FACTORS LIMITING THE REPRODUCTIVE SUCCESS OF NĒNĒ

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Extinction of the remnant population of Nēnē (Branta sandvicensis (Vigors)) on the island of Hawai'i was forestalled by releases of birds reared in captivity at Pōhakuloa, Hawai'i, and the Wildfowl Trust, England. The Hawaii State Department of Land and Natural Resources (DLNR) has released 1319 Nēnē on Hawai'i since 1960 and 474 on Maui since 1962 (Lee 1978; Nelson Santos, pers. comm.). The National Park Service has reared and released 50 in Hawaii Volcanoes (HAVO) since 1975 and 17 in Haleakala (HALE) National Parks since 1973.

While many released Nēnē are still surviving and some are nesting successfully in the wild, the same factors which nearly resulted in the species' extinction 30 years ago have not been alleviated and are preventing natural restoration from occurring. There has been much speculation, but little data, concerning the identity and nature of the more important inimical factors which must be controlled if Nēnē are to thrive in the wild. The purpose of this paper is to dicuss in a general way several of the most serious factors limiting Nēnē reproductive success which have been revealed during three years of field work in HAVO and HALE.

Nēnē nests are difficult to locate and monitor efficiently because of the remote and rugged nature of the breeding grounds and because nesting pairs may be scattered throughout a very large area. The most productive areas for finding nests have been around release sites, such as Keauhou Ranch and 'Āinahou on Hawai'i and the eastern interior of Haleakalā Crater on Maui. Nest searches are made on foot and a trained dog is frequently used to detect birds. Nests may be discovered soon after encountering females which appear gravid or have an incubation patch and/or males which behave defensively. Pairs tend to utilize approximately the same nest sites as in the previous year, and these traditional sites are always revisited in subsequent years with the expectation of finding a new nest nearby.

During the past three years 32 active nests have been discovered. Eighteen inactive (unattended) nests were found in which the eggs had hatched, had been abandoned, had been destroyed, or were missing. Fifteen broods were encountered after having left nests which were not located. Judging from the incubation patches on the females, at least 12 to 16 other pairs

which nested in unknown locations were apparently unsuccessful in rearing young. Another 13 to 23 females were gravid when observed and may have nested, but their nests were not found and they were not observed later with incubation patches or young. The carcasses of two females which were in egg-laying condition were found but no nest could be located nearby.

The fates of some inactive nests can be guessed, probably with fair reliability, if eggs or shell fragments are still present but only the productivity of active nests will be discussed here. Active nests are those at which at least the female is in attendance and is either laying or incubating eggs or is brooding hatchlings. Males defend females, eggs, and young but do not incubate or brood. Consequently, if the female disappears from the nest it fails but the loss of the male may not affect the success of the nest.

BREEDING EXPERIENCE

It has not been demonstrated that experienced pairs enjoy greater reproductive success than newly-formed pairs but it is reasonable to expect that this is so, partly because Nēnē nest in the same general location each year and may benefit from a greater familiarity with their nest territory. Some of these benefits might include knowing where the best nesting, rearing, and feeding sites are. The productivity of older pairs might also be enhanced because basic nesting skills such as lining the nest with down, rotating eggs, maintaining proper egg temperature, brooding young, etc., may improve with experience.

Nēnē are monogamous and generally mate for life; however, sibling pair bonds appear less stable than those of unrelated individuals and polygamy does occur in captivity. The prevalence of long-term, stable pair bonds suggests that breeding experience has a positive influence on productivity.

BREEDING AGE

While middle-aged experienced pairs may be more productive than newly-mated pairs, fecundity declines after males and females pass their eighth or ninth years of age. Males become capable of fertilization when they are only one year of age, but females ordinarily do not lay eggs until their second or third year.

BREEDING SEASON

Nēnē nest in the wild from early November through early April. Most nests are initiated in November, December, and January. If the first nest fails, a pair frequently renests in February, March, or April. This very long breeding season is uncharacteristic of waterfowl and while it may result in increased productivity, it also prolongs the physiological stress incurred during reproduction and extends the nesting pairs' vulnerability to predation.

The obvious advantage of a long breeding season is that if conditions for nesting or rearing young are unfavorable early in the season, they may improve in time for better success later. Some Nēnē attempt to breed in November or December regardless of how dry or otherwise poor conditions may appear, while other pairs apparently make no effort to nest when conditions are unfavorable. Proximate factors responsible for initiating egg-laying in Nēnē are not yet clearly identified.

CLUTCH-SIZE

Nēnē lay up to six eggs per clutch but the normal clutch of 3 or 4 eggs is somewhat less than that of the closely related Canada Goose (Branta canadensis L.). In captivity Nēnē may lay three clutches if the first two are removed for artifical incubation. In the wild if the first clutch fails or is destroyed Nēnē will often lay a replacement clutch; however, they do not attempt to nest again if the first clutch hatches and young fledge.

EGG SIZE

Nēnē lay very large eggs relative to their body size in comparison to other geese, and there is a great range in egg size between clutches of different females. Egg lengths vary from about 42 to 91 mm while widths range from 34 to 60 mm. It appears as though goslings which hatch from larger eggs survive longer than those from smaller eggs within the same clutch.

All Nēnē goslings lose weight during the first few days after hatching. Ankney (1980) discovered that large Snow Goose (Chen caerulescens caerulescens L.) hatchlings had more yolk and survived longer than smaller hatchlings when starved. If this is true also for Nēnē, than goslings which hatch from larger eggs would probably have a survival advantage during the critical period of initial weight loss. Lack (1968) demonstrated that the proportion of yolk to other egg constituents was constant by weight regardless of egg size within and between many species of waterfowl. Consequently, hatchlings from large eggs have proportionally the same amount of yolk available to them as do smaller

hatchlings. The longer survival of large hatchlings perhaps can be accounted for by more efficient metabolization of the yolk contained in their yolk sacs but not by having disproportionately more yolk than small hatchlings. The extent to which Nēnē egg size is genetically or environmentally controlled is not certain, but there appears to be a rather strong selection for larger eggs and hatchlings. It is expected that large egg size is gained at the expense of clutch-size, and presumably there is some upper limit beyond which it becomes disadvantageous to the female to lay larger eggs.

EGG FAILURE

About 80% of the eggs in active wild nests were found to be fertile. This is approximately the same fertility rate as for captive-breeders at HAVO and is not much less than reported values for Canada Geese. Consequently, it is possible to discard the idea that Nēnē productivity suffers unduly because of high infertility.

About 64% of all fertile eggs in active wild nests hatch, while 7% pip but fail to hatch. The remaining 29% are destroyed by mongooses (Herpestes auropunctatus auropunctatus (Hodgson)) or are otherwise broken or disappear from the nest. The hatchability of eggs in wild nests that are not destroyed by mongooses (85%) is essentially the same as that of eggs laid by HAVO captive-breeders.

GOSLING MORTALITY

Over 64% of all wild goslings disappear from the company of their parents before fledging. Only two wild fledglings have been seen in the past three years, although others probably have gone undetected. The ultimate fate of many broods is never learned because families or pairs are not resighted at the time when the young are expected to fledge.

In contrast, only about 30% of the captive-reared goslings die in HAVO breeding pens. Nutritional problems are probably the principal causes of mortality, since captive goslings are not vulnerable to predation. Captive goslings that have died in HAVO pens lost weight or grew very slowly prior to their deaths. So far, no diseases or parasites have been implicated in any of the deaths.

It might also be expected that poor nutrition accounts for much of the mortality of wild goslings. Young and adults are primarily grass grazers and do not feed on arthropods. The nutritive value of the introduced grasses dominant throughout lowland areas is unknown. Certain widespread grasses, such as

Andropogon spp. and molassesgrass (Melinis minutiflora Beauv.), appear to be little utilized by Nēnē.

PREDATION

The most important factor limiting the reproductive success of Nēnē is predation by mongooses. Mongooses are primarily egg predators but also kill incubating females on the nest. About 30% of all active nests found during the past three years failed because mongooses stole eggs or killed incubating geese. Five nesting females disappeared or were found dead before incubation was completed. However, mongoose predation on goslings is still undocumented and may be rather infrequent. On one occasion a gander was seen successfully chasing a mongoose away from his family.

Mongooses are perhaps opportunistic predators of Nēnē eggs and females. They may wait for the pair to take a recess from incubation before venturing close to the nest. If the pair is absent, an egg may be removed from the nest and eaten. This may reoccur until all eggs are taken. Should the female be sleeping on the nest and the male is inattentive, a mongoose would have little trouble in killing the goose.

Although studies of Nēnē incubation behavior have not been concluded, one wild female took about eight daily recesses (averaging 19 minutes each) from incubation during a renesting attempt. This female frequently appeared to be asleep on the nest during incubation sessions. Cooper (1978) found that Giant Canada Geese (Branta canadensis maxima Delacour) took no more than two daily recesses from incubation, each averaging less than 15 minutes in duration. It appears, then, that mongooses may have frequent opportunities to steal eggs or kill females without risking a confrontation at the nest.

Evidence that mongooses are the primary predators of Nēnē eggs and females comes from the unique style in which eggs are eaten. The egg is bitten into and a small opening is made through which the contents can be lapped up with the tongue. Usually, at least half of the egg shell remains intact after a mongoose has eaten the contents. Rats, at least Rattus rattus L., do not seem capable of opening Nēnē eggs, judging from the lack of success in getting them to eat chicken eggs (which are smaller than Nēnē eggs) in captivity. One small egg covered with small tooth marks, presumably those of a rat, was found unopened in an abandoned wild nest.

DISCUSSION AND CONCLUSION

Nēnē cannot be considered prolific breeders when compared to other geese, despite having a very long nesting season. While fertility and hatchability of wild eggs do not appear abnormally low, small clutch-size, high gosling mortality, and a high incidence of predation on eggs and incubating females account for the very low productivity observed during the past three years.

Three major factors can be suggested as contributing to poor nesting results. Dry weather during the breeding season may inhibit breeding and/or negatively affect hatchability and gosling survival. The quality and availability of grasses and other food plants may be seriously reduced during dry periods.

Habitat quality may be lower in recent years because of the spread and dominance of many introduced grasses and shrubs, some of which are little utilized by the geese. Cattle (Bos taurus L.) and feral goats (Capra hircus L.) have also altered or destroyed native plant communities which once may have been more suitable for nesting and rearing young.

Predation by introduced animals, especially mongooses, is an extremely important factor limiting Nēnē reproductive success. It is not known what native animals, if any, originally preyed on Nēnē eggs, young, or adults.

Disease has not yet emerged as an identifiable factor in limiting Nēnē productivity.

In conclusion it should be clear that management action is needed to reduce predation at nests. Also, further habitat degradation by feral goats and by the continued spread of exotic plants should be halted. Accompanying such projects should be a careful effort to monitor Nēnē productivity to assess the effectiveness of management programs. The present natural productivity of the Nēnē is low enough such that vigorous, well-planned management to reduce unnatural limiting factors is necessary to enable Nēnē populations to recover in the wild.

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