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Joy Tamayose for the degree of Master of Science in Wildlife Science presented on September 21, 2006.

Title: Supplemental Feeding Influences Reproductive Success of the Hawaiian Goose (*Branta sandvicensis*) at Haleakalā National Park, Maui, Hawai‘i.

Abstract approved:

Robert L. Jarvis

Low reproductive success has been typical of high elevation populations of the Hawaiian goose (*Branta sandvicensis*) or nēnē. Researchers identified predation and inadequate nutrition as limiting factors. Reproductive success remained low in most years despite on-going predator control programs. I used a supplemental feeding program over two breeding seasons in 2001-2003 at Haleakalā National Park, Maui, Hawaiʻi to determine if increased nutritional resources would influence reproductive success. I used field observations of marked nēnē to track activity at feeding stations and to monitor nests and broods. To evaluate reproductive success I compared nest success and recruitment between breeding pairs that used supplemental food and those that did not. Reproductive success was higher for breeding pairs that used supplemental food during a year of severe weather (heavy rainfall and greater percentage of low temperature days) but did not differ between groups during the year of mild weather. I concluded that for this high elevation population, reproductive success was limited by nutrition and weather, and that weather in particular strongly influenced the importance of nutrition. Habitat management to provide nutritious forage is recommended to improve and sustain the reproductive performance of this population.

Supplemental Feeding Influences Reproductive Success of the Hawaiian Goose (*Branta sandvicensis*) at Haleakalā National Park, Maui, Hawai‘i

by
Joy Tamayose

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APPROVED:

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SUPPLEMENTAL FEEDING INFLUENCES REPRODUCTIVE SUCCESS OF THE HAWAIIAN GOOSE (*Branta sandvicensis*) AT HALEAKALĀ NATIONAL PARK, MAUI, HAWAIʻI

INTRODUCTION

The Hawaiian goose (*Branta sandvicensis*) or nēnē is an endangered species on federal and state listings. The wild population was reduced to approximately 30 birds by the early 1950s (Smith 1952) due to lowland habitat loss, introduction of mammalian predators, and over hunting (Kear and Berger 1980). Through captive propagation and release programs, populations have been reestablished on four islands within the state (Figure 1). Obstacles to full recovery of this species vary from island to island; in this study I focused on evaluating limiting factors for the main population on Maui.

Nēnē were extirpated on Maui by the late 1800s (Baldwin 1945) and reintroduced beginning in 1962. Although nēnē originally nested at lower elevations and used higher elevations for flocking and feeding prior to the breeding season (Perkins 1903, Malo 1951), the main population on Maui was established in high elevation habitat at Haleakalā National Park (HALE; Figure 2). Palikū, the remote release site at HALE, appeared to provide excellent habitat, year-round food resources (due to high rainfall levels), few introduced predators, and limited human disturbance (Walker 1970) but after nearly 500 releases of captive-reared birds, from 1962-1978 (USFWS 2004), population estimates hovered near 150 (Santos and Medeiros 1968, Conant and Stemmermann 1979, Devick 1981, Natividad Hodges 1991, Black et al. 1991). During the past 10 years the population has stabilized at 250-300 (HALE unpubl. data) with

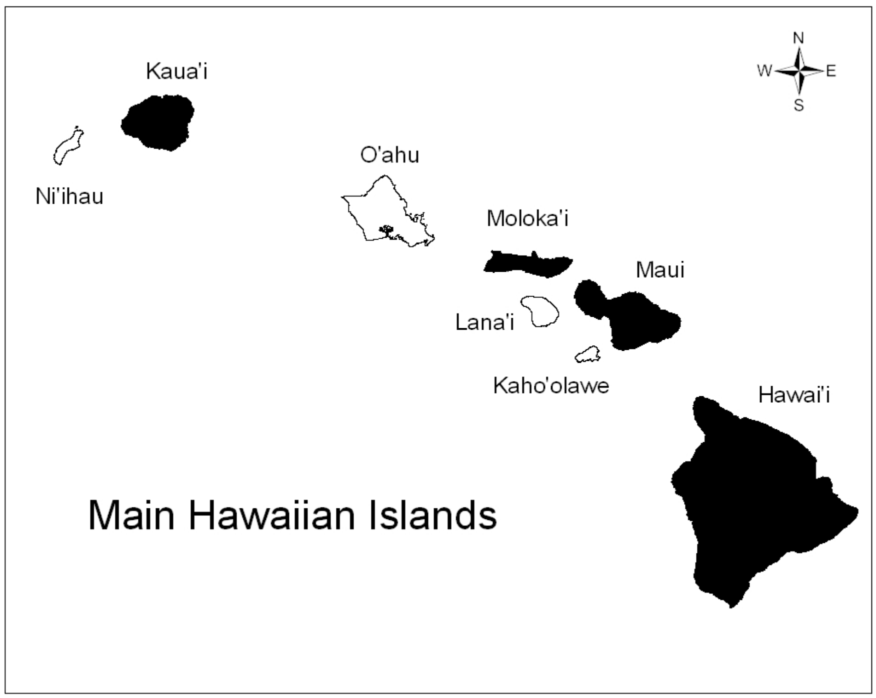

Figure 1. Map of main Hawaiian Islands showing islands with nēnē populations (in black).

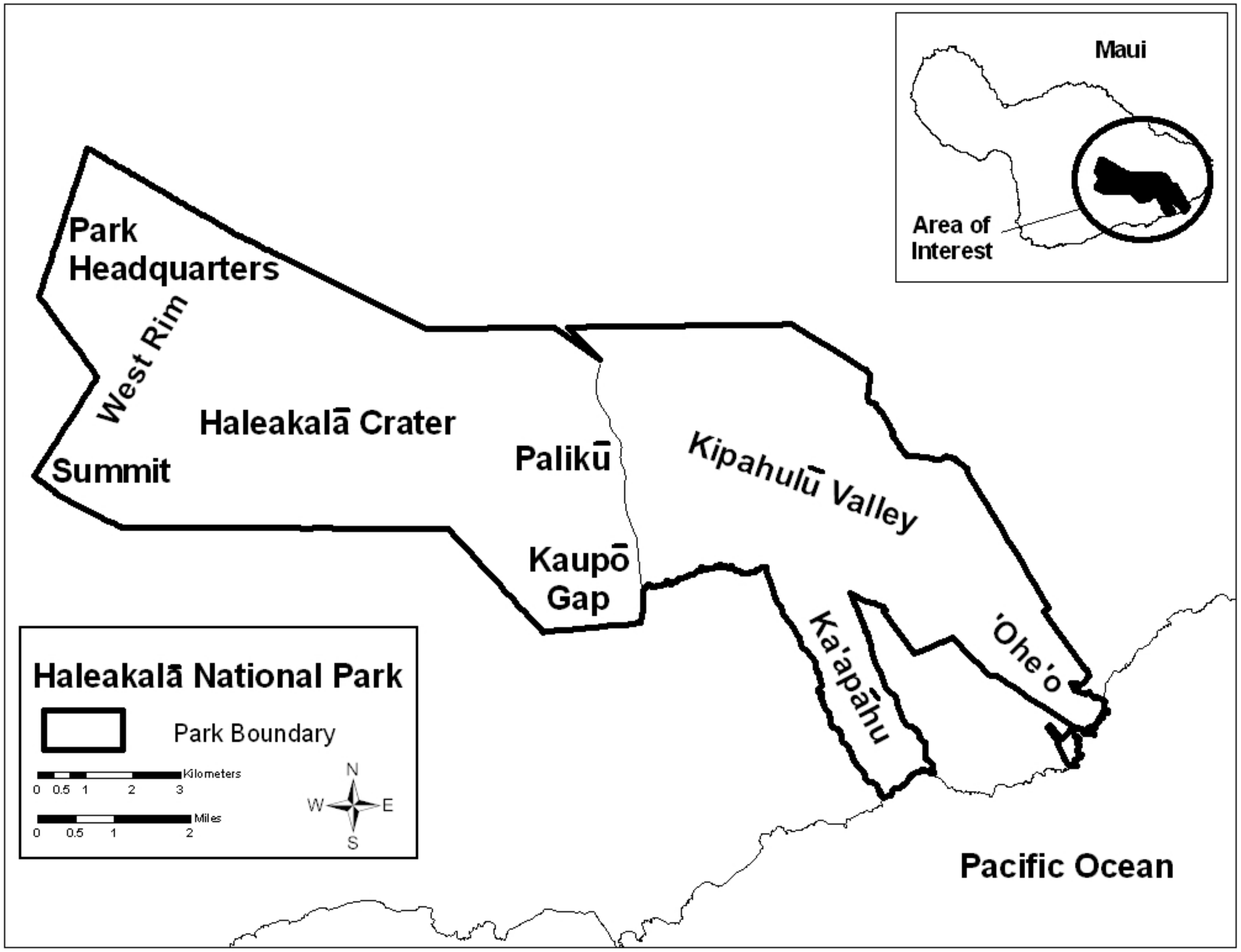

Figure 2. Map of island of Maui with larger view of Haleakalā National Park boundary and main features.

limited releases of captive-reared birds to replenish the population (18 nēnē from 1992-2001).

Nēnē at HALE have high annual survival of adults but low reproductive success. Adult mortalities average 8 per year (1990-2001) and birds live to be 20-30 years old (Banko et al. 1999, HALE unpubl. data). Nēnē have smaller clutch sizes (2 to 5 eggs) than their Canada goose relatives and lower nest success (avg. = 44%, Banko 1988; avg. = 53%, range = 31-88%, HALE unpubl. data). The more closely-related, large lineage of Canada goose (Paxinos 1998) are limited primarily by predators and available nesting sites but typically have high nest success (70 to > 90%, range <20% to ≥ 85%, Mowbray et al. 2002). Water sources provide protection from predators for the Canada goose. Nēnē, however, are highly terrestrial and not dependent on water for breeding or rearing young (Kear and Berger 1980, Banko 1988); their nests and goslings are highly vulnerable to predation. Recruitment of juveniles, measured in the succeeding pre-breeding season when juveniles are nearly 1 year old, is <1 young per adult female and averages 15 total recruits annually (HALE unpubl. data; Figure 3). Additionally, nēnē breed over an extended period (October-March) that coincides with the winter, wet season. The terrestrial habits and breeding during the winter season may work to limit the high elevation population at HALE (HALE unpubl. data; Figure 4).

Both nest predation and inadequate nutrition for breeding females and goslings were identified as important factors limiting reproductive success (Banko 1988; Black et al. 1994, Baker and Baker 1999). Predator control of feral cats (*Felis catus*), small Indian mongooses (*Herpestes auropunctatus*), and rats (*Rattus* spp.) was initiated in the

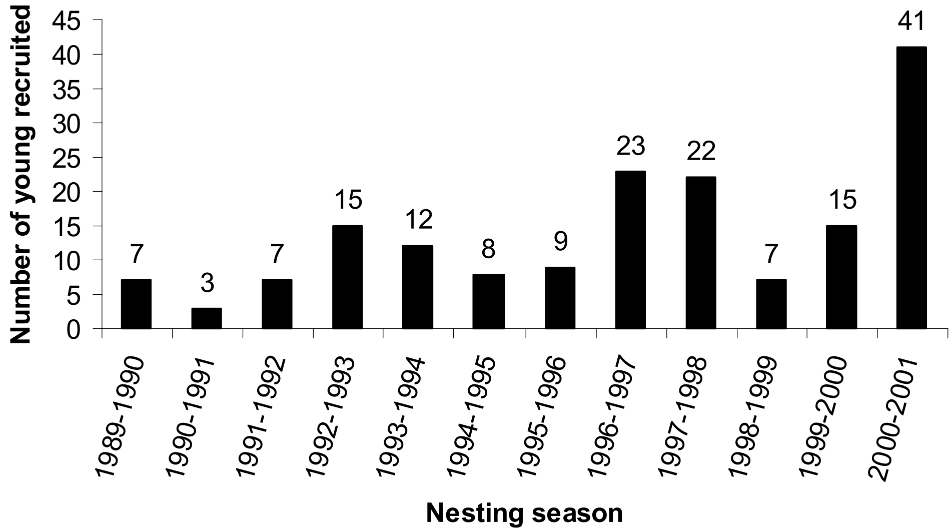

Figure 3. Number of nēnē recruited at Haleakalā National Park, Maui, 1989-2001.

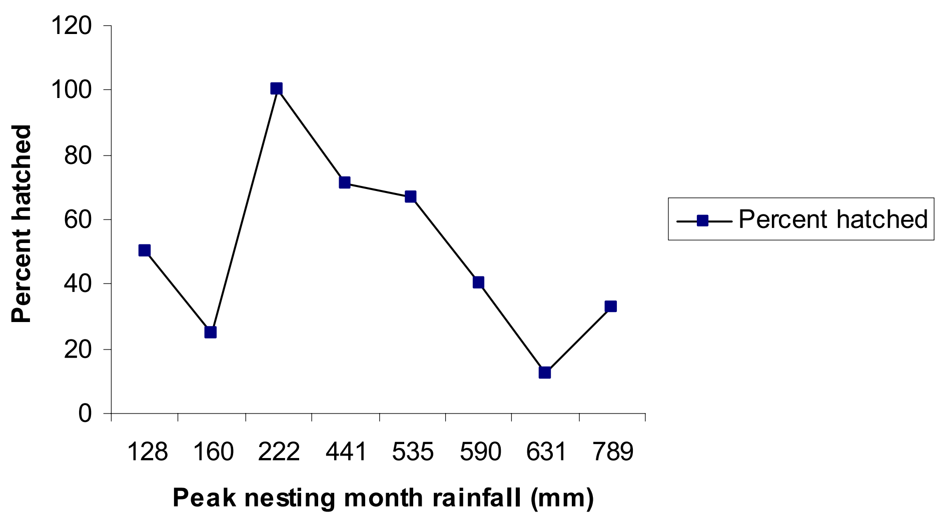

Figure 4. Nēnē nest success relative to rainfall levels during peak nesting month, Haleakalā National Park, Maui, from 1992-2001.

main nesting areas in the early 1980s. Predator control efforts intensified and have been consistent since the early 1990s but reproductive success remains low. The diet of over 30 native and non-native plants (Baldwin 1947, Black et al. 1994) appeared to provide adequate nutrition for adults (Black et al. 1994). Many goslings however reportedly died from starvation and dehydration (Baker and Baker 1994, 1995, 1999). Over the last 10 years resource managers have had some success with propagation in the wild (open-top release pens), egg salvage, and foster-rearing but these efforts were labor intensive for limited staff.

Recent management recommendations for nēnē recovery focus on intensive habitat management (Baker and Baker 1999, Woog 2000, USFWS 2004). Such programs to improve the quality and quantity of food for nēnē are potentially costly for HALE managers. Supplemental feeding programs have been proposed as a means to evaluate the importance of nutrition for nēnē. Together with predator control, supplemental food should increase reproductive success in the wild (Banko 1988, Woog 2000). I devised a test of the hypothesis that inadequate nutrition limits the reproductive success of nēnē at HALE.

OBJECTIVES

I provided supplemental food to nēnē adults and goslings during the breeding season to test the prediction that increased nutritional food resources would increase nest success and recruitment of 1 year-old juveniles in the wild. I contrasted these statistics between breeding pairs that used supplemental food and breeding pairs that did not. I also examined rainfall and temperature data for possible influence on reproductive success.

STUDY AREA

Palikū is the main nesting and rearing site for the HALE population; it is also an important flocking and feeding site. The 60 ha area is on the northeast end, adjacent to the Kīpahulu Valley Rainforest. Hiking trails provide the main access (16.1 km one way) to this popular backcountry destination equipped with cabins and a campground. Nēnē benefit from the close proximity of feeding (pasture) and nesting (shrubland) areas (Banko 1988, Black et al. 1994, Baker and Baker 1999, Woog 2000; Figure 5). High annual rainfall (>3,810 mm) promotes year-round plant growth. HALE manages an extensive small mammal trapping program for feral cats, mongooses, and rats year-round to protect nēnē (Figure 6). Feral goats (*Capra hircus*) and pigs (*Sus scrofa*) were eliminated from the park's summit area through aggressive hunting and fencing in the 1980s. HALE maintains a surrounding fence (~ 48 km, 1.2 m high) that deters goats, pigs, and Axis deer (*Axis axis*) from entering and destroying nēnē nesting habitat.

Non-native, sward-forming grasses (velvet and kikuyu) grow in the main pasture and provide high quality forage that nēnē primarily feed upon (Black et al. 1994; Table 1). Pastures are important feeding and rearing sites (McLandress and Raveling 1981, Banko 1988, Gates et al. 2001, USFWS 2004) but large sections at Palikū are overgrown. Over the years, areas of short, cropped grass for nēnē to feed on have been reduced in size. Horses and mules graze fenced sections and help to maintain the forage

Figure 5. Study site showing Palikū Pasture ("X") surrounded by native shrubland, Haleakalā National Park, Maui.

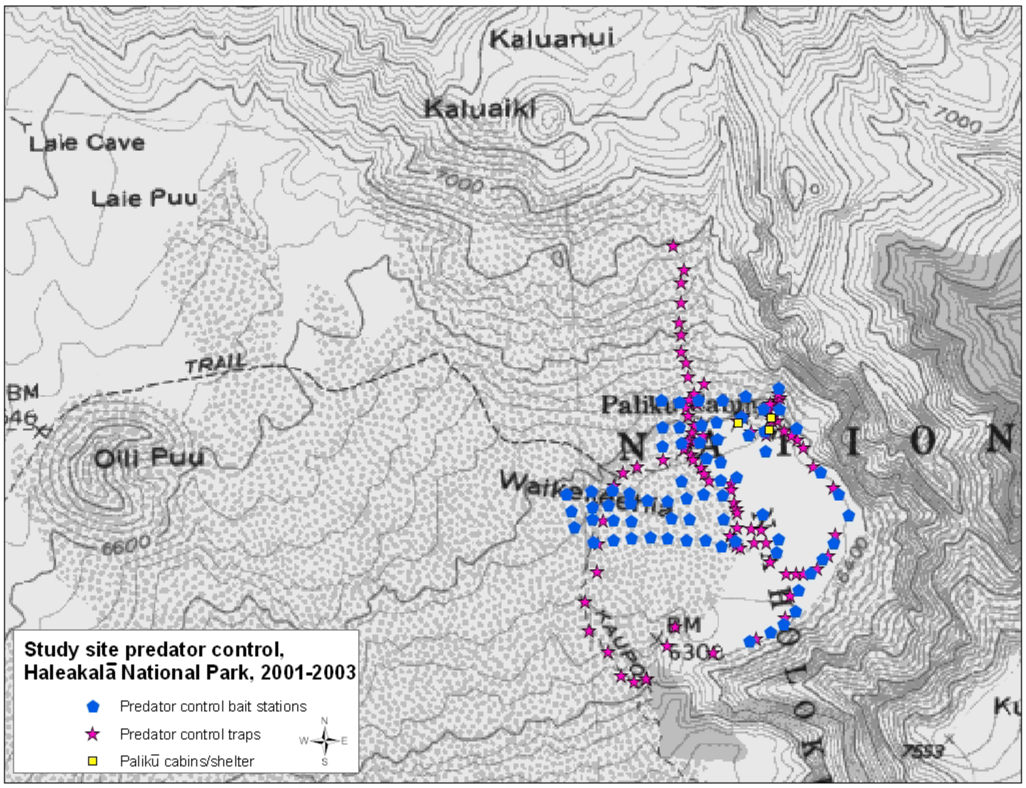

Figure 6. Map of predator control at Palikū, Haleakalā National Park, Maui.

Table 1. Protein content of nēnē food items commonly found at Palikū, Haleakalā National Park Maui, Hawai‘i. Protein content based on dry weights. Adapted from Black et al. (1994)

Common name, plant part	Scientific name	Protein content (%)
Velvet grass, leaves	*Holcus lanatus*	19
Kikuyu grass, leaves	*Pennisetum clandestinum*	17
Gosmore, leaves	*Hypochoeris radicata*	16
Rattail grass, seeds	*Sporobolus africanus*	8
Kukaenēnē, berries	*Coprosma ernoideoides*	4
‘Ōhelo, berries	*Vaccinium reticulatum*	3
Pūkiawe, berries	*Styphelia tameiameiae*	2

for nēnē but only intermittently. Cabin and campground lawns also used by nēnē receive minimal mowing. Invasive Florida blackberry (*Rubus argutus*) grows unchecked; large patches encroach upon the pasture. Nēnē do not feed on blackberry or use blackberry for nesting.

METHODS

To test my hypothesis that inadequate nutrition restricted reproductive success, I used a supplemental feeding program during the breeding season and compared nest success and recruitment of juveniles between pairs and families that used feeders with those that did not. These were wild birds and were self-selected to control and treatment groups rather than randomly assigned. Approximately 80 percent of the adults in this population were previously marked with individually identifiable leg bands. Thus, I was able to gather histories via observations of known pairs and families.

Supplemental feeding

I implemented the supplemental feeding program at Palikū from November to March for two breeding seasons, 2001-2002 and 2002-2003. I used an all-purpose, commercial, grain-based crumble formulated for starting and growing chicks, laying females, adult waterfowl and game birds (Trip-L Duty®, 15% min. crude protein) that had been used successfully for nēnē propagation programs. Concerns over introduction of non-native plants precluded use of a seed-based feed.

I placed feeders and fresh supplies of water in known feeding areas (HALE unpubl. data) (Figures 7 and 8) without "pre-feeding" the birds. In Palikū Pasture, I used large, durable, rubber bowls for adults and low, flat metal trays and foil pans for goslings. During 2001-2002, I also set supplemental food (small, flat metal trays) and water (1-quart or 1-gallon poultry water dispensers--trays with upright screw-in reservoirs) near active nest sites. For two pasture feeders, A-frame wooden shelters were built and secured with metal rebar and wire to keep the feed dry and to reduce tampering by horses and mules (Figure 9). In year 1, I set 20 feeders—five in Palikū Pasture and 15 near nest sites (as nests were discovered). "Nest feeders" were at least 10 meters away from nests in open sites to provide visibility and accessibility for nēnē. In year 2, I randomly spaced 10 feeders in Palikū Pasture to allow more birds to feed. I monitored feeders and water with help from field staff from prior to the peak nesting period to the end of March in both years.

I cleaned and replenished feeders and water units twice daily (morning and afternoon) in the pasture, daily for nests near the pasture, and every 2-3 days for nests beyond the pasture and adjacent shrubland.

Placement and maintenance of feeders in the pasture were complicated by unrestricted use of the pasture by humans and livestock. Livestock grazed the Palikū Stables and fenced pasture approximately 8-12 days a month during the nesting season. During these periods, supplemental feeders and water units were temporarily removed and set at alternate locations inaccessible to livestock.

Figure 7. Nēnē family using supplemental feeder in Palikū Pasture, Haleakalā National Park, Maui.

Figure 8. Nēnē pair guarding water and supplemental feeder in Palikū Pasture, Haleakalā National Park, Maui.

Figure 9. Nēnē pair defending sheltered supplemental feeder near Palikū Ranger Cabin, Haleakalā National Park, Maui.

Feeder observations

I recorded and identified all birds seen in the feeder area. I recorded feeder and water use (food consumption, bathing, and drinking of water), date, time, bird identity, location, activity, and weather conditions, on the same schedule as that noted above for attending to the feeders and water units.

I scored nēnē pairs as "users" if they were consistently seen (daily or stretches of several days in a row) feeding from a feeder over the course of the breeding season. "Non-users" were 1) not seen at feeder sites at all, 2) not seen feeding from feeders, 3) seen only once at the feeders or 4) seen intermittently at the feeders (one sighting separated by a week or more from the next sighting).

I correlated feeding observations with subsequent data on nest initiation date then assigned observations into four general stages: pre-nesting, incubating, brood-rearing, and post-nest failure. To evaluate the influence of supplemental food on 1) nest success, I used observations during pre-nesting and incubating, and 2) for recruitment, I used observations from any stage from pre-nesting through brood rearing.

Nest searches and monitoring

I included in the study only nesting attempts (nests and broods) that could be traced to banded nēnē. I conducted systematic nest searches 1-3 times weekly in Palikū and surrounding areas, monitoring all nests found. I tracked potential nesting activity by noting increasing abdominal profiles (based on Owen 1981) and directed, quick feeding activity of females, and the consistent presence of sentry males on vantage points. I observed birds with binoculars (10 x 42) or spotting scope (20-60x) 10-20 m away but occasionally at shorter range. I also used vantage points to scan large areas and then searched on foot. I found nests by tracking large fecal droppings from female birds, associated strong odors, and down feathers along established nest paths. I flagged and tagged nests on nearby bushes and after nests were vacated by nēnē, entered locations into GPS (Garmin 2000 or Trimble Pro XL). For each nest, I recorded nest status, clutch size, and aggression of the nesting pair. I monitored active nests from a distance by re-sighting sentry males daily for shrubland nests adjacent to Palikū Pasture and every 2-3 days for other areas. I was able to directly view incubating females from a distance for a small number of sparsely vegetated nests. I assigned nest status for each nest found—laying, incubating, hatched, rearing (goslings observed), or failed (e.g., abandoned, depredated, or unknown)—based on nest signs such as the amount of down present (from none to ample amount as incubation progresses), number of eggs, presence and amount of female fecal matter, condition of the nest path, and sightings of the nesting pair. I used nest status to estimate hatch dates. To minimize disturbance, I physically rechecked active nests only near hatch date or when nests appeared to be repeatedly unattended by the nesting pair.

A breeding pair had a successful nest if it hatched at least one egg. I defined nest success as the percentage of successful nests out of all nests included in the study. I confirmed hatches by 1) an actual sighting of the nesting pairs with goslings, and 2) at the nest, the presence of a mostly intact eggshell with detached membrane and an opening ("lid") on the rounded or flat end of the egg.

Brood monitoring

Once eggs hatched, I located and followed broods visually, observing them daily at supplemental feeding stations in Palikū Pasture and other feeding sites. Broods were most often seen in the mornings and afternoons (active feeding periods, from 0630-1030 and from 1300-1600; Woog 2000). I also recorded any incidental brood sightings. I used the same protocols listed under “Nest searches and monitoring” for brood observations and took precautions to minimize disturbance to the families. I usually watched broods until they were out-of-view (e.g., walked away or visibility compromised due to fog). For each observation I recorded date, time, brood identity, brood size, gosling age (based on Hunter 1995), brood activity, and weather conditions.

A breeding pair was considered successful in recruiting young if it reared at least one juvenile. I defined recruitment as juveniles that survive until after the annual molt, during the summer and fall flocking season (June-October), a period when young ranged from 4-8 months old.

Nest success and recruitment data analyses

I used Fisher’s exact tests to 1) compare nest success and recruitment between breeding pairs that used supplemental food (treatment) and those that did not (control) and 2) to compare nest success and recruitment between years within each user group. I used one-sided tests for both. In the first scenario, I hypothesized that supplemental food would increase nest and gosling survival while in the second scenario, I suspected lower reproductive success during the severe weather year (year 1).

Weather Data

I recorded rainfall from the National Weather Service rain gauge at Palikū Ranger Cabin a minimum of once weekly but often daily within my 3-5 day field trips. I obtained average daily air temperature readings from a nearby weather station (Pohaku Palaha, station #161; HaleNet website). Temperature data was unavailable for part of February-March 2002 and for January-March 2003.

I used a Chi-squared test to determine if the number of cold days—days colder than the average temperature for those months (≤10ºC)—varied significantly between years in an attempt to explain differences in nest failures.

RESULTS

Nest success

There were 22 nesting attempts (nests and broods found) in year 1 (2001-2002) and 25 nesting attempts in year 2 (2002-2003) (Figure 10). Supplemental food use was low in both years—18% or 4 nesting pairs in year 1 and 24% or 8 nesting pairs in year 2. Overall nest success (for supplemental food users and non-users) was similar and relatively low in both years: 50% in year 1 and 56% in year 2 (Table 2). Eleven nests failed in both years. In year 1, 8 nest failures (73%) were attributed to abandonment, 2 to predation, and 1 to undetermined cause (eggs were found crushed in nest). In contrast, in year 2 there were only 2 cases of nest abandonment but 5 nest failures (45%) due to predation. Other recorded nest failures in year 2 were due to undetermined

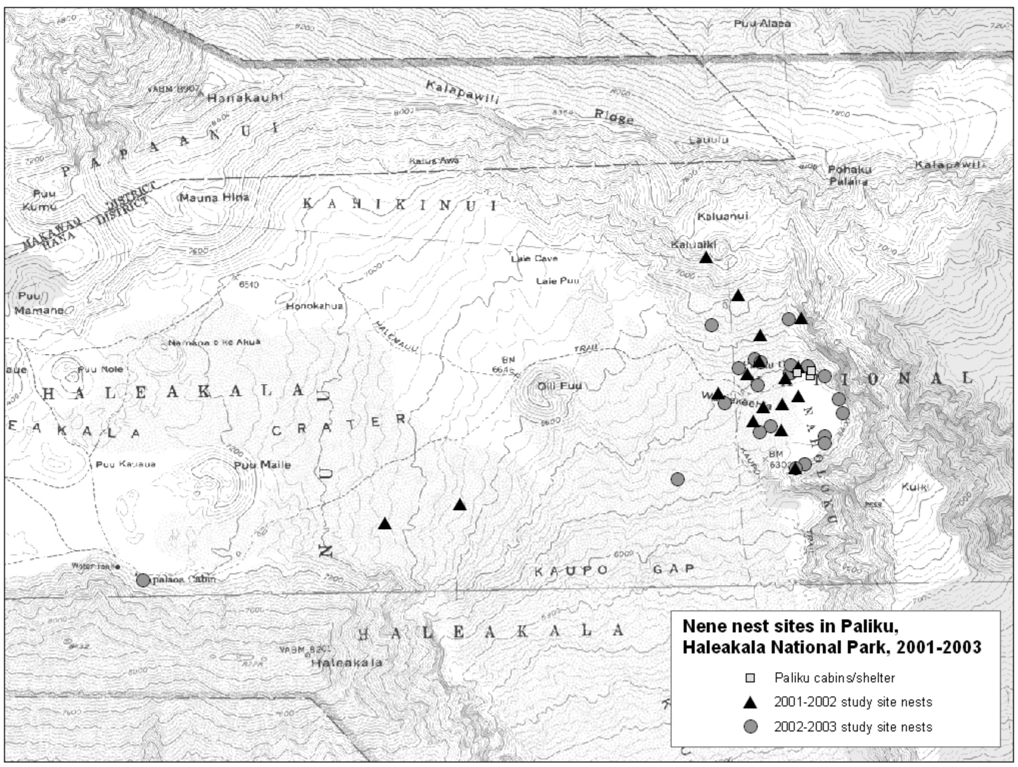

Figure 10. Locations of nēnē nests at Palikū, Haleakalā National Park, Maui, 2001-2003.

Table 2. Nēnē nest success; comparisons between supplemental food users and non-users and between years for each user group at Palikū, Haleakalā National Park, Maui, 2001-2003.

	Year 1			Year 2			
Breeding pairs	Number of nests	Successful nests	Nest success (%)	Number of nests	Successful nests	Nest success (%)	Fisher's Exact Test
Used supplemental food	4	4	100	6	3	50	$p = 0.2$
Did not use supplemental food	18	7	39	19	11	58	$p = 0.2$
Totals	22	11	50	25	14	56	
Fisher's Exact Test			$p = 0.05$			$p = 0.5$	

causes (2 nests) and tiny, non-viable eggs (2 nests). In year 1, nest success was higher for treatment birds vs. control birds ($p = 0.05$; Table 2). In year 2, nest success was similar between groups ($p = 0.5$). Nest success did not differ between years for either the treatment ($p = 0.2$) or the control groups ($p = 0.2$).

Recruitment

Supplemental food use was low in both years—18% of breeding pairs in year 1 and 32% (8 breeding pairs) in year 2. The longer time period (approximately 6-9 months) to determine recruitment accounted for the difference in supplemental food use recorded for nest success (24%) versus recruitment (32%). In general, few breeding pairs recruited young (9% in year 1 and 24% in year 2) and recruitment was low in both years (3 juveniles in year 1 and 11 juveniles in year 2). The number of breeding pairs that successfully recruited young did not differ between treatment or control pairs in year 1 ($p = 0.3$) or in year 2 ($p = 0.7$; Table 3). The percentages of breeding pairs that successfully recruited young remained the same for both years for supplemental food users (25 %, $p = 0.7$) but was very low in year 1 compared to year 2 (5% vs. 24%) for breeding pairs that did not use the supplemental food. This difference between years however was not significant for the control group ($p = 0.2$).

Weather

Weather patterns varied between study years. Nesting season rainfall totals for Palikū were considerably higher in year 1 (3854 mm, 152 in) than in year 2 (1121 mm, 44 in). Peak nesting and hatching periods (December and January, respectively) in year 1 coincided with heavy rainfall periods (Figures 11 and 12). Fourteen of the 20 nests

Table 3. Nēnē recruitment; comparisons between supplemental food users and non-users and between years for each user group at Palikū, Haleakalā National Park, Maui, 2001-2003.

	Year 1			Year 2			
Breeding pairs	Number of pairs	Recruited young	Recruited young (%)	Number of pairs	Recruited young	Recruited young (%)	Fisher's Exact Test
Used supplemental food	4	1	25	8	2	25	$p = 0.7$
Did not use supplemental food	18	1	5	17	4	24	$p = 0.2$
Totals	22	2	9	25	6	24	
Fisher's Exact Test			$p = 0.3$			$p = 0.7$	

that failed to recruit young in year 1 were subject to heavy rainfall during weeks 9-11 and 16-18. There were significantly more days with temperatures <10º C in October to December of year 1 than the same time period in year 2 ($\chi^2 = 2.6$ with Yates correction, df =1, $p = .05$; Figure 13). The lower temperatures generally overlapped with periods of heavy rainfall.

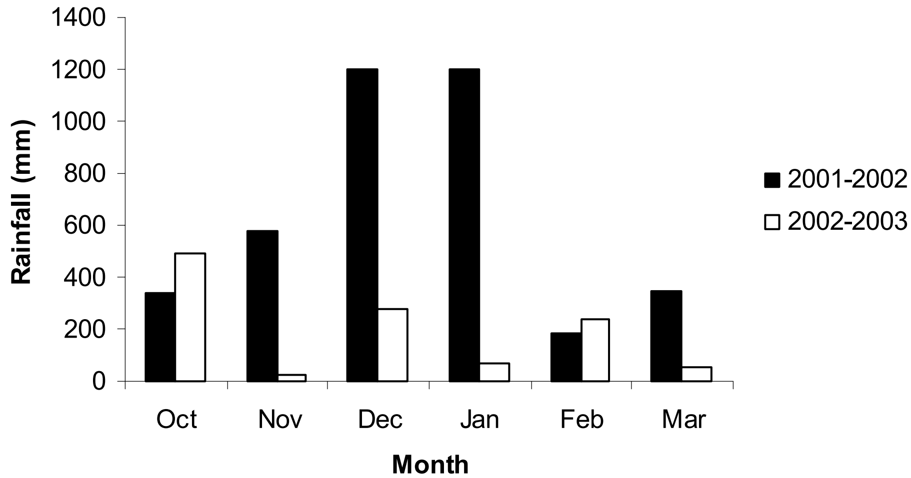

Figure 11. Monthly Palikū rainfall, Haleakalā National Park, Maui, October-March, 2001-2003.

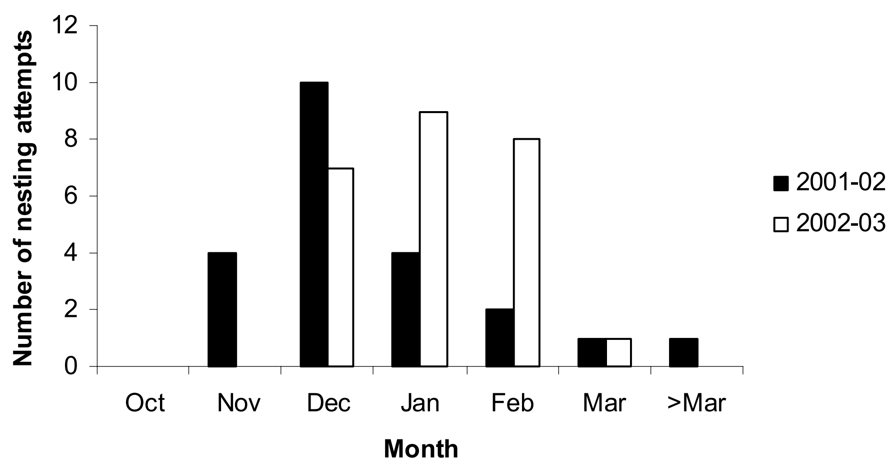

Figure 12. Monthly nēnē nesting attempts at Palikū, Haleakalā National Park, Maui, October-March, 2001-2003.

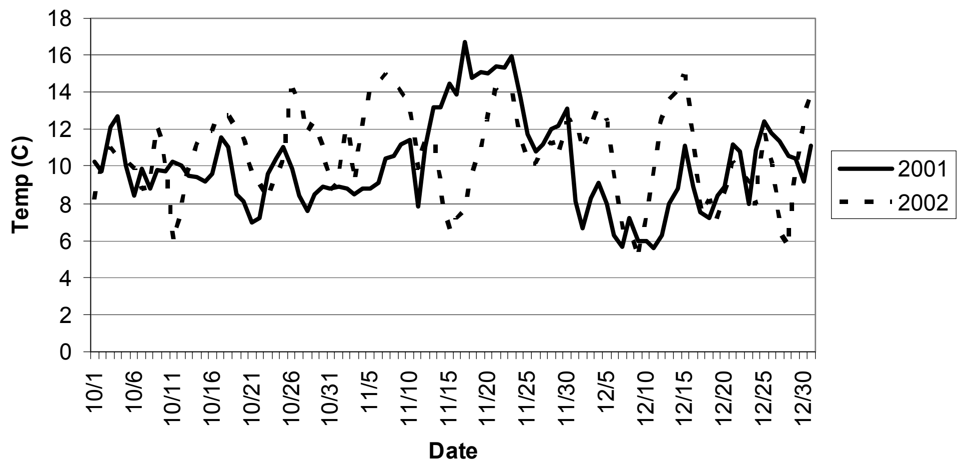

Figure 13. Average daily air temperatures, HaleNet weather station #161, Haleakalā National Park, Maui, October-December 2001-2002.

DISCUSSION

Influence of supplemental feeding on reproductive success

Nutrition can be an important factor limiting reproductive success and it appears to be strongly influenced by weather. Nest success was higher (100% vs. 39%) for breeding pairs that used supplemental food in year 1 but similar for supplemental food users and non-users (50% and 58%, respectively) in year 2. The notable difference between study years was the severity of the weather. The higher nest success for supplemental food users suggests that additional nutrition may be critical in determining whether a nest fails or succeeds during prevailing cold, wet weather when nest abandonment is more probable. Better-provisioned females may not need to leave nests as often to feed, and thereby reduce nest exposure and the probability of egg death and abandonment during inclement weather.

Similar to Boutin (2000), I found that under favorable weather conditions, the influence of food supplementation was less pronounced. There was no evidence that nest success differed between supplemental food users and non-users during the milder conditions present in year 2. The milder weather during year 2 was likely more conducive to feeding and nesting for nēnē. Overall nest success was slightly higher in year 2 (56%) compared to year 1 (50%). However, the mild weather probably translated to favorable conditions for predators as well. Nest abandonment was the major cause of nest failure (73%) during the wet, cold year; predation was of lesser importance (18% of nest failures) in the same year. In contrast, during the mild year, predation was the main cause of nest failure (45%) and nest abandonment was of lesser importance (18% of nest failures) in the same year.

There were no significant differences in recruitment between supplemental food users and non-users or between years for each group. However, supplemental food users appeared able to recruit young at the same level (25%) in both years while non-users showed a notably lower level of recruitment (5%) in the poor weather year (year 1) followed by a level comparable to that of food users (24%) under better weather conditions in year 2. The low recruitment in year 1 suggests weather conditions were unfavorable for rearing young. While supplemental food users had higher nest success than non-users in year 1, survival of hatched young was low. Young waterfowl mortality is commonly associated with poor weather (Johnson et al. 1992, Kostin and Mooij 1995, Schmutz et al. 2001). Young goslings may fail to grow and may die as a result of difficulty feeding and keeping warm in cold, wet weather (Banko 1988, Cooch et al. 1991, Baker and Baker 1995, Hu 1998, Baker and Baker 1999).

Overall recruitment was higher in year 2 (24%) compared to year 1 (9%). The contrasting weather conditions probably affected the availability of food resources (Cooch et al. 2001); the heavy rainfall the previous nesting season may have provided for better food resources in year 2. In addition, the mild weather in year 2 probably presented better feeding and growing opportunities for goslings. Other wildlife including predators and their non-nēnē prey base probably benefited from the mild weather also. During favorable years, it may be worth examining predation events to determine if greater predator control efforts are needed to ensure greater reproductive success (nest success and recruitment).

Small sample size was a major challenge in studying this endangered species. I documented as many nests and broods as I could find within the study area. I could not expand the study area beyond Palikū to increase sample size since outlying areas lacked comparable foraging grounds, nesting habitat, weather conditions, predator control, and access to water sources.

Based on this short-term study, reproductive success appears to be limited by nutrition, especially during adverse weather. While weather is a factor that cannot be controlled or accurately predicted, nutritional resources can be managed to benefit nēnē.

Management recommendations

The HALE nēnē population represents one of the major wild populations and has been instrumental in establishing new populations throughout the state. As part of the captive propagation and release program, HALE birds produced eggs and young for releases on Hawai‘i, Kaua‘i, Moloka‘i, and Maui. There is a continuing need to protect and manage the HALE population (HALE 1999) until major limiting factors are understood and fully addressed. Recovery of the species rests on the existing populations until more suitable habitat is secured and additional self-sustaining populations are established.

Although nēnē appeared to benefit from this study’s supplemental feeding design, I do not advocate supplemental feeding as a management action to increase the nutritional status of this population. Decreased wariness and dependence on humans for food may place wild birds in danger of harm (Archibald 1978 and Myers et al. 1982). I found that nēnē habituated readily to supplemental feeders and despite their escalation of aggressive behaviors toward other nēnē as the breeding season progressed, nēnē became tame around humans. Wild nēnē that are able to survive on their own is the ultimate recovery goal. In addition, managing a supplemental feeding program in remote location proved to be labor-intensive and logistically difficult. Feeders and water units needed regular maintenance to ensure that supplies were fresh and not a potential source of disease.

Hu (1998) criticized that supplemental feeding creates an unnatural setting that mitigates but does not correct the problem of suboptimal habitat. The HALE nēnē population may derive a greater benefit from a long-term habitat management plan. I recommend year-round active management (e.g., mowing, grazing, and control of invasive alien blackberry) of the pasture at Palikū to increase both forage quality and quantity for nēnē. By managing the habitat, this valuable food resource will be continue to be available for nēnē to utilize and over the long-term may result in a substantial difference in reproductive success.

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