarely indeed visited by man, and it is to these deserted solitudes that the nene resorts at the beginning of the love season.

The cause of the desertion of the uplands by the geese for the low-lying lava flats near the sea is doubtless the failure of the food supply in the former, at least of such as is adapted to the wants of the young. At high altitudes there is but a scanty crop of berries in winter, and most of the pualele dies; whereas near the sea there is an abundance of this plant and of freshly sprouted grasses during the winter and spring months.

R. C. L. Perkins (1903) also believed that Nene bred primarily in the lowlands:

As is well-known the Goose, like many other native birds, changes its abode at different seasons of the year, being no doubt chiefly influenced by the food supply. In the summer months it affects the open upland region, which is covered with a scrubby vegetation and traversed by many lava flows, such for instance as parts of the plateau between the three great mountains of Hawaii, at an elevation of four or five thousand feet above the sea. Near the crater of Kilauea about two miles from the Volcano House hotel flocks of some size may be occasionally seen in the later summer. In such situations it feeds on the abundant Ohelo berries (Vaccinium), on the wild strawberry (Fragaria chilensis) where the cattle still allow this to exist, and still more commonly on the black berries of the creeping Coprosma, one of the commonest plants in some of its favourite localities. In the winter months large numbers of these upland geese resort to the lowlands and remain there for such time as the vegetation is fresh and green, and they are said to breed during this season.

G. C. Munro (1944) provides further documentation of lowland breeding, as follows:

It [Nene] had become accustomed to semiarid waterless country where it obtained the moisture it needed from the upland berries on which it fed in the summer and the rich soft plants of the lowland lava flows where it wintered and raised its young . . . The sparse vegetation on the open lava flows is rich, especially on the lowlands in the wet season, hence the birds migrated to the lowlands to breed. These we collected there were much fatter than the specimens we took at about 2,000 feet elevation.

We hunted this goose in December 1891 on the rough lava flow of 1801, down nearly to sea level, and up the side of the mountain on the Huehue ranch to about 2,200 feet elevation. It was open shooting season and a party of hunters went over ground at the higher elevation where we had taken specimens a few days before. They found a nest with four eggs, caught two very young chicks and shot a young bird nearly full grown.

When the following record, reported in Baldwin (1945), is considered in the context of the observations of Henshaw, Perkins, and Munro, there is little doubt that the Nene was once a breeding resident of low and mid-elevations in HAVO:

An old Hawaiian resident of Puna, Sam Konanui, who traveled across the Puna lowlands to Kau around 1894, says Nene were plentiful above the inshore cliffs around 1,500 to 2,000 feet but not on the flats which line the shore. He saw them as far to the east as Panau.

In light of what was known about Nene in the 1890's, there is ample justification for attempts to reestablish a breeding population at lower elevations in HAVO. Further, since Hawaii State Division of Fish and Game (HSDFG) has operated its restocking program exclusively at high elevations--above 1525 m (5000 ft)--there is even a greater need for the HAVO program to concentrate on lowland population restoration. The overall effect of both state and federal programs will hopefully be to complementarily repopulate the full altitudinal range of Nene habitat, at least in Puna and Ka'u.

Besides focusing management efforts at different elevations, the HSDFG and HAVO programs differ fundamentally in the methods of propagation and release. HSDFG employs a "game farm" approach. Captive birds are intensively bred by incubating eggs artificially and naturally (by the goose) and by removing eggs of the first clutch so that a second or third clutch will be laid. Goslings are brooded artificially and naturally and are kept at Pohakuloa until their distribution to release pens prior to fledging. Once their wing feathers have fully emerged, the young are free to leave the release pen and begin their life in the wild.

At HAVO Nene are bred in pens which are already situated in habitats where wild populations are to be reestablished. The eight pens so far in use are located from 213 m to 1219 m (700-4000 ft) elevation and range in size from about 0.11 ha to 1.47 ha (0.27-3.63 acres). Pens 1, 2, and 3 are stationed in upper 'Ainahou where Mr. Herbert Shipman temporarily maintained his flock of semi-domesticated Nene from which the original stock was obtained for the HSDFG program in 1949. Pen 4 is situated near Kilauea Crater, 5 is stationed at Pu'u Kaone, 6 is found at Kukalau'ula Pali, and 7 and 8 are situated along the top of Hilina Pali in lower 'Ainahou.

Breeding inside HAVO is unmanipulated in that eggs are not removed for artificial incubation nor for obtaining a second or third clutch. Parents brood and rear their own goslings during the entire period prior to fledging. Once the young are capable of flight they depart from and return to the pen many times before becoming fully independent. By employing this method of propagation and release, young Nene have full contact with their parents and siblings, as well as free-living birds which frequently visit the pens. The young inside the pens also become quickly acquainted with the habitat which they will inhabit as fledglings and adults. In addition, the young are thoroughly acclimatized to the temperature and rainfall regimes with which they must cope in the wild.

Although Nene in HAVO pens are exposed to conditions similar to those in the wild they are not totally self-sufficient. Prolonged occupancy in the pens results in depletion of food plants, so a commercially available game bird ration is supplied regularly. Fresh drinking water is continually available, but Nene are prevented from bathing in the water and fouling it. Potential predators such as mongooses and feral cats, are trapped outside of the pens and are further discouraged from entering the pens by small-mesh, buried wire along the bottom portion of the pens. However, rats and mice occur in all of the pens and Barn Owls are present regularly at Pu'u Kaone.

HAVO breeding stock has been obtained from two sources, HSDFG and U. S. Fish and Wildlife Service (USFWS). HSDFG has contributed three pairs, one each in 1972, 1973, and 1976, plus three unpaired females and a male in 1976. All were raised at Pohakuloa. USFWS has contributed eight females and four males reared at Patuxent Wildlife Research Center, Patuxent, Maryland, and three females from Northern Prairie Wildlife Center, Jamestown, North Dakota. All USFWS birds were less than one year old when received in 1974. USFWS has since distributed its breeding flock to various U. S. zoos.

In any program involving penned birds there are deaths and escapes which deplete the stock. Opportunities for losses are probably higher in the type of program operating in HAVO because birds are unattended most of the time and predators, disease, or other factors may not be detected or prevented from occurring before damage is done. Eight captives have died and one has escaped from pens since 1972. In 1973, the only pair of Nene in HAVO died, apparently as the result of predation by feral cats which were trapped at the pen soon after the incident. One of the females obtained from Jamestown died of exhaustion in December 1974 while trying to free herself from a piece of fence wire which had become caught on her leg band. A pair of Patuxent birds died with one of their juveniles in August 1976. A predator may have been involved but the actual cause of death was impossible to determine since the carcasses were already decomposing when found. Two other juveniles were found unharmed in the pen. A Pohakuloa male died in a pen accident in January 1978. Again in January a Pohakuloa male and Patuxent female died in their pen. Both were emaciated although food was plentiful in the pen and the intestines and gizzards were nearly full. Results of autopsy have revealed no clues as to causes of death.

To determine if coccidia might be present in the captive birds, fecal samples were sent to Hawaii State Department of Agriculture laboratories for analysis in 1976, but results were negative.

One Pohakuloa female escaped from her pen in November 1976 and was never resighted. Pohakuloa and Jamestown birds have temporarily escaped in the past despite clipped primary feathers. When strong winds are blowing, as frequently occurs at Pu'u Kaone and Kukalau'ula Pali, even wing-clipped birds are sometimes able to clear the pen fence which stands nearly 2 m (6 ft). They are

usually recaptured near the pen and returned. Patuxent Nene have not escaped, because they have been tenectomized or tenotomized as youngsters and are consequently unable to fully extend one wing. Their primary feathers do not require clipping.

Breeding results at HAVO are summarized in Tables 1 and 2. Of 21 nesting attempts since 1974, one was initiated in October, four in November, nine in December, two in January, one in February, and four in March. The one February and two of the March nests represent renest efforts. A total of 77 eggs have been laid in the pens, 56 (73%) of which have hatched. The mean number of eggs laid per female, including renests, is 4.28 (range 2 to 12), while the mean clutch size is 3.67 (range 2 to 6).

Of the 56 eggs which have hatched, 21 goslings (37%) have died, almost all within four weeks after hatching. Causes of gosling mortality have been difficult to assess; however, predation cannot be implicated in at least 13 cases where carcasses which showed no wounds were recovered. Disease or nutritional deficiencies may have been involved in some fatalities.

Of the 35 goslings which fledged successfully only three are known to have died. As mentioned during the discussion of adult mortality, one juvenile died with its parents inside a pen while its two siblings survived. Another juvenile died of injuries sustained when it flew into the water catchment system at the pen. The third known fatality occurred when a juvenile was struck by a car on Hilina Pali Road at night.

Twenty-six of the 32 surviving juveniles have been sighted since November 1977 and the majority of these have been seen very recently. Only two pen-reared birds have not been sighted since July 1977. Most fledglings remain with their parents until the following breeding season when finally they appear to leave the vicinity of the pen and begin wandering. By the time they are one-and-a-half to two years old, pen-reared birds usually reappear at or near their natal pen. They may be accompanied by a mate from another pen, or by one or more siblings, or they may be alone. Females have proven to be more faithful than males in returning to the vicinity of their natal pen. Only one individual, a male, has been sighted more than a few kilometers from his natal pen. This bird was accompanying an unbanded female at about 2010 m (6600 ft) elevation near the terminus of Mauna Loa Strip Road. All pen-reared Nene are sexed and banded before fledging, using unique combinations of colored plastic and serially numbered aluminum leg bands. Birds released by HSDFG are banded using plastic leg bands only.

One of the problems affecting the early stage of the HAVO propagation-release program has been the lack of mates available to birds produced during the first three years. The problem has been compounded by the great distance between most pens. Consequently, the initial broods produced in the pens have been widely separated from other broods and have not had the opportunity to contact previously released birds which would be expected to be found in the vicinity. As a result, independent, pen-reared

birds have been forced to mate with siblings and even captive individuals inside the pens. Three free-living, pen-reared females have returned to pens and mated with captive ganders. Two of these nests resulted in goslings while the eggs failed to hatch in the third nest. One sibling mating occurred in the wild in 1977, resulting in two offspring, but this pair bond dissolved and the female nested with another male in 1978, producing one fledgling. Ironically, this new male partner is a brother of the female which was hatched in a different pen. Captive stock is rotated annually in the pens so that different localities will be seeded by more than one pair. In any case, sibling pair bonds will prevail for a few more years until fledglings have been produced to provide mates for newly released birds.

To obtain information concerning the breeding biology of wild populations in and near HAVO, field work was begun during the 1977-8 breeding season at high elevations--1675 m to 2134 m (5500-7000 ft)--with the objective of locating and monitoring nesting success. Six nests were found between 1860 m and 1980 m (6100 & 6500 ft) elevation in the state Keauhou Nene sanctuary, while five nests were found between 1920 m and 1950 m (6300 & 6400 ft) elevation in the adjacent lands of Kapapala within HAVO. One wild nest was located at 1160 m (3800 ft) elevation near Kilauea Crater. Eight of these nests were active when found and the remaining four had been vacated not long before their discovery. The progress of the active nests was followed for as long as possible, but after the eggs hatched, broods were difficult to locate. Four of six pairs that were known to have produced viable offspring lost one or more of their young within four weeks after hatching. In addition, three pairs were observed with young, but nests were not located.

At least 28 pairs were identified which did not breed successfully, although some apparently made nesting attempts, judging from the brood patches evident on a few females. Poor nesting results in the wild and in HAVO pens was perhaps partly due to extraordinarily dry weather occurring throughout the breeding season.

Additional research is being conducted on breeding biology, food habits, habitat utilization, behavior, population dynamics, and inimical factors of wild and captive Nene in conjunction with Park breeding-release programs. The objectives of this research are to contribute to the restoration of viable, wild populations of Nene and to explore the biology of this unique species of goose.

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TABLE 1. Individual results of Nēnē breeding in HAVO pens (* = wild-release female which bred with captive male; + = died).

Breeding Season	Male	Female	Pen	Approx. Date		Eggs Produced		Eggs Hatched		Gosling Mortality		Fledglings Produced		Fledgling Mortality	
				1st Egg Laid		Clutch		Clutch		Clutch		Clutch		Clutch	
				1	2	1	2	1	2	1	2	1	2	1	2
1974-75	962	917	2	29 Nov	-	4	-	4	-	0	-	4	-	0	-
1975-76	8088	283	5	8 Dec	-	3	-	2	-	2	-	0	-	-	-
	8087	8093	1	16 Dec	-	4	-	4	-	0	-	4	-	0	-
	8090	285	3	24 Dec	-	3	-	2	-	2	-	0	-	-	-
	+8094	+8081	4	7 Mar	-	3	-	3	-	0	-	3	-	1	-
	8089	8092	4	8 Mar	-	4	-	4	-	0	-	4	-	1	-
	962	917	2	-	-	-	-	-	-	-	-	-	-	-	-
	-	8083	4	-	-	-	-	-	-	-	-	-	-	-	-
	8080	-	4	-	-	-	-	-	-	-	-	-	-	-	-
8082	-	4	-	-	-	-	-	-	-	-	-	-	-	-	
8084	-	4	-	-	-	-	-	-	-	-	-	-	-	-	
						17		15		4		11		2	

TABLE 1--Continued.

Breeding Season	Male	Female	Pen	Approx. Date		Eggs		Eggs		Gosling		Fledglings		Fledgling	
				1st Egg Laid		Produced		Hatched		Mortality		Produced		Mortality	
				Clutch	Clutch	Clutch	Clutch	Clutch	Clutch	Clutch	Clutch	Clutch	Clutch		
				1	2	1	2	1	2	1	2	1	2	1	2
1976-77	8088	283	5	19 Nov	1 Feb	4	3	4	3	4	0	0	3	-	0
	962	917	8	12 Dec	-	4	-	4	-	0	-	4	-	1	-
	8089	8092	1	13 Dec	7 Mar	6	6	4	6	4	0	0	6	-	0
	8087	8093	6	29 Dec	-	3	-	2	-	2	-	0	-	-	-
	8090	*403	3	30 Dec	-	3	-	3	-	0	-	3	-	0	-
	8090	285	3	24 Jan	-	3	-	0	-	-	-	-	-	-	-
	576	8083	3	-	-	0	-	-	-	-	-	-	-	-	-
	8080	929	7	-	-	0	-	-	-	-	-	-	-	-	-
	8084	912	2	-	-	0	-	-	-	-	-	-	-	-	-
	511	922	5	-	-	0	-	-	-	-	-	-	-	-	-
	8082	-	6	-	-	-	-	-	-	-	-	-	-	-	-
							32		26		10		16		1
1977-78	8088	283	6	30 Oct	10 Mar	4	4	2	0	0	-	2	-	0	-
	8082	*406	4	4 Nov	-	3	-	3	-	3	-	0	-	-	-
	8087	8093	5	30 Nov	-	4	-	2	-	1	-	1	-	0	-
	962	917	1	4 Dec	-	4	-	3	-	3	-	0	-	-	-
	8090	285	3	12 Dec	-	3	-	1	-	0	-	1	-	0	-
	8084	*401	2	24 Dec	-	2	-	0	-	-	-	-	-	-	-
	8084	912	2	-	-	0	-	-	-	-	-	-	-	-	-
	8089	8092	8	-	-	0	-	-	-	-	-	-	-	-	-
	8080	929	7	-	-	0	-	-	-	-	-	-	-	-	-
	+576	+8083	3	-	-	0	-	-	-	-	-	-	-	-	-
	+511	922	4	-	-	0	-	-	-	-	-	-	-	-	-
						24		11		7		4		0	
						77		56		21		35		3	

TABLE 2. Combined results of Nēnē breeding in HAVO pens.

Breeding Season	1974-75	1975-76	1976-77	1977-78	Total
¹ No. Pairs Available	1	6	10	11	28
¹ No. Pairs Bred	1	5	6	6	18
Eggs Produced	4	17	32	24	77
Mean No. Eggs/Female (range)	4.0	3.4 (3-4)	5.33 (3-12)	4.0 (2-8)	² 4.28 (2-12)
Mean Clutch Size (range)	4.0	3.40 (3-4)	4.0 (3-6)	3.43 (2-4)	³ 3.67 (2-6)
Eggs Hatched (%)	4(1.0)	15(.88)	26(.87)	11(.46)	56(.75)
Gosling Mortality (%)	0(0)	4(.27)	10(.38)	7(.64)	21(.37)
Fledglings Produced (%)	4(1.0)	11(.73)	16(.62)	4(.36)	35(.63)
Fledgling Mortality (%)	0(0)	2(.18)	1(.06)	0(0)	3(.08)

¹ Includes free-living females which voluntarily occupy and breed inside pens with captive males.

² 18 females nesting, 3 of which were involved in renesting efforts.

³ 21 clutches