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Limitations on Canada Goose Production at Fish Springs National Wildlife Refuge, Utah

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LIMITATIONS ON CANADA GOOSE PRODUCTION AT

FISH SPRINGS NATIONAL WILDLIFE REFUGE, UTAH

by

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ABSTRACT

Limitations on Canada Goose Production at
Fish Springs National Wildlife Refuge, Utah

by

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Canada geese (Branta canadensis) recently have become management problems in some areas due to overpopulation. At Fish Springs National Wildlife Refuge (NWR), managers are concerned with the opposite situation: Despite attempts to boost production, only 18 to 34 goslings of the western Canada goose (B. c. moffitti) were produced per year, from 1989 to 1993. I studied the breeding population from March to July in 1996 and 1997. Results suggest that production is limited in 3 ways: low gosling survival, low nesting success for ground nests, and low number of breeding pairs.

Gosling survival to fledging was 25% in 1996 and 52% in 1997. I examined the potential causes of low gosling survival, especially the effects of saline drinking water. Specific conductivities in the spring-fed marshes of the desert refuge range from 3.0 to 25.0+ µS/cm. I conducted an experiment on captive wild-strain goslings. Three groups received different levels of saline water as measured by specific conductivity: control (0.63 µS/cm), intermediate (12.0 µS/cm), and high (18.0 µS/cm). I found mortality only at the high level. Effects on growth were growth were evident at both the intermediate and high levels, although statistically significant only at the high level.

To examine the effects of saline drinking water on survival of free-ranging wild goslings, I collared and radio marked breeding adults, then monitored brood location and gosling numbers. I found that mortality was independent of specific conductivity levels on the brood-rearing impoundments. Observations suggest that the primary causes of low gosling survival involve predation and human disturbance.

I compared my results to the results of other studies. Accuracy of results appears to be related to the estimation technique used. Radio tracking of broods has the potential to be very accurate.

At Fish Springs NWR, I monitored nesting pairs, nests, and broods throughout the breeding season. Ground nests had lower nesting success in both years (56%, 41%) than artificial nesting platforms (90%, 83%). The number of nesting pairs was 26 and 34 in 1996 and 1997, respectively.

Based on these results, I made several management recommendations, including installing more artificial nesting platforms, and minimizing human disturbance.

(117 pages)

DEDICATION

To my grandmother, Bernice Goldenberg, who inspired me to continue my education by earning her master's degree at the age of seventy-eight. And, to my parents, JoAnn and Paul Stolley, who have given me support and encouragement in all my endeavors.

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Dorie S. Stolley

FOREWORD

This thesis is presented in six chapters using a multiple-paper format. Chapter 1 is a general introduction and overview, and Chapter 6 is an overall review. My research was organized into the four middle chapters (2-5), each addressing an aspect of this project. All chapters, except chapter 4, were formatted in the style of the Journal of Wildlife Management. Chapter 4 follows the style of Great Basin Naturalist. Literature citations, tables, and figures are organized within individual chapters.

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CHAPTER 1

INTRODUCTION

Canada geese (Branta canadensis) recently have become management problems in many areas due to overpopulation (Conover and Chasko 1985, Conover and Kania 1991, Ankney 1996). At Fish Springs National Wildlife Refuge (NWR) in western Utah, managers must grapple with the opposite problem; a local population with poor reproductive success.

STUDY SITE

Fish Springs NWR is located at the southwest edge of the Great Salt Lake Desert in Juab County, Utah (refer to Fig. 3-1). The refuge is at an elevation of 4,300 feet (1,311 m), and receives an average of 20 cm of rain annually. Temperatures range from -26.1 to 42.7 C. The refuge is 17,992 acres in size and contains approximately 8,905 acres of saline marsh, 7,084 acres of mud and alkali flats, and 2,003 acres of semi-desert uplands (Annu. Rep., Fish Spring NWR, 1995). At optimum water levels there are about 3,500 surface acres of water in a complex of pools, sloughs, and springs. As ancient Lake Bonneville lake bottom, the refuge is very flat, and the soil is saline and alkaline.

Five major, and several minor thermal springs arise from a fault line running parallel to the east side of the Fish Springs Mountain Range and feed the refuge's marsh. The springs are moderately brackish with specific conductivity measurements ranging from 2.9 to 3.4 μS/cm, except for North Spring, which measures 5.1 μS/cm. For comparison, fresh water measures about 0.3 μS/cm.

An aerial photograph taken before modification of the wetlands began (circa 1960) shows an area of sloughs and narrow waterways lined with emergent marsh vegetation (refer to Fig. 3-2). After the refuge was established in 1959, 9 large, shallow pools, impounded by dikes and fed from the springs through canals, were created, enlarging and modifying the natural marsh. Much of the area of the more southern impoundments, viz., Avocet, Mallard, Curlew, Egret, and Shoveler, was original slough; thus, there are numerous islands and peninsulas. The southernmost impoundments also are closer to the springs that provide their water. Because of this, and because the soil underlying these impoundments is flushed continually with relatively low salinity water, most of the year the water in these pools is only slightly to moderately more saline than the springs. They contain typical emergent marsh vegetation, e.g., Olney's three-square bulrush (Scirpus americanus), cattail (Typha domingensis), hardstem bulrush (S. acutus), alkali bulrush (S. maritimus), wirerush (Juncus arcticus), and saltgrass (Distichlis spicata). Abundant mats of submergent vegetation, primarily wigeongrass (Ruppia maritima) and muskgrass (Chara spp.), and spiny, or pond naiad (Najas marina), and coontail (Ceratophyullum demersum) grow in the springs, canals, and pools. Additionally, the native Phragmites australis has expanded into much of the marsh.

The northern impoundments, viz., Ibis, Pintail, Harrison, and Gadwall, were constructed on the northern edge of the original wetlands, and contain little of the original marsh structure. Most of the water feeding these pools comes from more southern pools that are more saline than the springs that supply them. Additionally, because of evaporation and leaching of salts from the original playa, the water in the northernmost impoundments is more saline than in the southern impoundments. These impoundments become dry or reduced during the summer because the volume of spring input does not match evaporation rates. The bordering vegetation is characterized by saltgrass (Distichlis spicata), pickleweed (Allenrolfea occidentalis), and annual samphire (Salicornia europaea). They contain little emergent or submergent vegetation. However, sloughs in these impoundments are fed from the less saline main canal, or from North Spring, and specific conductivities range from 4.7 to 7.5 μS/cm during the breeding season. They contain vegetation similar to the southern sloughs.

HISTORY

Fish Springs NWR was established in 1959 to provide nesting, wintering, and migratory habitat for waterfowl. Creation of impoundments and other development of the marshlands was completed in 1964. It is not known definitely whether Canada geese nested in this area prior to the establishment of the refuge (Annu. Rep., Fish Springs NWR, 1992; J. Banta, Fish Springs NWR, pers. commun.); however, they were not nesting in the refuge area in 1959.

In July, 1960, the U. S. Fish and Wildlife Service (USFWS) secured 40 goslings of the western subspecies of Canada goose (B. c. moffitti) from Tautphaus Park, Idaho Falls, Idaho, and transferred them to Bear River NWR to form the basis of a captive flock that was intended to encourage wild geese to utilize the refuge. By January 1961, these birds were caged at Fish Springs NWR and a wild Canada goose was observed near them. Over the years, increasingly more wild birds spent time at the refuge. In 1962, 40 western Canada geese from Bear River NWR were added to the captive flock, making a total of 108 geese, and the first wild nest was observed. It held five eggs; unfortunately there is no record as to its fate. In 1963, approximately 100 geese either escaped from the captive flock enclosure, or were released. In 1964, the first substantial production of goslings by wild geese occurred. Approximately 30 goslings hatched, and 18-20 (60-67%) survived to fledging.

By 1965, significant numbers of free-flying Canada geese were using the refuge for a migration stop and for breeding. Refuge personnel reported that 38 goslings hatched with 35 (92%) surviving to fledging. The Tracy Aviary in Salt Lake City gave approximately 7 dusky

Canada geese (B. c. occidentalis) to the refuge for the captive flock. One died soon after its transferral. From 1965 to 1969, Canada goose numbers gradually increased, as did gosling production. However, production estimates are unreliable because of the estimation techniques used (see Chapter 5). I reviewed old annual reports from Fish Springs and found no description of the estimation technique used prior to 1983. I assumed that total gosling counts were employed for quantification purposes when the total number of goslings was small, because the technique is accurate and easy, and because there was great interest in the fate of the population. For greater numbers, the estimation technique may have been similar to that used in 1983 by then assistant manager, James Alphonso. He described how he estimated production by comparing the average number of young hatched per nest with the average size of broods recorded at a later dates (J. Alphonso, Goose Production, Fish Springs NWR, 1983). This estimation method has been employed by other researchers (Steel et al. 1957, Hanson and Eberhardt 1971, Mickelson 1973). Alphonso used the following formula to estimate total production:

$$P_T = \bar{x}_{PR} S_N N_B$$

where $\bar{x}_{PR}$ = average number of pairs, S_N = nesting success, N_B = average 4-6 week old gosling brood size, and P_T = total production. Alphonso based average number of pairs on the average from 4 counts of pairs in early spring. This may have resulted in an erroneous result because not all pairs become territorial, and not all territorial pairs nest; even copulation and nest site selection do not necessarily signify a nesting attempt (Martin 1964, Sherwood 1966, Ball et al. 1981). Thus, it is highly possible that Alphonso overestimated number of nesting pairs. Additionally, his formula did not take into account those broods in which all goslings were lost prior to the 4-6 week brood count. This can result in an overestimation of production (Krohn and Bizeau 1980, Eberhardt 1987). In 1983, production may have been overestimated by as much as

79.5% or 61 goslings (D. Stolley, unpubl. data). If earlier estimates at Fish Springs NWR were done in the same manner, it is most probable that they overestimated gosling production. Thus, trends become more important than actual number; although, as mentioned previously, smaller numbers (<50) are probably more accurate than larger ones (Fig. 1-1).

Canada goose production increased from 1963 to 1968. In 1970, poor gosling production was attributed to "violent spring storms" (Annu. Rep., Fish Springs NWR, 1970). Only 25 goslings were produced. In 1971, production increased (Annu. Rep., Fish Springs NWR, 1971). During the 3 following years, 1972 to 1974, productivity decreased (Annu. Rep., Fish Springs NWR, 1972, 1973, 1974), possibly because these were drought years that may have reduced clutch size and lowered numbers of successful breeders (Davies and Cooke 1983). These years were followed by 4 boom years, 1975 to 1978, with greater numbers of goslings produced (Annu. Rep., Fish Springs NWR, 1975, 1976, 1977, 1978). The increase was credited to intensive predator control in 1974 and 1975 (Annu. Rep., Fish Springs NWR, 1978). Habitat improvement for breeding geese, such as creation of nesting islands, was also completed during these 2 years (Annu. Rep., Fish Springs NWR, 1978).

The lowered production from 1979 to 1981 was attributed to coyote predation on eggs and goslings (Annu. Rep., Fish Springs NWR, 1981). On April 9, 1982, Animal Damage Control personnel from Salt Lake City flew over the refuge with the objective of shooting coyotes; none were seen. That year even fewer goslings fledged, however, the poor production was not credited to coyote predation (Annu. Rep., Fish Springs NWR, 1982). Another bad year followed; nesting success was 66% with all nest failures attributed to predation by raven, coyote, or an "unknown" predator (J. Alphonso, Goose Production, Fish Springs NWR, 1983). Gosling mortality was estimated at 45% and attributed to predation.

The next major drop in production came in 1989 following the only 2 years of hunting on Canada geese ever allowed in the refuge (1987 and 1988). Total population, number of pairs, and gosling productivity declined (Annu. Rep., Fish Springs NWR, 1989). Since 1989, refuge managers have been concerned with the low production and have assigned personnel to closely monitor nesting. From 1989 to 1993, gosling mortality rates were between 49 and 70%. Gosling production was determined by total gosling count and was between 18 to 34 per year. Number of nesting pairs was stable at 18 to 22 pairs (Annu. Rep., Fish Springs NWR, 1989, 1990, 1991, 1992, 1993).

In 1994, refuge personnel reported that 69 goslings hatched from a maximum number of 15 nests (4.6 per nest). They were unable to count number of goslings surviving to fledging, but estimated it as 24, based on a mortality rate of 35%, the average rate for the previous 3 years (Annu. Rep., Fish Springs NWR, 1994). In 1995, a maximum number of 17 goslings fledged (Annu. Rep., Fish Springs NWR, 1995). In 1993, the refuge personnel became concerned with the possibility that the high salinity levels in some of the impoundments might diminish gosling vigor and contribute to mortality. Workers moved 5 artificial nesting platforms from the more saline northern impoundments to the less saline Avocet and Curlew units. Many artificial nesting islands in the northern pools were destroyed at this time. The intent was to deter geese from nesting in the northern impoundments, and to encourage them to nest and raise their young in the less saline southern impoundments.

GOSLING SURVIVAL RATES

The western subspecies of the Canada goose, B. c. moffitti, breeds over an extensive area, ranging from Alberta and British Columbia south to northern California and southern Utah, and from the Cascade Mountains of Washington, Oregon, and California east to central Montana, central Wyoming, and Alberta (Krohn and Bizeau 1980). Based on studies of band returns, Krohn and Bizeau (1980) divided this subspecies into two populations: the Rocky Mountain population (RMP) and the Pacific population (PP). Historically, the RMP was known as the Great Basin population, however, it was found that this population breeds outside of the Great Basin region. Thus, the term "Great Basin" was dropped in favor of Rocky Mountain, which is more descriptive of the actual range of the population (Krohn and Bizeau 1980).

B. c. moffitti is the second largest of the 11 subspecies of Canada goose recognized by Delacour (1954). It is distinguishable from the other races in size, weight, body proportions, color, flight characteristics, and call (Ball et al. 1981). Some researchers consider B. c. moffitti and B. c. maxima (the giant Canada goose) to be the same race (Palmer 1976, Owen 1980). Krohn and Bizeau (1980) consider the 2 subspecies to be "closely related" due to similar blood serum proteins, similar molt migrations to subarctic Canada, and only clinal differences in body size and color

Studies of B. c. moffitti and B. c. maxima have shown gosling survival rates from 49 to 95% (Geis 1956, Steel et al. 1957, Martin 1963, Dey 1964, Brakhage 1965, Sherwood 1966, Hanson and Eberhardt 1971, Glasgow 1977, Knight 1978, Krohn and Bizeau 1980, Ball et al. 1981, Zicus 1981, Wang 1982, Warhurst et al. 1983, Eberhardt et al. 1989) (refer to Table 3-1). Krohn and Bizeau (1980), in a meta-analysis involving weighted averages from the results of 10 studies, estimate RMP gosling survival at 92 to 95%. Sherwood (1966) monitored gosling survival of giant Canada geese at Seney NWR in Michigan for 3 years. In 1963 and 1965, he found survival rates of 78 and 72%, respectively. In 1964, he documented a survival rate of only 16% due to an outbreak of disease, probably Leucocytozoon, a blood parasite.

From 1989 to 1993, and in 1995, Fish Springs NWR personnel closely monitored breeding geese to obtain accurate production numbers and survival rates (refer to Table 3-2). Overall gosling survival (weighted average) for these 6 years was near 35% with annual production averaging 26 individuals. This low survival rate suggested the need for an in-depth study of the causes of gosling mortality.

CAUSES OF GOSLING MORTALITY

Mortality of young waterfowl between hatching and fledging may be caused by numerous factors including environmental contaminants (Blus et al. 1979, Ohlendorf et al. 1986, Stephens and Waddell 1989, Sargeant and Raveling 1992) , predation (Geis 1956, Brakhage 1965, Sherwood 1966, Mickelson 1973, Wang 1982, Sargeant and Raveling 1992, Sedinger 1992), human disturbance (Sherwood 1966), inadequate nutrition (Sedinger 1992), storms or unusual weather (Sargeant and Raveling 1992), disease (Sherwood 1966), and poor parenting skills (Raveling 1981, Afton and Paulus 1992). In North America, the greatest danger from contaminants comes from agricultural areas. For instance, ducklings in the Central Valley of California died from the effects of selenium poisoning, either as embryos, or soon after hatching (Ohlendorf et al. 1986). The selenium was concentrated in agricultural runoff. Canada geese in Washington experienced mortality and lowered reproductive success from ingesting cereal grain treated with heptachlor (Blus et al. 1979). In the Klamath Basin of California and Washington, Canada geese feeding on oats treated with zinc phosphide died in large numbers (Ashworth 1979). Despite these examples, contaminants rarely are the direct cause of death of prefledged waterfowl (Sargeant and Raveling 1992).

Predation is an important cause of mortality in goslings (Geis 1956, Brakhage 1965, Sherwood 1966, Mickelson 1973, Wang 1982, Sargeant and Raveling 1992, Sedinger 1992). Goslings are especially vulnerable when traveling overland from nesting areas to brood-rearing areas (Geis 1956). Young birds weakened by disease or malnutrition may more easily fall prey to a predator, thus making it difficult to determine the effects of predisposing causes of mortality. Because predators are usually scavengers as well, finding animal remains at a predator den or perch is not necessarily indicative of the cause of mortality. Because the presence of an observer may affect predator behavior, it is difficult to observe predators taking goslings. These facts make it difficult to determine the true effect of predation on survivorship.

Human disturbance can cause lower nesting success in geese due to abandonment (Sherwood 1966, but see Sedinger 1990). Disturbance can lower fledging success (Sherwood 1966). Broods may avoid areas with regular human disturbance (Evans et al. 1952, Stoudt 1982). Sedinger (1992) observed black brant (Branta bernicla) temporarily abandoning specific areas in response to human disturbance. If broods that leave choice brood-rearing areas go to areas of lower quality forage or higher predation risk, they increase the chances of mortality. Additionally, Geis (1956) associated gosling mortality in the first few days after hatching with overland brood movement. She attributed these mortalities to predation. If broods are more vulnerable to predation while traveling overland, human disturbance may cause mortality indirectly.

Biochemical changes from disturbance-related stress may also have an effect on the vitality of young. For instance, Fernandez and Azkona (1993), in a study of northern harriers (Circus cyaneus), found that the young in disturbed nests had higher blood urea levels than did controls. They concluded that this might affect nestling condition. More directly, goose broods that are disturbed and forced off dikes by visitors on foot or in vehicles may leave slower young behind in their hurry to escape (Sherwood 1966; D. Stolley, pers. obs.).

Adequate nutrition is important to the survival of young waterfowl (Sedinger 1992). Street (1977) reported that mallard ducklings raised in a flooded quarry with low densities of their primary food item (aquatic invertebrates) had a high mortality rate (77%). Pehrsson (1986) and Pehrsson and Nyström (1988) found that oldsquaw (Clangula hyemalis) ducklings suffered from higher mortality when present at higher densities, presumably because of reduced food availability per bird.

In addition to playing an important role in the survival of young waterfowl, nutrition during the prefledging period may affect population size, vigor, or recruitment by affecting the adult size of an individual duck or goose (Sedinger and Raveling 1986, Cooch et al. 1991). Würdinger (1975) showed that food availability affected growth rate and feather development in young Anser and Branta goslings. Cooch et al. (1991) found that gosling growth rates were significantly affected by differences in nutritive intake, and that gosling growth rates affected adult body size in lesser snow geese. They surmised that adult body size may affect fecundity and survival (but see Davies et al. 1988). Under laboratory conditions, Wink (1980) found that reduced food intake caused decreased body weight, femoral weight, and femoral radiocapacity.

Mineral deficiencies can cause problems in young waterfowl (National Research Council 1994). Perosis, a crippling condition caused by manganese deficiency, was indicated in the mortality of numerous goslings in the captive flock at Fish Springs NWR in 1964 (Annu. Rep., Fish Springs NWR, 1964).

During the prefledging period, goslings depend on their parents to lead them from the nest to the brood-rearing area, a potentially hazardous and arduous journey. Additionally, goslings brood underneath the female for warmth during the first few days following hatch or during inclement weather. The parents keep the goslings together as a group, lead them to feeding areas, keep alert for predators and other dangers, and sometimes actively defend them against predators. They also aid them in social interactions that may affect survival (Raveling 1981). Female goslings appear to learn successful brood-rearing locations from their parents (Lessells 1985). Adults with poor parenting skills due to inexperience or low parental investment will lose more goslings than "good" parents (Raveling 1981; D. Stolley, pers. obs.).

Weather, especially extremely cold or wet weather, can affect gosling survival adversely (MacInnes et al. 1974, Raveling 1977, Sargeant and Raveling 1992), particularly in northern regions (Sargeant and Raveling 1992). Disease has the potential to drastically affect the survival of prefledged waterfowl, as Sherwood (1966) documented. He observed Leucocytozoon, a blood parasite, devastate goslings at Seney NWR resulting in a fledging rate of only 16% in 1964. However, in general, the actual extent to which disease is responsible for gosling mortality is unknown (Sargeant and Raveling 1992).

POTENTIAL CAUSES OF GOSLING MORTALITY AT FISH SPRINGS NWR

The pattern of mortality at Fish Springs NWR does not fit either that displayed by the effects of storms or unusual weather or epidemic disease. If weather were causing mortality, there would be a rash of deaths after a storm or cold period. This has been noted at Fish Springs only once, although it was low nesting success, rather than direct mortality, that was attributed to violent spring storms in 1970. Additionally, during the years of this study, I noted no unusually violent rainstorms or hailstorms, or cold periods. Epidemic disease can also cause many deaths over a short period of time, and, if present, I would have expected to see obviously ailing goslings. I did not. Because they are stochastic events, extreme weather conditions or epidemic disease would be unlikely to cause the consistently low gosling survival reported over the years.

I ruled out most contaminants as being the cause of either low egg success or low gosling survival from egg content analysis done in 1990 (B. Waddell, USFWS Contaminants Division, unpubl. data), and water quality analysis done in 1990 (D. Stevens, USGS, unpubl. data). Selenium was undetectable in the water at concentration lower limits of 1 μg/L. Although boron concentrations exceeded the standard for agricultural protection (750 μg/L), they were not sufficiently high to affect either eggs or goslings (J. Kadlec, Utah State University, pers. commun.). Additionally, my examination of 10 unhatched eggs showed no deformities in embryos. The only obvious deformity I saw in any gosling was one case of "wry-neck" or scoliosis, believed to be caused by a genetic condition, or malposition in the egg (D. Holderread, Holderreads' Waterfowl Farm and Preservation Center, pers. commun.).

However, Fish Springs NWR has a feature that has the potential to lower reproductive success in waterfowl. Due to moderately brackish springs as the main source of water, there is no fresh water in the marsh. Even the small amounts of rainfall this area receives are immediately incorporated in the larger bodies of saline water. In the preferred brood-rearing impoundments of the geese, salinity levels can rise above levels that are lethal or can cause sublethal effects to young waterfowl (Mitcham and Wobeser 1988a,b). Thus, salinity, as a natural contaminant, may be considered a potential cause of gosling mortality.

Historically, the low gosling survival at Fish Springs NWR was attributed to predation by coyotes (Canis latrans). Coyotes are present at the refuge, and are not subject to any form of animal control (i.e., poison, trapping, shooting). I have observed them stalking geese, and a refuge volunteer observed a juvenile coyote carrying an adult Canada goose carcass in 1996 (K. Jenkins, Fish Springs NWR, pers. commun.). At the refuge, other potential predators of goslings include red fox (Vulpes fulva), black-crowned night herons (Nycticorax nycticorax), and raptors, such as golden eagles (Aquila chrysaetos), great-horned owls (Bubo virginianus), short-eared owls (Asio flammeus), and various hawks. These are not present in large numbers, except for northern harriers (Circus cyaneus) that do not feed on live waterfowl, and short-eared owls that were observed all over the refuge, and were active during the day.

In 1965, refuge personnel were concerned with the low quality of forage available on the refuge for the young geese, and initiated a crop planting program (Annu. Rep., Fish Springs NWR, 1965). This, and subsequent attempts to grow crops, proved impractical due to the salinity and alkalinity of the soil, and the large amount of water necessary for irrigation (J. Banta, Fish Springs NWR, pers. commun.). I often observed several broods feeding together, and in the same place on subsequent days. It may be that at high brood densities, the geese are reducing the availability of their preferred food items, as Sedinger and Raveling (1984) found with cackling geese. In-depth research of the effects of nutrition were beyond the scope of this project. However, I do address it in discussions.

Fish Springs NWR has not been a prime area for the production of goslings. This may be reflected in the behavior of the nesting geese. In a low-quality area, parental investment theory postulates that adults will invest less energy in any one breeding season, in order to survive and attempt breeding the next year (Afton and Paulus 1992). I would expect these adults to abandon nests more easily and be less attentive parents than geese in high-quality habitats. Less attentive parents will probably fledge fewer goslings (Raveling 1981).

The poor reproductive success of the Fish Springs Canada goose population may be a result of other factors besides low gosling survival. These factors include number of breeding pairs, number of available territories, quality of territories, clutch size, nesting success, egg success, overwinter survival and recruitment, and age of first breeding. Many of these elements are examined in more detail in chapter 4.

OBJECTIVES

The objectives of my research at Fish Springs NWR in 1996 and 1997 were 3-fold:

1. To examine the effects of saline drinking water on gosling survival and growth.
2. To determine if, and at what stage in the reproductive cycle, production is being limited.
3. To make management recommendations regarding goose and gosling management.

FORMAT AND CONTENT OF CHAPTERS

All of the chapters of this thesis, except chapter 4, are written in Journal of Wildlife Management manuscript format. Chapter 4 follows the format of Great Basin Naturalist. The following 2 chapters address objective 1. In chapter 2: *The Effects of Saline Drinking Water on Captive Wild-Strain Goslings*, I established a dosage response of goslings to levels of saline water naturally occurring at Fish Springs NWR. In chapter 3: *The Effects of Saline Drinking Water on Gosling Survival at Fish Springs National Wildlife Refuge*, I utilized the natural experiment that the pools of varying salinity provided to determine if gosling mortality was dependent on salinity. Together, chapters 2 and 3 reveal that saline drinking water was not important in causing gosling mortality at Fish Springs NWR in 1997.

In chapter 4: *Limitations on Canada Goose Production at Fish Springs National Wildlife Refuge*, I addressed the problem of low gosling production from a larger perspective. I described the observational study I conducted at Fish Springs NWR to quantify breeding parameters. I identified 3 limitations on gosling production: number of breeding pairs, nesting success, and fledging success. I also quantitatively explored the relationship between brood location and gosling mortality. Circumstantial evidence pointed to several causes of gosling mortality that I discussed. I concluded the chapter with management suggestions intended to increase production at Fish Springs NWR.

In chapter 5: *Techniques of Determining Gosling Survival*, I compare the various estimation and quantification techniques used to measure gosling survival. Some common techniques consistently overestimate gosling survival. These have been used in a number of studies, results from which are often cited. By comparison to results from research utilizing more accurate techniques, I put gosling survival at Fish Springs NWR into a more realistic perspective. Chapter 6 integrates the information from chapters 2-5 to provide an overall conclusion.

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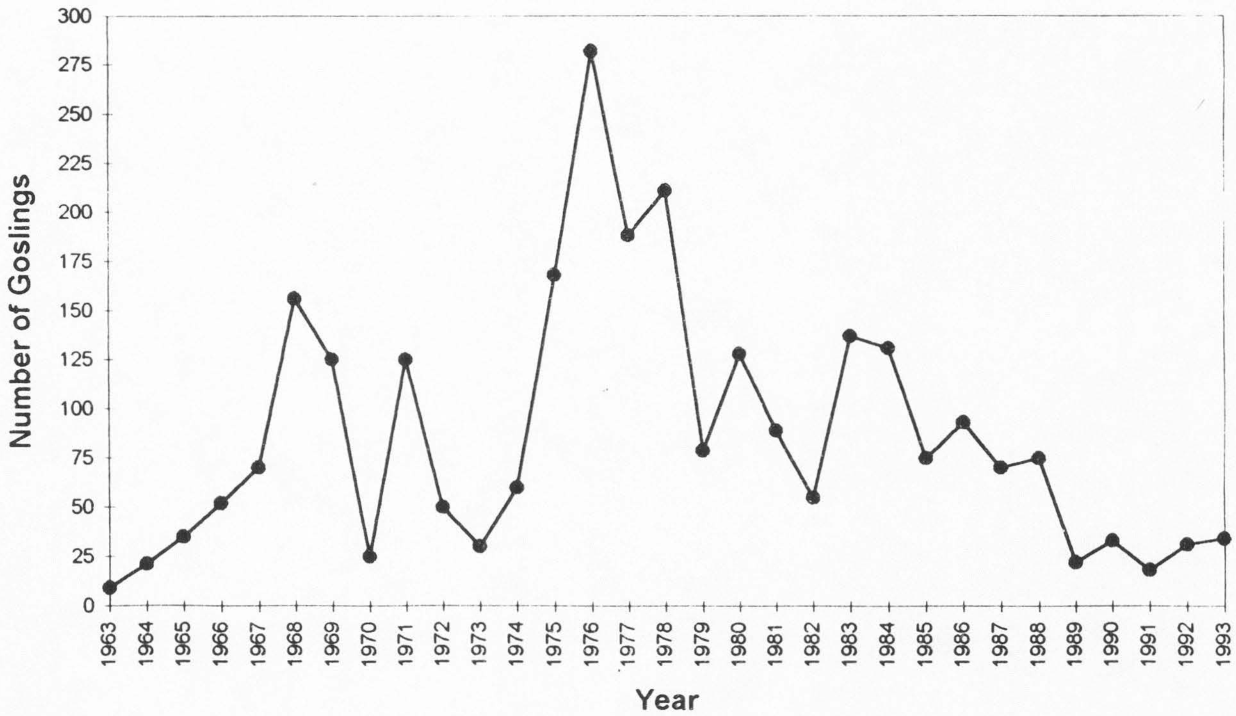

Fig. 1-1. Trend of Canada goose gosling production at Fish Springs NWR, Juab County, Utah, 1963-1993.

CHAPTER 2

THE EFFECTS OF SALINE DRINKING WATER ON CAPTIVE WILD-STRAIN GOSLINGS[1]

Abstract: Saline inland wetlands exist all over the world, and are used by breeding birds. At certain levels, saline drinking water adversely affects the growth and development of young waterfowl. At Fish Springs NWR in western Utah, saline drinking water was suspect in the low survival rate of goslings of Canada geese (Branta canadensis). We researched the effects of naturally occurring saline drinking water on the survival and growth of captive wild-strain goslings from day 1-28 following hatch. We compared survival and growth (as measured by body mass, wing length, and culmen length) between a control group on tap water with a specific conductivity of 0.6-0.7 μS/cm, and 2 saline water treatments: intermediate level (12 /cm) and high level (18 μS/cm). The only mortalities occurred in the 18 μS/cm treatment (33%, n=9). We measured the slopes of regression of mean body mass, wing length, and culmen length on age from day 4-28 for the 3 treatments, and compared the slopes between treatments using t-tests. We found all slopes to be significantly different from one another, except for culmen length for the intermediate and high treatment levels. We expect free-ranging wild goslings to experience mortality at lower salinity levels than captive goslings due to the combined effects of depressed growth and environmental stresses.

INTRODUCTION

Local populations of Canada geese (Branta canadensis) generally experience high

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fledging success rates, often between 80 and 97% (Geis 1956, Steel et al. 1957, Martin 1963, Dey 1964, Mickelson 1973, Krohn and Bizeau 1980). Other researchers have reported gosling survival rates to fledging from 60 to 79% (Brakhage 1965, Sherwood 1966, Knight 1978, Zicus 1981, Wang 1982). Lower rates occasionally are reported. For instance, Eberhardt et al. (1989) found a fledging success rate of 49% in his study in Washington, and results from a study in Alberta indicate a survival rate of 56% (Glasgow 1977). Extremely low gosling survival rates may be the result of stochastic events, such as an epidemic or unusual weather conditions. Sherwood (1966) documented a survival rate of 16% in 1964 at Seney National Wildlife Refuge (NWR), as compared to 78 and 72% in 1963 and 1965, respectively. The extremely low rate was due to an epidemic disease, probably Leucocytozoon, a blood parasite (Sherwood 1966). Canada geese at Fish Springs NWR in western Utah have experienced low (25 to 60%) fledging rates from at least 1989 to 1997 (D. S. Stolley and J. A. Bissonette, Utah State Univ., unpubl. manuscript).

Due to moderately brackish springs as the main source of water, no fresh water is available on or around the Fish Springs NWR's human-modified marsh. Even the small amounts of rainfall this area receives are immediately incorporated into the larger bodies of saline water. The preferred brood-rearing pools of the geese become highly saline as the spring and summer progress due to the leaching of salts in the soil and because evaporation exceeds spring output.

Adult geese and ducks are able to drink saline water because they possess nasal salt glands that function to excrete excess salt from the bloodstream. The kidneys alone are incapable of excreting sufficient salts to ensure the survival of a bird exposed to hypertonic saline drinking water (Bradley and Holmes 1972). It takes, however, about 6 days after hatching for goslings and ducklings to develop fully functioning salt glands (Ellis et al. 1963; Riggert 1977; D. Stolley, pers. obs.). Holmes et al. (1961) showed that gull chicks given solutions of NaCl experienced growth depression. Ellis et al. (1963) established the same for ducklings. Since then researchers have conducted more in-depth studies of the effects of saline drinking water on ducklings of various species, both in the lab and in the field (Riggert 1977; Wink and Hossler 1979; Wink 1980; Swanson et al. 1984; Mitcham and Wobeser 1988a,b)

Several field and lab studies have established dosage responses of mallard (Anas platyrhynchos) and other ducklings to saline drinking water (Swanson et al. 1984; Mitcham and Wobeser 1988a,b). Swanson et al. (1984) exposed 4 groups of 10 1-day-old mallards each to saline lake water diluted in 1 µS/cm increments from 20 to 17 µS/cm for 9 days to determine effects on growth, as defined by body mass. They compared results to ducklings given well water routinely used for raising young waterfowl. They found that saline water significantly reduced growth, and, as specific conductivity increased, growth decreased. They observed no mortalities at 17 µS/cm, 10% mortality at 18 and 19 µS/cm, and 30% at 20 µS/cm. In a different experiment, they supplied 10 1-day-old mallard ducklings to 16 µS/cm lake water for 12 days. They recorded 10% mortality after 4 days. In the water they utilized, the sulfates were the main anions, and sodium, magnesium, and potassium (in that order) were the predominant cations.

Mitcham and Wobeser (1988b) gave water from 10 saline Saskatoon wetlands to mallard ducklings under laboratory conditions. All ducklings given water with conductivities of 35 and 67 µS/cm died within 60 and 30 hours, respectively. They found 60% mortality at 20 µS/cm by the sixth day of a 14-day trial; no additional mortalities occurred after the sixth day. At 21.5 µS/cm only 2 of 9 ducklings survived to day 14. Mitcham and Wobeser observed poor growth, delayed feathering, and effects on several other physiologic functions in ducklings reared on water with conductivity as low as 7.72 µS/cm in a 14-day trial. Ducklings raised on water with conductivities ranging from 3.75 to 7.49 µS/cm grew as well as control birds supplied with fresh water in 14-day trials. However, when those supplied with water measuring 4.0 µS/cm were monitored to day 28, they had a significantly lower growth rate during the second 14 days.

We investigated the effects of naturally occurring saline water on the survival and growth of captive wild-strain goslings of the western Canada goose (B. c. moffitti). Our objective was to establish a dosage response to levels of salinity that goslings might experience during the brood-rearing period at Fish Springs NWR.

METHODS

The experiment was completed in 2 28-day trials during April and May 1997. Trial 1 began on 20 April, 11 days before trial 2, and used 9 goslings that were collected while pipping from 2 nests of a population of Canada geese in Cutler marsh in Cache County, Utah. We took them directly to Fish Springs NWR. For the second trial, we collected eggs from incomplete nests in Cutler marsh in March 1997, and took them to the Willow Park Zoo in Logan, Utah, where they were incubated for 28 to 30 days. We used 18 goslings in trial 2. When these goslings hatched, we took them as a group to Fish Springs NWR where we randomly assigned them to treatments, placed colored and numbered expandable plastic bands on their legs for individual and treatment identification, and placed them in 3' x 3' cages, 3 goslings per cage. Each cage was equipped with a heat lamp, a brooding box filled with straw, a water dish (of graduating size as the birds grew), and a food dish.

We supplied a standard starter diet (Chick Starter) ad libitum to all cages, as well as water of the appropriate salinity (see below) with commercial grit deposited in the water dishes. On days 1 and 2 following hatching, we dipped the goslings' bills into the water and feed to induce them to drink and feed. All goslings were observed drinking and feeding independently by day 3. We gave fresh grass to the goslings several times a week. We took daily measurements of body mass, wing length, and culmen length. We removed dead goslings as soon as we discovered them, and conducted necropsies to look for gross evidence of reason for death, e.g., food impacted in the esophagus.

We used the following saline water treatments: a control on tap water at 0.63-0.68 μS/cm (treatment 1), and intermediate level of 12.0 μS/cm (treatment 2), and a high level at 18.0 μS/cm (treatment 3). We collected water from one water control structure at Fish Springs NWR over a span of several months in 1996 to obtain samples of increasing specific conductivity. We then utilized this water in 1997 for the experiment, diluting samples with distilled water when necessary to obtain the correct specific conductivity. We mixed the saline water in 20-L batches, to within ± 0.2 μS/cm of the treatment level. We confirmed conductivity levels on a daily basis, and mixed more water as needed. Neuman Consulting in Salt Lake City, Utah, did the analysis of chemical characteristics of the water (Table 2-1). Sodium predominated the cations by an order of magnitude, followed by magnesium, calcium, and potassium. The major anions were chlorides and sulfates, and carbonate and bicarbonate were present.

In trial 1, there were 3 goslings in each of the 3 treatments. In trial 2, there were 6 goslings in each treatment. Overall, 9 goslings were assigned to each treatment. Goslings in trial 1 were the same age while goslings in trial 2 hatched over a span of 3 days.

We measured body mass on an electronic scale to the 0.1 g until the goslings reached 1,000 g, and then we switched to an Ohaus spring scale, accurate to 20 g. To measure entire culmen, we used a dial caliper, accurate to 0.1 mm. We measured wing length from the joint between the ulna and humerus to the end of the fleshy part of the wing, utilizing a wing rule accurate to 1.0 mm.

One gosling in treatment 2 was injured during the course of the experiment. Measurements for this bird were used only until the day of the injury (day 14). One wing length, and 5 culmen length measurements were not used in analyses because they were done improperly. On one day, 14 May, ground mixed grain was substituted for the Chick Starter, which was unavailable. This resulted in a decrease in body mass for many goslings of different ages; these measurements were not used in the analyses.

RESULTS

During the 28-day trial, no mortalities occurred in treatments 1 or 2. Three of 9 goslings died in treatment 3. On day 1 and day 2 following hatching, one of these treatment 3 goslings, #12, was about average, one, #10, was below average, and one, #31, was above average in body mass, wing length, and culmen length when compared to the mean values for treatment 3.

We measured the slopes of regression of mean body mass, wing length, and culmen length on age from day 4-28 for the 3 treatments, and compared the slopes between treatments using t-tests (Table 2-2). We found all slopes to be significantly different from one another, except for culmen length for treatments 2 and 3.

For each day, we did an ANOVA of mean differences among the 3 salinity levels in body mass, wing length, and culmen length . We set an alpha level of 0.10. Body mass was not significantly different among treatment groups on days 1 and 2 (Table 2-3, Fig. 2-1). From days 4-28, body mass was significantly less in treatment 3 than in treatment 1. Treatments 1 and 2, and 2 and 3 were not significantly different in body mass on 26 of 28, and 24 of 28 days, respectively.

Wing length was significantly different between treatments 1 and 3 on 2 days from days

3-13 (Table 2-4, Fig. 2-2). From days 14-28 it was significantly different between treatments 1 and 3 every day. Treatments 1 and 2 were significantly different on 4 days from days 3-28. Treatments 2 and 3 were significantly different on 7 days from days 3-28; all differences occurred later in the experiment, between days 19-28.

Culmen length was not significantly different between any of the treatment groups on days 2 and 3 (Table 2-5, Fig. 2-3). From days 4-28, culmen lengths from treatment 3 were significantly smaller than treatment 1 every day. From days 2-14, culmen lengths from treatments 1 and 2 birds were not significantly different. From days 15-28, treatment 2 goslings had significantly smaller culmens than treatment 1 goslings every day. Treatment 2 and 3 were significantly different on one day between days 4-28.

We first observed water dripping from the nostrils, indicating functioning nasal salt glands, on day 5 for a few birds, and on day 6 for the majority of goslings.

DISCUSSION

We established a dosage response of captive wild-strain goslings to naturally occurring saline drinking water. In our experiment, some mortality (33%) occurred at 18 μS/cm. This is comparable to the 30% mortality that Swanson et al. (1984) observed in ducklings at the same specific conductivity. We observed a downward trend in size and body mass averaged across the treatment groups. Many of the daily differences in means between treatments 1 and 2, and 2 and 3 were not statistically significant. This may have been due to the small sample sizes ($n \leq 9$), and large individual variation. Although not all are statistically significant, the measured daily average differences may have ecological significance. Figures 2-1, 2-2, and 2-3 illustrate the clear and consistent trends.

In wild Canada goose populations, most mortality occurs in the first 10 to 15 days following hatching (Geis 1956, Steel et al. 1957, Martin 1963, Dey 1964, Mickelson 1973, Krohn and Bizeau 1980, Ball et al. 1981, Eberhardt et al. 1989, Sargeant and Raveling 1992). Stolley and Bissonette (Utah State Univ., unpubl. manuscript) found that 51% of all mortalities that occurred in the first 15 days after hatch happened in the first 5 days. In our experiment, goslings supplied with 18 μS/cm water, on average, decreased in body mass from day 1 to day 2, and day 2 to day 3. From day 3 to day 4, they regained enough weight to match their average weight on day 1. It was not until the fifth day following hatching that they increased significantly in body mass. In the wild, these first few days are critical. Smaller goslings more easily succumb to predation, exhaustion, or exposure.

By day 28, treatment 2 goslings were on average one day behind control goslings in body mass, 2 days behind in wing length, and 4 days behind in culmen length. Treatment 3 goslings were 5 days behind control goslings in body mass, 4.5 days behind in wing and culmen lengths. Growth depression, if continued, often results in delayed fledging lengthening the exposure of goslings to predators, and delaying onset of migration. Slower growing goslings become smaller adults (Cooch et al. 1991). This might have an effect on future survival and fecundity (Cooch et al. 1991, but see Davies et al. 1988).

Salt gland secretions contain high concentrations of sodium and chloride and moderate concentrations of potassium and bicarbonate; other ions are virtually absent (Schmidt-Nielson 1960). Magnesium salts may be more toxic than sodium salts (Swanson et al. 1984, Mitcham and Wobeser 1988b). The results of this experiment using water high in sodium and lower in magnesium may underestimate the toxicity of saline water of different composition.

MANAGEMENT IMPLICATIONS

Riggert (1977) showed that mountain duck (Tadorna tadornoides) raising their broods on saline water selectively brought their young to drink at freshwater seeps. Swanson et al. (1984) found that on saline lakes in North Dakota, ducklings were closely associated with fresh water seeps or nearby wetlands of low salinity. Wild ducklings with no access to relatively fresh water died.

The marshes at Fish Springs NWR are fed by moderately brackish (3.0-5.1 μS/cm) springs. The only fresh water comes from the scant rainfall, about 18.2 cm annually, and it is quickly absorbed into the soil, or incorporated into the saline bodies of water. In addition, much of the soil is saline and alkaline, a legacy from ancient Lake Bonneville, which once covered the region. Spring water is channeled through a series of canals and pools. Due to leaching of salts from the soil and high levels of evaporation in the desert environment, the water becomes increasingly saline as the spring and summer progress. Thus, the preferred brood-rearing impoundments of Canada geese contain brackish to subsaline water during the breeding months. We expect wild goslings to experience mortality at lower conductivities than laboratory birds due to the additional effects of other environmental stresses and the hazards of living in the wild. The effects of saline drinking water on the survival of wild gosling at Fish Springs NWR deserve further investigation.

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Table 2-1. Chemical characteristics of water collected from water structure G-2 at Fish Springs NWR, Juab County, Utah, 15 May 1996.

Characteristic	**Value**
Spec.cond. (mmhos/cm)	11
pH (25g:100ml)	8.62
Na (ppm)	2159
Mg (ppm)	226
Ca (ppm)[a]	112
K (ppm)	105
Cl (ppm)	3072
SO_4 (ppm)	1441
HCO_3 (ppm)	277
CO_3 (ppm)[a]	17

[a] Ca and CO_3 levels may be depressed due to presence of precipitated calcium carbonate in the sample that was not measured.

Table 2-2. Results of t-tests differences in regression slopes of measurements of captive wild-strain Canada goose goslings on age, from day 4-28 following hatching in three treatment groups of increasing specific conductivity of drinking water[a], Fish Springs NWR, Juab County, Utah, 1997.

Body mass

Comparison	Point estimate	SE	T-ratio	P-value
1 vs. 2	-5.1	1.7	-3.0	0.0030
1 vs. 3	-12.6	1.8	-6.9	0.0001
2 vs. 3	-7.5	1.8	-4.1	0.0001

Wing length

Comparison	Point estimate	SE	T-ratio	P-value
1 vs. 2	-0.37	0.09	-4.19	0.0001
1 vs. 3	-0.91	0.09	-9.66	0.0001
2 vs. 3	-0.54	0.10	-5.63	0.0001

Culmen length

Comparison	Point estimate	SE	T-ratio	P-value
1 vs. 2	-0.09	0.02	-4.26	0.0001
1 vs. 3	-0.10	0.02	-4.30	0.0001
2 vs. 3	-0.01	0.02	-0.28	0.7813

a The three treatment groups were: 1 = control (650 µS/cm), 2 = 12,000 µS/cm, and 3 = 18,000 µS/cm.

Table 2-3. Daily mean values for body mass (g) of captive wild-strain goslings given tap water (1), or saline drinking water measuring 12 µS/cm (2), or 18 µS/cm (3),1997.

	Treatment								
	1			2			3		
Day	*n*	$\bar{x}$	SD	*n*	$\bar{x}$	SD	*n*	$\bar{x}$	SD
1	9	95.4a	5.7	7	98.1a	8.5	9	98.2a	7.6
2	9	95.7a	8.7	9	100.7a	11.5	9	92.9a	9.5
3	9	102.0a,b	12.7	9	107.6a	10.8	9	94.0b	14.8
4	9	117.3a	20.2	9	117.4a	15.2	9	98.3	19.8
5	9	141.1a	23.8	9	132.0a,b	15.8	8	119.3b	31.6
6	9	169.3a	23.6	9	159.6a,b	20.1	8	138.0b	43.3
7	9	196.3a	31.3	9	180.8a,b	24.7	8	165.5b	50.5
8	9	242.1a	34.5	9	224.9a,b	29.6	8	201.3b	64.1
9	9	277.2a	23.0	9	262.2a,b	39.3	8	232.4b	67.2
10	9	339.8a	36.8	8	312.6a	52.1	7	273.0	72.6
11	9	390.0a	45.4	9	359.1a	60.9	7	303.9	78.3
12	9	441.1a	31.7	9	383.7a	85.5	7	362.7b	104.1
13	9	482.9a	42.1	9	429.1a,b	81.9	7	389.9b	119.6
14	8	509.9a	40.8	6	493.7a,b	92.1	6	410.8b	125.9
15	9	600.9	68.2	8	514.3a	114.9	7	458.3a	128.5
16	6	668.7a	83.9	7	575.9a,b	147.0	7	460.3b	155.0
17	9	704.9a	86.7	8	630.9a	140.4	5	496.4b	112.5
18	9	743.8a	92.5	8	679.5a,b	148.2	6	572.0b	113.4
19	9	799.6a	107.7	8	742.0a,b	155.6	6	631.3b	166.0
20	9	852.6a	154.8	8	800.3a,b	176.5	6	673.8b	172.6
21	9	918.7a	140.7	8	853.4a,b	173.3	6	708.5b	209.7
22	9	977.4a	158.0	8	917.5a,b	197.9	6	763.8b	201.3
23	9	1040.3a	137.4	8	977.3a,b	226.0	6	819.0b	217.4
24	9	1103.7a	192.1	8	1007.8a,b	230.6	6	876.2b	205.6
25	9	1164.8a	202.0	8	1053.0a,b	227.1	6	917.3b	213.0
26	9	1245.6a	172.4	8	1111.4a,b	212.8	5	1000.0b	206.9
27	6	1260.0	167.3	6	1057.2a	158.1	6	948.7a	199.8
28	9	1357.8a	188.8	8	1265.4a,b	293.1	6	1058.0b	210.0

a,b Means denoted by the same letter are not significantly different on the same day using ANOVA with $\alpha = 0.10$.

Table 2-4. Daily mean values for wing length (mm) of captive wild-strain goslings given tap water (1), or saline drinking water measuring 12 µS/cm(2), or 18 µS/cm (3), 1997.

	Treatment								
	1			2			3		
Day	*n*	x̄	SD	*n*	x̄	SD	*n*	x̄	SD
3	9	24.8a	1.7	9	25.3a	1.3	8	24.8a	1.0
4	9	25.6a	1.8	9	24.6a	1.0	9	25.0a	1.1
5	9	25.9a	1.5	9	25.8a	0.8	8	25.4a	1.3
6	9	26.4a	0.7	9	25.8a	0.8	8	25.9a	0.8
7	9	26.9a	0.9	9	26.0a	1.1	8	26.4a	1.6
8	9	28.4a	1.5	9	27.4a,b	1.7	8	27.0b	1.9
9	9	29.4a	1.6	9	29.4a	1.0	8	28.8a	2.7
10	9	31.0a	2.1	8	30.8a	1.5	7	29.6a	3.3
11	9	32.8a	1.9	9	31.3a	2.1	7	30.1a	3.1
12	9	35.1a	1.7	9	33.1a,b	2.2	7	32.0b	4.2
13	9	36.3a	2.2	9	34.9a	2.8	7	33.7a	4.7
14	9	39.3a	2.9	8	36.9a,b	2.6	7	35.6b	6.0
15	9	43.0a	2.5	8	39.6a,b	4.1	7	36.1b	6.4
16	9	45.4	3.0	8	41.8a	4.4	7	37.9a	6.4
17	9	47.7	3.7	8	43.6a	4.4	6	40.3a	6.3
18	9	50.0	3.9	8	45.6a	4.5	6	41.7a	7.1
19	9	53.3a	4.4	8	49.3a	5.5	6	43.3	8.1
20	9	55.7a	5.3	8	51.9a	6.1	6	45.5	8.6
21	9	58.6a	5.6	8	54.1a	7.0	6	47.0	9.6
22	9	62.1a	6.6	8	57.5a	7.4	6	49.0	10.6
23	9	64.9a	7.0	8	59.8a	7.3	6	50.3	11.8
24	9	68.2a	8.5	8	62.4a	10.0	6	52.5	11.5
25	9	71.8a	9.3	8	65.0a,b	11.1	6	55.8b	12.3
26	9	77.2a	9.8	8	69.0a,b	13.3	6	58.5b	12.7
27	9	80.3a	9.7	8	71.8a,b	14.5	6	60.3b	13.2
28	9	84.9	9.9	8	75.5	14.9	6	66.6	13.4

[a,b] Means denoted by the same letter are not significantly different on the same day using ANOVA with $\alpha = 0.10$.

Table 2-5. Daily mean values for culmen length (mm) of captive wild strain goslings given tap water (1), or saline water measuring 12 µS/cm (2) or 18 µS/cm (3), 1977.

	Treatment								
	1			2			3		
Day	*n*	$\bar{x}$	SD	*n*	$\bar{x}$	SD	*n*	$\bar{x}$	SD
2	9	17.4a	1.2	9	16.8a	0.8	9	17.2a	0.7
3	9	18.0a	1.2	9	17.5a	0.8	9	17.6	0.9
4	9	18.7a	1.0	9	18.3a,b	0.9	9	17.9b	1.0
5	9	19.6a	1.1	9	19.1a,b	1.0	8	18.5b	1.1
6	9	20.5a	1.1	9	19.9a,b	1.0	8	19.2b	1.3
7	9	21.4a	1.1	9	20.6a,b	1.0	8	20.0b	1.6
8	9	22.4a	1.2	9	21.8a,b	1.2	8	20.9b	1.7
9	9	23.5a	1.1	9	22.7a,b	1.1	8	21.8b	2.0
10	9	24.6a	1.3	8	23.9a,b	1.2	7	22.6b	2.2
11	9	25.5a	1.1	9	24.6a,b	1.1	7	23.5b	2.5
12	9	26.6a	1.1	9	25.6a,b	1.2	7	24.4b	2.6
13	9	27.6a	1.0	7	26.4a,b	1.1	7	25.3b	2.7
14	9	28.1a	1.1	8	26.7a,b	0.9	7	26.0b	2.7
15	9	29.1	1.2	8	27.6a	1.0	7	26.7a	2.7
16	9	29.8	1.2	8	28.4a	0.9	7	27.4a	3.0
17	9	30.9	1.1	8	29.3a	1.0	6	28.6a	2.5
18	9	31.7	1.1	8	29.9a	1.1	6	29.3a	2.7
19	9	32.4	1.1	8	30.8a	1.1	6	29.9a	2.7
20	9	33.1	1.0	8	31.4a	1.1	6	30.5a	2.9
21	9	33.9	1.0	8	31.9a	1.1	6	31.2a	3.3
22	9	34.7	1.2	8	32.7a	1.4	6	31.7a	3.4
23	9	35.6	1.3	8	32.9a	1.5	6	32.2a	3.5
24	9	36.2	1.4	8	33.9a	1.4	6	32.8a	3.3
25	9	36.8	1.2	8	34.4a	1.4	6	33.2a	3.6
26	6	37.6	1.3	8	35.0a	1.5	6	33.9a	3.5
27	9	38.3	1.5	8	35.7a	1.6	6	34.6a	3.2
28	9	38.7	1.2	8	36.3a	1.4	6	35.8a	3.7

a,b Means denoted by the same letter are not significantly different on the same day using ANOVA with $\alpha = 0.10$.

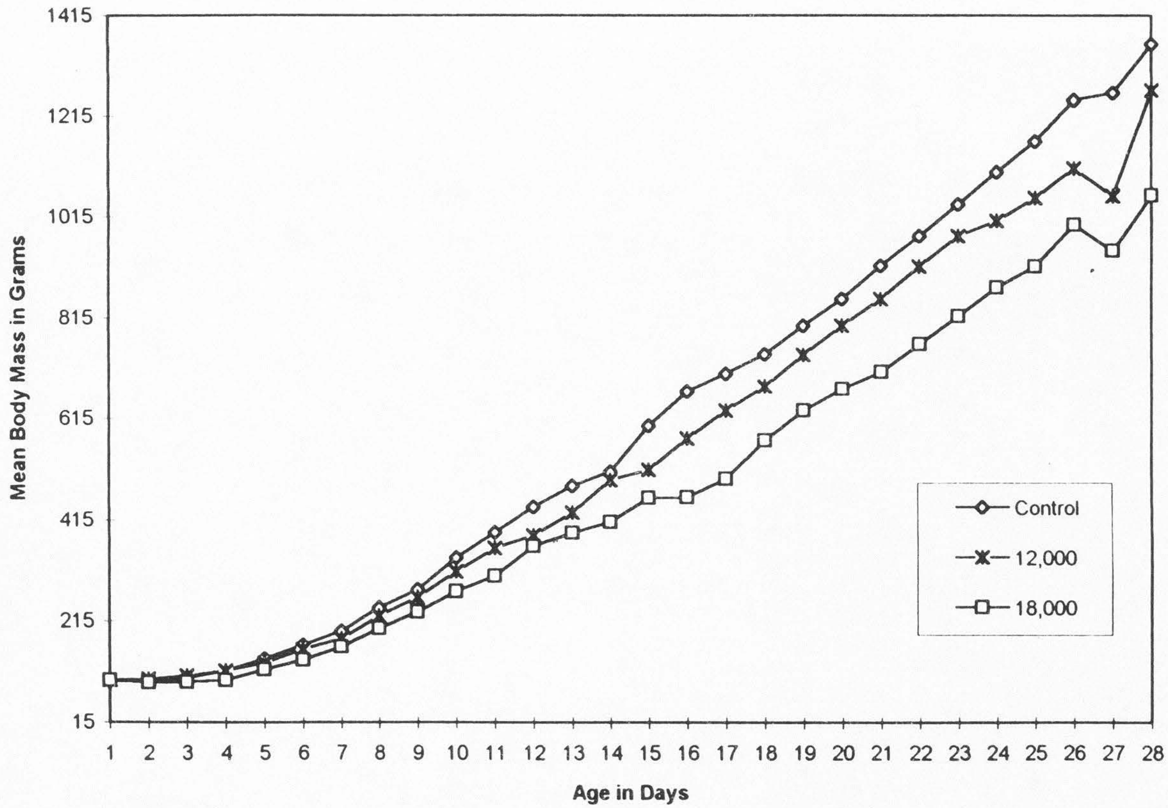

Fig. 2-1. Daily mean body mass (g) for goslings given tap water, or saline water of 12 mmhos/cm or 18 mmhos/cm, from day 1 to day 28 after hatching, Fish Springs NWR, Juab County, Utah, 1997.

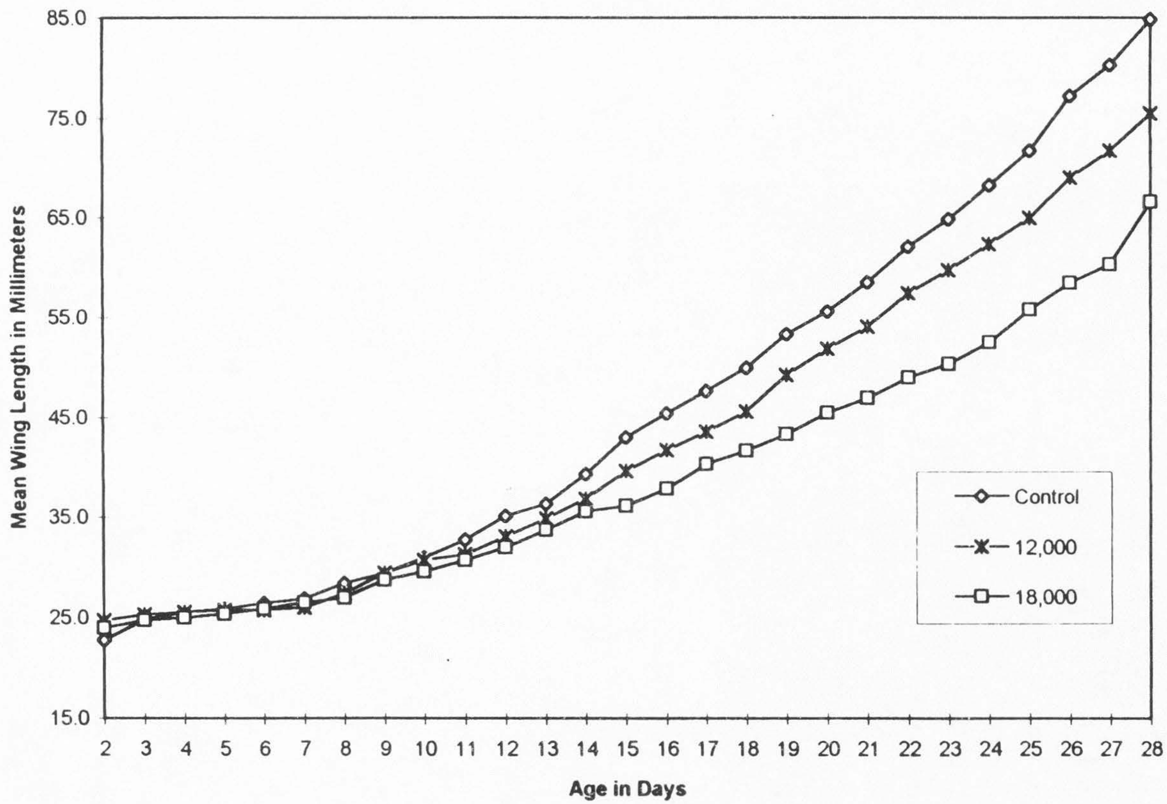

Fig. 2-2. Daily mean wing length (mm) for goslings given tap water, or saline water of 12 mmhos/cm or 18 mmhos/cm, from day 1 to day 28 after hatching, Fish Springs NWR, Juab County, Utah, 1997.

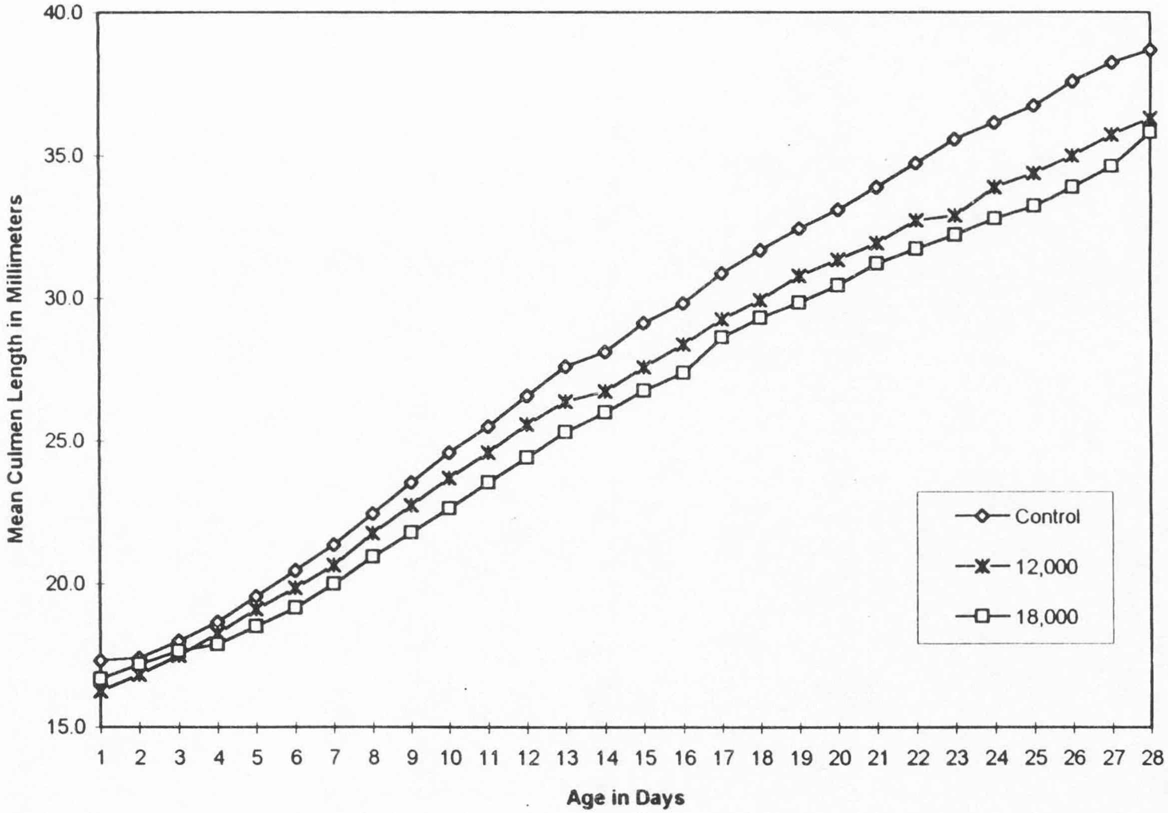

Fig. 2-3. Daily mean culmen length (mm) for goslings given tap water, or saline water of 12 mmhos/cm or 18 mmhos/cm, from day 1 to day 28 after hatching, Fish Springs NWR, Juab County, Utah, 1997.

CHAPTER 3

THE EFFECTS OF SALINE DRINKING WATER ON GOSLING SURVIVAL AT FISH SPRINGS NATIONAL WILDLIFE REFUGE[2]

Abstract: Research on ducklings and goslings demonstrates that if they have access only to moderately to highly saline drinking water, they will suffer increased mortality or sublethal effects on growth and other physiological processes. At Fish Springs National Wildlife Refuge (NWR) in western Utah, the water available to Canada goose (Branta canadensis) goslings ranges from brackish to highly saline (3,100-25,000+ µS/cm). We followed collar-marked, radio-marked, and unmarked broods from hatch to banding (5.5-10.5 weeks) to determine location and survival of all goslings hatched at Fish Springs NWR in 1996 and 1997. We tested the relationship between specific conductivity of gosling location and mortality, and found them to be independent of each other. Two of the 3 most saline locations had the most broods on them. We suggest that managers at Fish Springs NWR not discourage nesting on, or brood use of saline locations.

INTRODUCTION

Study Site

Fish Springs National Wildlife Refuge (NWR) is located at the southwest edge of the Great Salt Lake Desert in Juab County, Utah (Fig. 3-1).The refuge is at an elevation of 4,300 feet (1,311 m), and receives an average of 20 cm of rain annually. Temperatures range from -26.1 to 42.7 C. The refuge covers 17,992 acres of land and contains approximately 8,905 acres of saline marsh, 7,084 acres of mud and alkali flats, and 2,003 acres of semi-desert uplands. At optimum

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water levels there are about 3,500 surface acres of water in a complex of pools, sloughs, and springs. As part of the ancient Lake Bonneville's lake bed, the refuge is very flat, and the soil is saline and alkaline.

Five major, and several minor thermal springs arise from a fault line running parallel to the east side of the Fish Springs Mountain Range and feed the refuge's marsh. The springs are moderately brackish with specific conductivity measurements ranging from 2,900 to 3,400 µS/cm, except for North Spring, which measures 5,100 µS/cm.

An aerial photograph taken before modification of the wetlands began (circa 1960) shows an area of sloughs and narrow waterways lined with emergent marsh vegetation (Fig. 3-2). After the refuge was established in 1959, 9 large, shallow pools, impounded by dikes and fed from the springs through canals, were created, enlarging and modifying the natural marsh. Much of the area of the more southern impoundments, viz.: Avocet, Mallard, Curlew, Egret, and Shoveler, was original slough and contains numerous islands and peninsulas. The southernmost impoundments also are closer to the springs that provide their water. Because of this, and because the soil underlying these impoundments is flushed continually with springs most of the year, the water in these pools is only slightly to moderately saline. They contain typical emergent marsh vegetation, e.g., Olney's three-square bulrush (Scirpus americanus), cattail (Typha domingensis), hardstem bulrush (S. acutus), alkali bulrush (S. maritimus), wirerush (Juncus arcticus), and saltgrass (Distichlis spicata). Abundant mats of submergent vegetation, primarily wigeongrass (Ruppia maritima) and muskgrass (Chara spp.), and spiny, or pond naiad (Najas marina), and coontail (Ceratophyullum demersum) grow in the springs, canals, and pools. Additionally, Phragmites australis has expanded into the marsh.

The northern impoundments, viz., Ibis, Pintail, Harrison, and Gadwall, were constructed on the northern edge of the original wetlands, and contain little of the original marsh structure. Most of the water feeding these pools comes from the more southern pools that are more saline than the springs that supply them. Additionally, because of evaporation and leaching of salts from the original playa, the water in the northernmost impoundments is more saline than in the southern impoundments. These impoundments become dry or much reduced during the summer because the volume of spring input does not match evaporation rates. The bordering vegetation is characterized by saltgrass (Distichlis spicata), pickleweed (Allenrolfea occidentalis), and annual samphire (Salicornia europaea). The pools contain little emergent or submergent vegetation. However, sloughs in these impoundments are fed from the less saline main canal, or from North Spring, and salinities range from 4,700 to 7,500 µS/cm during the breeding season. They contain vegetation characteristic of the southern sloughs.

History

Fish Springs NWR was established in 1959 to provide nesting, wintering, and migratory habitat for waterfowl. Creation of impoundments and other development of the marshlands was completed in 1964. It is not known definitely whether Canada geese (Branta canadensis) nested in this area prior to the establishment of the refuge (Annu. Rep., Fish Springs NWR, 1982; J. Banta, Fish Springs NWR, pers. commun.); however, they were not nesting in the refuge area in 1959. Using a captive flock to entice wild geese to Fish Springs, and through release and unintentional escape of captives, refuge managers established a year-round population of geese.

Fledging Success

Fledging success is the percentage of hatched goslings that survive to reach flight stage, about 70 days in the local subspecies, the western Canada goose (B. c. moffitti) (Yocom and Harris 1965, Eberhardt 1987). Most Canada goose gosling mortality occurs in the first 10 days to 2 weeks after hatching (Steel et al. 1957, Martin 1963, Brakhage 1965, Zicus 1981, Eberhardt et al. 1989). Thus, many researchers use survival to a certain age (i.e., 4-6 weeks, 8 weeks, age at banding) as a surrogate for survival to fledging. In this study, we used survival to banding (5.5 to 10.5 weeks after hatching) to estimate fledging success. Williams et al. (1993) showed that goose roundups (for banding) disrupted family cohesiveness and led to increased gosling mortality (but see Cooch 1956, and Prevett and MacInnes 1980).

Populations of Canada geese generally experience high fledging success rates, often between 80-97% (Geis 1956, Steel et al. 1957, Martin 1963, Dey 1964, Mickelson 1973, Krohn and Bizeau 1980, Ball et al. 1981, Eberhardt et al. 1989) (Table 3-1). Other researchers have reported gosling survival rates to fledging from 60 to 79% (Brakhage 1965, Sherwood 1966, Knight 1978, Zicus 1981, Wang 1982, Warhurst et al. 1983). Occasionally, lower rates are documented. Eberhardt et al. (1989) found a fledging success rate of 49% in their study in Washington, and results from a study in Alberta, indicate a survival rate of 56% (Glasgow 1977). Extremely low gosling survival rates may be the result of stochastic events, such as an epidemic or unusual weather conditions. Sherwood (1966) documented a survival rate of 16% in 1964 at Seney NWR, as compared with 78 and 72% in 1963 and 1965, respectively. The extremely low rate was due to an epidemic disease, probably Leucocytozoon, a blood parasite (Sherwood 1966).

From 1989 to 1993, and in 1995, Fish Springs NWR personnel closely monitored breeding geese to obtain accurate production numbers and survival rates (Table 3-2). Overall fledging success (weighted average) for these 6 years is near 35% with annual production averaging 26. This low survival rate suggested the need for an in-depth study of the causes of gosling mortality.

Causes of Gosling Mortality

Causes of mortality of young waterfowl between hatching and fledging include environmental contaminants (Blus et al. 1979, Ohlendorf et al. 1986, Stephens and Waddell 1989, Sargeant and Raveling 1992), predation (Geis 1956, Brakhage 1965, Sherwood 1966, Mickelson 1973, Wang 1982, Sargeant and Raveling 1992, Sedinger 1992), human disturbance (Sherwood 1966), inadequate nutrition (Sedinger 1992), storms or unusual weather (Sargeant and Raveling 1992), disease (Sherwood 1966), and poor parenting skills (Raveling 1981, Afton and Paulus 1992).

Saline Drinking Water As a Cause of Gosling Mortality

Fish Springs NWR has moderately brackish springs as the main source of water; there is no fresh water in the marsh. The small amounts of rainfall this area receives are immediately incorporated in the larger bodies of saline water. In the brood-rearing impoundments preferred by geese, salinity levels can rise to sublethal and even lethal levels (Mitcham and Wobeser 1988a,b). Thus, salinity, as a natural contaminant, is a potential cause of gosling mortality.

Adult geese and ducks are able to drink saline water because they possess nasal salt glands that function to excrete excess salt from the bloodstream. The kidneys alone are incapable of excreting sufficient salts to ensure the survival of a bird exposed to hypertonic saline drinking water (Bradley and Holmes 1972). Goslings and ducklings develop fully functioning salt glands about 6 days after hatching (Ellis et al. 1963; Riggert 1977; D. Stolley, pers. obs.). Holmes et al.

(1961) showed that gull chicks given solutions of NaCl experienced growth depression. Ellis et al. (1963) demonstrated the same result for ducklings. Since then, researchers have conducted more in-depth studies of the effects of saline drinking water on ducklings of various species, both in the lab and in the field (Riggert 1977; Wink and Hossler 1979; Wink 1980; Swanson et al. 1984; Mitcham and Wobeser 1988a,b)

Several field and lab studies have established dosage responses of mallard (Anas platyrhynchos) and other ducklings to saline drinking water (Swanson et al. 1984; Mitcham and Wobeser 1988a,b). Swanson et al. (1984) exposed 4 groups of 10 1-day-old mallards apiece to saline lake water diluted in 1 μS/cm increments from 20 to 17 μS/cm for 9 days to determine effects on growth, as defined by body mass. They compared results to ducklings given well water routinely used for raising young waterfowl. They found that saline water significantly reduced growth, and as specific conductivity increased, growth decreased. They observed no mortalities at 17 μS/cm, 10% mortality at 18 and 19 μS/cm, and 30% at 20 μS/cm. In a different experiment, they supplied 10 1-day-old mallard ducklings with lake water measuring 16 μS/cm for 12 days. They recorded 10% mortality after 4 days. In the water they utilized, the sulfates were the main anions, and sodium, magnesium, and potassium (in that order) were the predominant cations.

Mitcham and Wobeser (1988b) gave water from 10 saline Saskatoon wetlands to mallard ducklings under laboratory conditions. All ducklings given water with conductivity of 35 and 67 μS/cm died within 60 and 30 hours, respectively. They found 60% mortality at 20 μS/cm by the sixth day of a 14-day trial; no additional mortalities occurred after the sixth day. At 21.5 μS/cm only 2 of 9 ducklings survived to day 14. Mitcham and Wobeser observed poor growth, delayed feathering, and effects on several other physiologic functions in ducklings reared on water with conductivity as low as 7.72 μS/cm in a 14-day trial. Ducklings raised on water with conductivities ranging from 3.75 to 7.49 μS/cm grew as well as control birds supplied with fresh water in 14-day trials. However, when those supplied with water measuring 4.0 μS/cm were monitored to day 28, they had a significantly lower growth rate during the second 14 days.

Stolley and Bissonette (Utah State Univ., unpubl. data) observed that providing saline drinking water with a specific conductivity of 12 μS/cm to captive wild-strain goslings caused sublethal effects on growth. The daily mean values for body mass, wing length, and culmen length for goslings given 12 μS/cm water were consistently less than for goslings given tap water. However, most of the differences were not statistically significant. We observed 33% mortality (n=9) and statistically significant reductions in growth, as compared to the goslings on tap water, at 18 μS/cm. We expected that wild young would experience mortality at lower conductivities than laboratory birds due to the additional effects of other environmental stresses and the hazards of living in the wild.

Objectives

We investigated the effects of naturally occurring saline water on the survival of wild goslings of the western Canada goose. Our goal was to test the hypothesis that the salinity of drinking water is correlated with gosling mortality at Fish Springs NWR. We had 3 objectives in 1997:

Objective 1: To identify hydrologically distinct locations within the marsh and to quantify the salinity levels of each location over the course of the Canada goose breeding season.

Objective 2: To determine the location and number of goslings in every brood daily from hatching through the fifteenth day after hatching.

Objective 3: To test the relationship between salinity of naturally occurring drinking water available to goslings and mortality using a chi square analysis.

METHODS

To identify hydrologically distinct locations within the marsh and to quantify the salinity levels of each location over the course of the Canada goose breeding season, we measured specific conductivity with a YSI model 30 temperature-corrected meter. From 15 April to 15 July in 1997, we took weekly conductivity measurements at 17 water control structures along canals and at the edges of impoundments.

To determine the location and number of goslings in every brood daily from hatching through the fifteenth day after hatching, we marked adults and found and monitored nests. We trapped molting, breeding adults in 1996, and placed individually marked plastic neck collars on them. In 1997, we trapped and put radio-collars on nesting females when their eggs were pipping. We used telemetry and observations to locate broods. We conducted all observations and radio tracking from the dikes surrounding each impoundment.

To test the relationship between salinity of drinking water available to goslings and mortality using a chi-square analysis, we first calculated daily estimates of specific conductivity. Next, we classified brood locations during day 1 through day 15 following hatching as either low (<8.2 μS/cm) or high (≥ 8.2 μS/cm) conductivity. These levels were determined arbitrarily. We tabulated the day of mortality for all deaths until day 15. We did not use broods that were in an unknown location for more than 2 days. If a brood found mostly in high-conductivity locations was found in a low-conductivity location for more than 2 days, or vice versa, we did not use it in the analysis.

RESULTS

Specific Conductivity

We identified 11 hydrologically distinct areas (Table 3-3) within the 9 impoundments. From 15 April to 15 July, conductivity measurements ranged from 3,080 to 25,350 μS/cm within these areas. The general trend for all but 3 locations (Avocet, Mallard, and S. Curlew) was an increase in salinity as the season progressed. The 3 most southern locations, that received water more directly from the springs, stayed within ±400 μS/cm of their first measurements.

Brood Location and Gosling Mortality

There were 20 broods at Fish Springs NWR in 1997. We monitored 19 of these from day 1 to day 15 after hatching. We followed 7 broods with collared-marked and radio-marked females, and 5 broods without radio-marked females, but with 1 or more collar-marked parents. Seven broods had parents with neither radio-marks nor collar-marks; we identified these broods by age of goslings and location. The first brood hatched on 25 April, the latest-hatching brood on 25 May. From day 1 to day 15 after hatch, the broods used locations with specific conductivities ranging from 4,200 to 11,900.

Only 2 broods utilized the 3 least saline locations, and only for a few days. The second most saline impoundment, N. Gadwall, was used for a total of only 3 days. On these days its specific conductivity ranged from 9,500 to 9,600 μS/cm.

The 19 broods contained 77 goslings on hatch day. Eleven mortalities occurred between hatch day and day 1. Twenty-four more deaths occurred from day 1 through day 15. These 35 deaths accounted for 87.5% of all prefledged gosling mortalities at Fish Springs NWR in 1997.

The Relationship Between Salinity and Gosling Mortality

We did a chi-square analysis to compare gosling mortality to specific conductivity of location. We used data from 15 broods. Two broods of one gosling each were not used because the goslings either died or disappeared on day 1. A third brood was not used because we never saw it until the goslings were approximately 41 days old. Two other broods were not used because they were in unknown locations for more than 2 days each.

We placed broods into 1 of 2 conductivity classes based on the specific conductivity of their location during the first 15 days following hatching. Some broods moved from pool to pool, yet remained in the same conductivity class. The classes were high salinity (≥ 8.2 μS/cm) and low salinity (< 8.2 μS/cm). The 15 broods we analyzed yielded a total of 63 hatched goslings. We ran a chi-square analysis, using mortalities from hatching to day 15 (Table 3-4). This included information on 27 mortalities, which was 68% of the total number of mortalities (n = 40), and 77% of all mortalities occurring before day 16 (n = 35). If salinity caused mortality, we expected a significant positive relationship between the 2 factors. We rejected the null hypothesis of independence ($\chi^2 = 9.35$, $\underline{P} = 0.0093$); however, our analysis showed a negative correlation of mortality with salinity.

DISCUSSION

We found no goslings under the age of 16 days on pools with water measuring more than 11,900 μS/cm. This is well below the 18,000 μS/cm demonstrated to cause 33% mortality in caged wild-strain goslings (D. S. Stolley and J. A. Bissonette, Utah State Univ., unpubl. data), and 10% mortality in caged ducklings (Swanson et al. 1984). However, lower levels of salinity cause sublethal effects (Swanson et al. 1984; Mitcham and Wobeser 1988a,b) that could contribute to mortality. If saline drinking water were contributing to mortality, we would expect higher salinity to lead to more mortalities. We found a negative correlation between salinity and mortality. Thus, we conclude that gosling mortality at Fish Springs NWR in 1997 was independent of specific conductivity of brood-rearing impoundment.

The more saline locations at Fish Springs NWR were also the most open impoundments. Broods congregated on these, resulting in a higher number of adults that alertly scanned their surroundings, presumably for predators and other dangers. Because their view was unimpeded, adults were more likely to see a predator from further away. Additionally, if broods were alarmed and scattered, goslings presumably had less of a chance of being abandoned because there were more adults to follow. We observed temporary brood mixing often after broods had been startled off the dikes and into the water. In almost all cases, goslings and their own parents were reunited, often within a few minutes. Because salinity levels were not high enough to cause direct mortality, the positive effects of grouping on large, open pools appeared to compensate for any sublethal effects caused by the salinity. We examine the effects of location of goslings on mortality in more detail in chapter 4.

The question of whether adult geese select against very saline locations to rear their broods warrants further investigation. In 1997, we saw no use of the most saline impoundment, Harrison, by broods younger than 16 days after 24 May when the specific conductivity measured 12.4 μS/cm. N. Gadwall, the second most saline pool, in 1997, was not used by goslings under the age of 16 days after 12 May when specific conductivity measured 9.5 μS/cm. In 1996, specific conductivity ranged from 3.3 to 11.6 μS/cm on impoundments where broods under the age of 16 days were located. No broods of any age were on the most saline impoundments, Harrison and Gadwall, past 28 May and 27 May, respectively. At that time, specific conductivity levels were 10.1 and 14.0μS/cm, respectively (D. S. Stolley and J. A. Bissonette, Utah State Univ., unpubl. data). We never observed any goslings in plumage class 1B or less (approximately 15 days or younger) (Yocom and Harris 1965) on N. Gadwall in 1996.

MANAGEMENT IMPLICATIONS

The low fledging success rate experienced by goslings at Fish Springs NWR in 1997 was independent of salinity. In fact, at 2 of the 3 high conductivity locations, Harrison and Pintail, goslings experienced the least mortality of all locations. Harrison and Pintail appear to be preferred brood-rearing locations. Broods that hatched on them spent most of their time on their respective pools, and were joined by broods from other impoundments. These broods may have benefited from unimpeded visibility at these pools and the alert behavior of numerous adults. Rather than discourage nesting attempts at these locations for fear of the effects of saline drinking water, it may be well-advised to encourage it by installing more artificial nesting platforms.

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Table 3-1. Gosling survival estimates for B. c. moffitti and B. c. maxima.

Authority	Location	Subspecies	Percent Survival
Ball et al. (1981)	Washington	moffitti	80
Brakhage (1965)	Missouri	maxima	64-80
Dey (1964)	Utah	moffitti	89
Eberhardt et al. (1989)	Washington	moffitti	49
Geis (1956)	Montana	moffitti	80-84
Glasgow (1977)	Alberta	moffitti	56
Hanson and Eberhardt (1971)	Washington	moffitti	86[a]
Knight (1978)	Washington	moffitti	62
Krohn and Bizeau (1980)	RMP[b] area	moffitti	92-95
Martin (1963)	Utah	moffitti	95
Sherwood (1966)	Michigan	maxima	75[c], 16[d]
Steel et al. (1957)	Idaho	moffitti	93[e]
Wang (1982)	Ohio	maxima	62-84
Warhurst et al. (1983)	Ohio	maxima	74
Zicus (1981)	Wisconsin	maxima	61-71

[a] Survival to third week
[b] Rocky Mountain population
[c] Average for 1963 and 1965
[d] 1964, disease outbreak
[e] Survival to two-thirds grown

Table 3-2. Percent survival of Canada goose goslings at Fish Springs NWR, Juab County, Utah, 1989-1995.

Year	Total Pairs	Nesting Pairs	Percent of total pairs that nested	Nests found	Goslings Hatched	Goslings Fledged	Percent Survival
1989	21-31	18	58.1-85.7	13	63	22	34.9
1990	24-25	19	76.0-79.2	14	55-65	33	50.7-60.0
1991	no data	18	no data	15	67	18	26.8
1992	24-27	22	81.5-91.7	13	95	31	32.6
1993	no data	21	no data	14	99	34	34.3
1994	no data	no data	no data	no data	69	no data	no data
1995	no data	no data	no data	no data	no data	17	no data
AVERAGES	**23-28**	**20**	**71.0-87.0**	**14**	**75-76**	**26**	**34.2-34.7**

Table 3-3. Specific conductivity measurements (µS/cm) for 11 hydrologically distinct locations at Fish Springs NWR, Juab County, Utah, 15 April to 15 July 1997.

Date	Avocet	Mallard	S.Curl.	N.Curl.	Shov.	Egret	S.Gad.	N.Gad.	Ibis	Pin.	Harr.
4/15	3250	3850	3930	4580	4740	5480	6310	9290	6290	7200	10960
4/22	3250	4020	4310	4840	5370	5500	5790	9640	6290	7480	10730
4/29	3260	4000	4260	4900	5610	5500	5630	9300	6260	7820	10850
5/06	3190	4010	4180	4750	5400	5450	5610	9650	6200	8170	10880
5/13	3170	4150	.	4950	5190	5920	5860	9530	6550	8700	11330
5/20	3150	4170	4200	5140	5770	6570	6200	10180	6840	9460	12230
5/27	3140	3850	3700	4810	5520	6540	6350	10000	7010	9640	12520
6/03	3110	4040	3770	5140	5840	7170	6780	11360	7410	10540	13800
6/10	3080	4010	3460	5040	5790	7430	7020	11460	7610	10910	14360
6/17	3180	3650	3890	4700	5310	6660	7040	11700	7660	10850	14520
6/24	3140	3900	4230	5380	5150	5920	7170	13640	8390	11510	16590
7/01	3130	4120	4200	6280	5610	9000	7170	15260	9170	13130	19350
7/08	3130	4170	4040	7280	6120	10470	7170	16640	9900	14190	22350
7/15	3120	4220	3880	8280	6630	11940	7170	18020	10630	15250	25350

Table 3-4. Comparison of mortality from day 2 to day 15 of Canada goose goslings at high (≥8.2 µS/cm) and low (< 8.2 µS/cm) conductivity locations at Fish Springs NWR, Juab County, Utah, 1997, using a chi-square test of independence.[a]

	Number dead [b]		Number alive	
	Observed	**Expected**	**Observed**	**Expected**
Low conductivity	20(74)	14(52)	13(36)	19(53)
High conductivity	7(26)	13(48)	23(64)	17(47)
TOTALS	27(100)	27(100)	36(100)	36(100)

[a] $\chi^2 = 9.35$; $\underline{P} = 0.0093$
[b] Percentages of column totals in parentheses

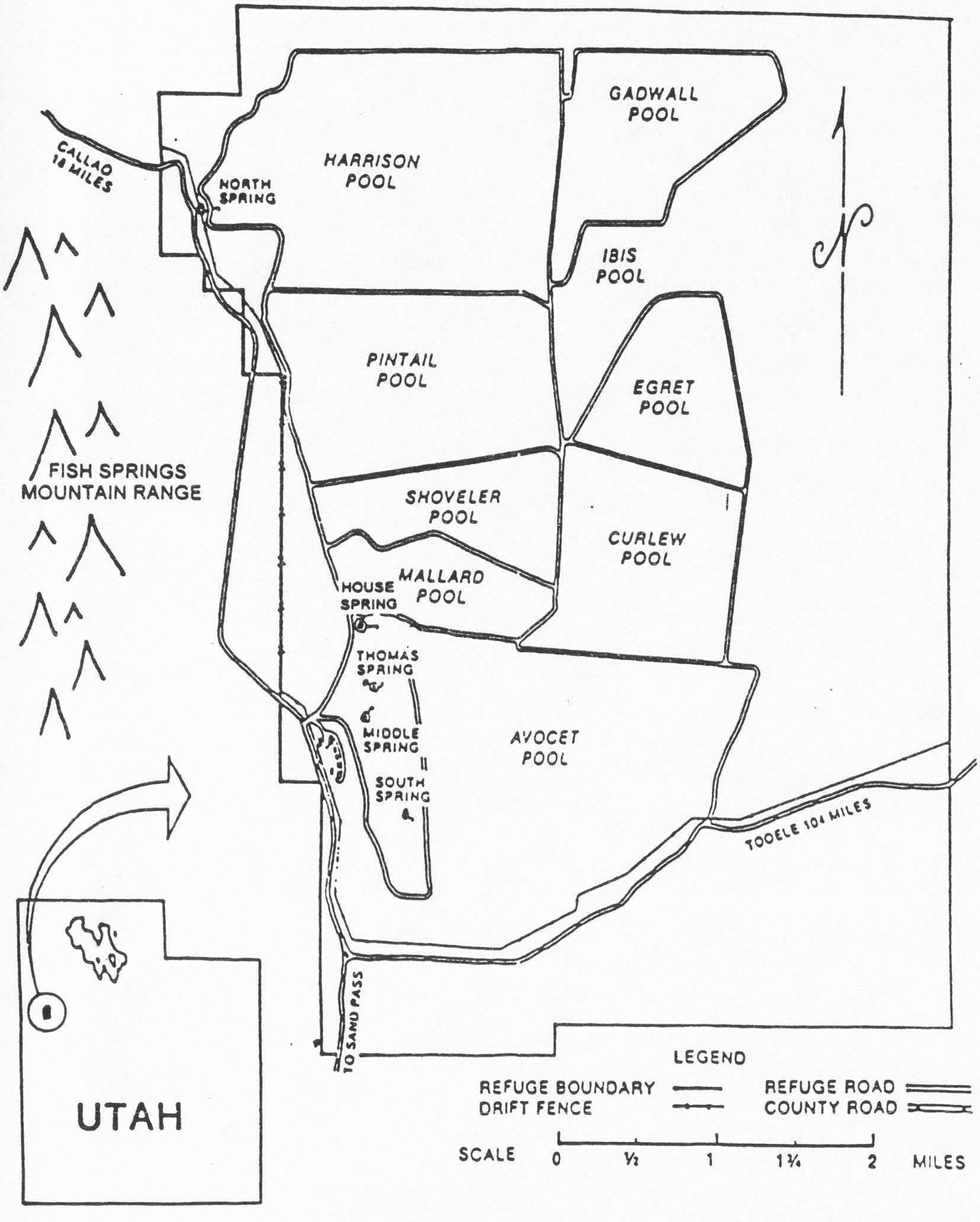

Fig. 3-1. Fish Springs National Wildlife Refuge, Juab County, Utah.

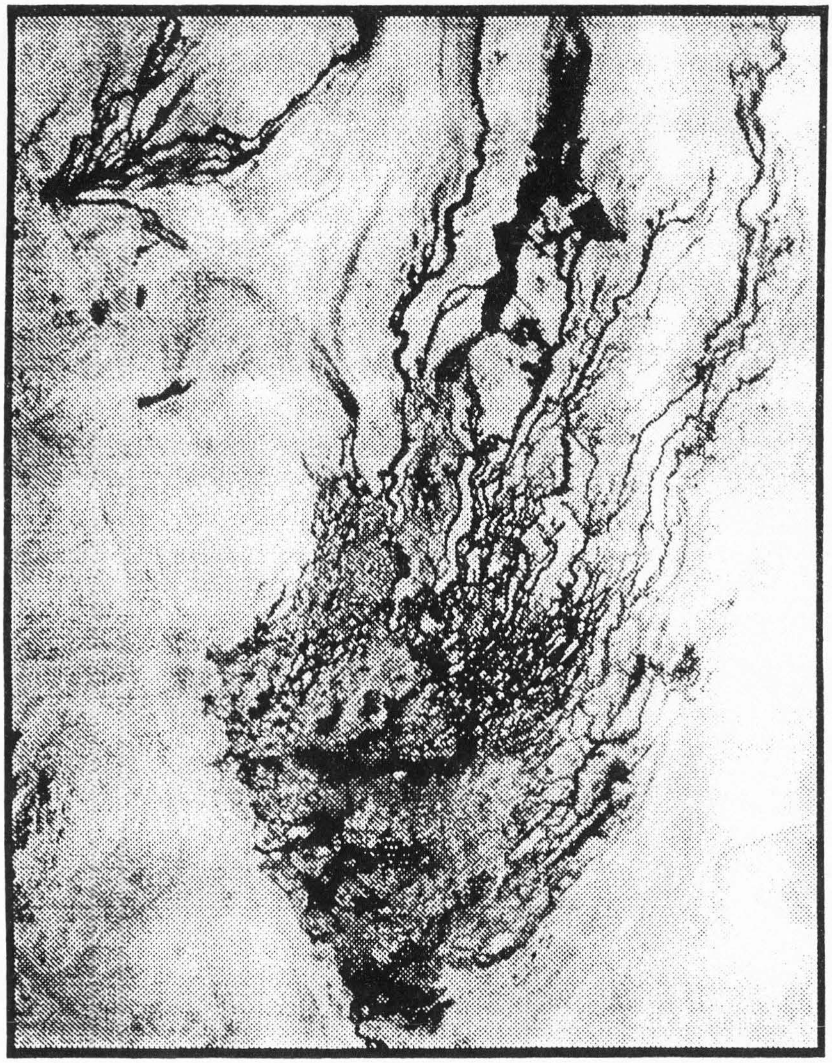

Fig. 3-2. The sloughs and marsh at Fish Springs before modification of the wetlands (circa 1960), Juab County, Utah.

CHAPTER 4

LIMITATIONS ON CANADA GOOSE PRODUCTION AT FISH SPRINGS NATIONAL WILDLIFE REFUGE[3]

Abstract - At Fish Springs National Wildlife Refuge (NWR), despite efforts to boost Canada goose production, only 18 to 34 goslings were fledged per year from 1989 to 1993. A wide variety of factors can affect the production of a population of Canada geese, including: number of breeding pairs, clutch size, nest success, egg success, and fledging success. We examined these factors at Fish Springs NWR in 1996 and 1997 by finding and monitoring nests, then following broods. We found that production was limited by 3 factors: low number of breeding pairs, low nest success for ground nests, and low fledging success. In 1997, we examined the relationship between gosling mortality and location, and found a higher number of deaths per use-day at certain locations. Predation and human disturbance are discussed as major factors contributing to mortality. Suggestions to managers on ways to increase gosling production at Fish Springs include installing more artificial nesting platforms, especially in locations with low numbers of deaths per use-day in 1997.

INTRODUCTION

Reproductive success in Canada geese (*Branta canadensis*) is determined by a number of factors. The size of the population and its age structure determine the number of potential breeders. While some females breed in their second year, the majority begin breeding in their third or fourth year (Bellrose 1980). Not all paired geese become territorial. Of those that do defend a

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[3] Coauthored by Dorie S. Stolley and John A. Bissonette.

territory, not all will initiate nesting. Ball et al. (1981) and Hanson and Eberhardt (1971) in separate studies of *B. c. moffitti* in Washington estimated that about 20% of territorial pairs did not nest. The number of potential territories can be a limiting factor in nesting. Higher densities of geese sometimes result in increased abandonment of nests due to harassment of the nesting female (Ewaschuk and Boag 1972).

Once nesting is underway, the important factors in reproductive success are clutch size, nest success, and egg success. Younger and less experienced geese lay smaller clutches (Brakhage 1965, Finney and Cooke 1978, Lessells 1982, Rockwell et al. 1983), and raise fewer goslings to wing (Brakhage 1965, Finney and Cooke 1978, Raveling 1981). Adult body size may affect clutch size since absolute nutrient reserves may determine clutch size (Ankney and MacInnes 1978, Raveling 1979). Lessells (1982) found a positive correlation between male body size and clutch size in Canada geese. Davies et al. (1988) found no relation between adult male or female body size and fecundity in lesser snow geese; but see Ankney and MacInnes (1978).

Nest success is affected by location of nest. In general, elevated platforms experience less predation than ground nests (Krohn and Bizeau 1980). Island ground nests are depredated less often than mainland ground nests when terrestrial predators are present (Klopman 1958, Vermeer 1970, Johnson and Shaffer 1990). Quality of territory can also affect nest success. A territory with poor forage may result in a female spending more time off the nest to get adequate nutrition, or ranging with her mate farther from the nest site. This leaves the nest vulnerable to predation. Abandonment may be caused by harassment of the nesting female by other geese (Ewaschuk and Boag 1972, Bellrose 1980, Raveling 1981), malnutrition (Harvey 1971, Ankney and MacInnes 1978), or human disturbance (MacInnes and Misra 1972, Bellrose 1980). Ankney and MacInnes (1978) found incubating female snow geese dead on the nest, apparently from starvation.

Flooding can be a problem during the nesting season (Bellrose 1980). An estimated 85% of monitored nests were flooded in a section of marsh in northern Utah in 1997 due to extremely high water along local rivers (D. Stolley, pers. obs.).

Nest success is also affected by age and experience of the breeding pair (Raveling 1981). Older, more experienced females generally have more body reserves (Aldrich and Raveling 1983), either due to more efficient foraging or to the ability of the male to provide protection from conspecific harassment, which allows more feeding time (Raveling 1981). Heavier females are more attentive to their nests (Aldrich and Raveling 1983), leading to less chance of predation. Experienced ganders are more successful at keeping other geese away from the incubating female.

Egg success is important in determining number of offspring. The number of eggs in a nest that do not hatch depends on the number of infertile eggs, dead embryos, and stage of development of embryos. Occasionally, a female will lay eggs after full incubation has commenced; thus, in the same nest, normally developing embryos may be a few days behind the others in development, and will not hatch synchronously with the others. Females sometimes incubate these eggs longer and successfully hatch them, but often they are abandoned as the hatched goslings are led to the brood-rearing area. Contaminants can lower egg viability or produce deformed goslings that do not hatch, or are incapable of surviving in the wild.

Fledging success is measured as the percentage of hatched goslings that survive to reach flight stage, about 70 days in *B. c. moffitti* (Yocom and Harris 1965, Eberhardt 1987). Most Canada goose gosling mortality occurs in the first 10 days to 2 weeks after hatching (Geis 1956, Steel et al. 1957, Martin 1963, Dey 1964, Mickelson 1973, Krohn and Bizeau 1980, Ball et al. 1981, Eberhardt et al. 1989, Sargeant and Raveling 1992).

A wide variety of factors can affect fledging success in geese. Predation is an important cause of mortality in goslings (Geis 1956, Brakhage 1965, Sherwood 1966, Mickelson 1973, Wang 1982, Sedinger 1992). Disease can have catastrophic effects on a population. Sherwood (1966) studied giant Canada geese at a refuge in Michigan. In 1963 and 1965, he documented 78% and 73% gosling fledging rates. However, in 1964, there was an outbreak of disease, probably *Leucocytozoon*, a blood parasite, that devastated the goslings, resulting in a survival rate of only 16%. He also noted that family ties were fragile when goslings were very young, and human disturbance could scatter the family leading to abandonment of slower or separated goslings (Sherwood 1966).

Nutrition is an important factor in the growth and development of all young birds. Inadequate nutrition can lead directly to mortality due to starvation or lack of essential minerals. It can also result in a weak or small bird that more easily succumbs to predation, exposure, or disease, or one that is unable to keep up with the rest of its siblings.

The quality of parental care affects fledging success in geese. Inexperienced or inattentive parents may not lead goslings to good grazing areas, guard well against possible predators, or react appropriately when there is danger (Raveling 1981).

STUDY AREA

Fish Springs NWR is located at the southwest edge of the Great Salt Lake Desert in Juab County, Utah (see Fig. 3-1). As ancient Lake Bonneville lake bottom, the refuge is very flat, and the soil is saline and alkaline. Five major, and several minor thermal springs arise from a fault line running parallel to the east side of the Fish Springs mountain range and feed the refuge's 8,900 acre marsh. Fish Springs NWR was established in 1959. Creation of impoundments and other development of the marshlands to provide habitat for waterfowl was completed in 1964. It is not known definitely whether Canada geese nested in this area prior to the establishment of the refuge (Annu. Rep., Fish Springs NWR, 1982; J. Banta, Fish Springs NWR, pers. commun.); however, they were not nesting in the refuge area in the late 1950's.

After the refuge was established, 9 large, shallow pools, impounded by dikes and fed from the springs through canals, were created, enlarging and modifying the natural marsh. Much of the area of the more southern impoundments, viz., Avocet, Mallard, Curlew, Egret, and Shoveler, was original slough; thus, they contain numerous islands and peninsulas. The southernmost impoundments also are closer to the springs that supply their water. Because of this, and because the soil underlying these impoundments is flushed continually with relatively low-salinity water, most of the year the water in these pools is only slightly to moderately more saline than the springs. They contain typical emergent marsh vegetation, e.g., Olney's three-square bulrush (*Scirpus americanus*), cattail (*Typha domingensis*), hardstem bulrush (*S. acutus*), alkali bulrush (*S. maritimus*), wirerush (*Juncus arcticus*), and saltgrass (*Distichlis spicata*). Abundant mats of submergent vegetation, primarily wigeongrass (*Ruppia maritima*) and muskgrass (*Chara* spp.), and spiny, or pond naiad (*Najas marina*), and coontail (*Ceratophyullum demersum*) grow in the springs, canals, and pools. Additionally, the native *Phragmites australis* has expanded into much of the marsh.

The northern impoundments, viz., Ibis, Pintail, Harrison, and Gadwall, were constructed on the northern edge of the original wetlands, and contain little of the original marsh structure. Most of the water feeding these pools comes from more southern pools, which are more saline than the springs that supply them. Additionally, because of evaporation and leaching of salts from the original playa, the water is more saline than in the southern impoundments. These impoundments become dry or reduced during the summer because the volume of spring input cannot match evaporation rates. The vegetation bordering these impoundments is characterized by saltgrass (*Distichlis spicata*), pickleweed (*Allenrolfea occidentalis*), and annual samphire (*Salicornia europaea*), and they contain little emergent or submergent vegetation. However, sloughs in these impoundments are fed from the less saline main canal, or from North Spring, and salinities range from 4.7 to 7.5 μS/cm during the breeding season. They contain vegetation characteristic of the southern sloughs.

In the early 1960s, Canada geese were established at the refuge through release of captive birds and arrival of wild birds. From 1965 to 1969, Canada goose numbers gradually increased, as did gosling production. In the mid-1970s, the highest estimates of gosling production were made. From 1983 to 1987, excluding 1985 (no data), the number of pairs present on the refuge during the breeding season was between 72 and 77. In 1987 and 1988, Canada goose hunting was allowed on the refuge; a total of 473 geese were taken. From 1989 to 1993, the number of nesting pairs ranged between 18 and 21. Gosling production during this same time was between 18 and 34.

OBJECTIVES

We conducted field research from March to July in 1996 and 1997 to determine what is limiting gosling production at Fish Springs NWR. Our objectives were:

1. To quantify number of territorial pairs and breeding pairs and to compare this to historical data.
2. To quantify clutch size, nest success, and egg success.
3. To quantify fledging success, and determine if mortality is related to location.
4. To compare the sizes of goslings and adult females at Fish Springs NWR to those in

a control area.

METHODS

To quantify number of territorial pairs and breeding pairs, we conducted daily to weekly pair counts, and daily to twice weekly observations of territorial and nesting behavior from 22 March to 5 May in 1996, and 21 March to 11 May in 1997. We drove slowly along the dikes that surround every impoundment and made observations from our vehicles using spotting scopes. Pairs, and singles (assumed to be lone males with a mate on a nest), aggressive behavior, and nesting behavior were recorded and location of geese was marked on a map.

To determine the number of breeding pairs, we located nests. We observed artificial nesting platforms for signs of use, and checked them several times over the season. We located ground nests with a variety of techniques. The vast majority of ground nests were found as we searched from an airboat. Every impoundment was completely traversed by airboat at least once, and many twice during the early part of nesting seasons. Also, during our daily observations, we scanned for signs of incubating females, and small pieces of down in the vegetation indicating a possible nest. We also looked for single ganders that might be guarding an incubating female, particularly in areas that previously had a pair evident. We found several nests and general nesting areas this way. We also traversed areas of the marsh by foot and inflatable kayak.

To examine historical data on number of pairs, we searched the file archives at Fish Springs NWR headquarters for relevant information. We read Canada goose study reports for 1983 and 1989-1994 and excerpts from all annual reports. We also examined archived pair count data. Unless noted otherwise, annual and goose study reports cited in the text are from Fish Springs NWR.

To quantify clutch size, nest success, and egg success, we observed nests from a distance, checking them by foot when it was suspected that either incubation was at least a few days underway, or the nest had been abandoned. In 1996, we avoided checking either platforms or ground nests if we suspected the female was still laying. In 1997, we did not check ground nests when the female was laying. All eggs were counted, numbered, and candled through a length of radiator hose to ascertain viability and approximate stage of development. We monitored status (i.e., incubating, pipping, abandoned, depredated) of all nests, either by observation from afar, or by visitation. After broods had hatched and left the nest, we returned to the nest to count and collect unhatched eggs for analysis. We opened unhatched eggs to determine number of infertile eggs, and those with dead or decomposed embryos.

To quantify fledging success, and determine if mortality was related to location, we monitored gosling numbers and location by observations of collared, radio-collared, and unmarked adults. Many researchers use survival to a certain age (i.e., 4-6 weeks, 8 weeks, banding) as a surrogate for survival to fledging. In this study, we used survival to banding (5.5 to 10.5 weeks after hatching) to estimate fledging success. Williams et al. (1993) showed that goose roundups (for banding) disrupted family cohesiveness and led to increased gosling mortality, but see Cooch (1956) and Prevett and MacInnes (1980) for different results.

When we began work in 1996, there was only one collared Canada goose on the refuge. During the breeding season in 1996, we trapped 5 nesting females and collared them with yellow plastic collars inscribed with individual alpha-numeric codes. We collared more adults and some goslings during the annual roundup. Thus, in 1997, many of the nesting geese were already collared. We concentrated our trapping activities on nests where neither parent was collared, although we attempted trapping on other nests as well. We attempted trapping when the eggs were pipping, since females are less likely to abandon their nests at this time (Eberhardt et al. 1986). We approached the nest, flushed the female, and set up a bownet trap modified from a design by Shor (1990) to include a trigger operated by remote control. We chose this design because of its low profile. We also painted it a straw color to blend in with the straw bales on the artificial nesting platforms and the dead saltgrass surrounding most of the ground nests. We then left the vicinity to allow the female to return. We returned after 2 to 4 hours to spring the trap from a distance of 50-150 m. We first tried trapping during the daytime, but many geese would not return to the nest until we removed the trap. We then began setting the trap after dark, and had more geese return to their nests.

In 1996, trapped birds were banded and collared. In 1997, with an assistant, we took various measurements of each female, including body mass, and wing, culmen, tail, and total body lengths during the banding procedure. In 1997, the collars were equipped with radio transmitters, and were color-coded (along with the inscribed alpha-numeric code,) so we could identify them at a distance if the transmitter failed. In 1996, 3 of the 5 trapped females abandoned their nests. In 1997, we utilized an injectable anesthesia, Propofol (Rapinovet, Mallinckrodt Veterinary, Inc.), to prevent nest abandonment. One of 8 females that were properly dosed abandoned her nest of pipping eggs. A ninth female did not receive a full dose; she also abandoned her nest.

After broods left the nest, we returned to ascertain the number hatched. Unhatched eggs were collected and examined. We attempted to locate all broods every day for the first 15 days following hatching, and then every other day. We located broods by telemetry or observation, and noted location and number of goslings.

When the goslings were between 50 and 65 days old and still flightless, but large enough to wear a collar, and the parents in molt, we initiated roundups to trap them for banding, collaring, and measuring. We also caught goslings of <50 and >65 days old if they were mixed in with the target goslings. We caught molting, adult females for measurements and removal of radio-collars. All geese and goslings were caught by hand, from an airboat or from the ground.

To compare gosling size to that of goslings in a control area we compared body mass and morphometric measurements from 3 groups of goslings 58-60 days old. One group was composed of 14 wild goslings from Fish Springs NWR, captured during the annual roundup. They were aged 58 (n=3), 59 (n=2), and 60 (n=9) days. The second group was a coterie of 58-day-old captive wild-strain goslings (n=9) taken as eggs from Cutler marsh in Cache County, Utah, and raised in cages on commercial chick feed. The third group was composed of 59-day-old wild goslings (n=2), all from the same brood from Cutler marsh.

We took measurements of body mass, culmen length, and wing length. We measured body mass with an Ohaus spring scale, accurate to 20 g. To measure entire culmen, we used a dial caliper, accurate to 0.1 mm. The wing length measurement (w1) was taken from the elbow joint (between the humerus and ulna) to the joint between the carpometacarpus and the first phalanx.

We used the measurements of 12 Cutler adult females and 13 Fish Springs adult females captured during roundups to test for population differences in adult female size. We measured wing length, w1, as described above, as well as length of wing from elbow to feather tips (w3). We also measured body length, tail length, and body mass.

RESULTS

Numbers of Pairs

Prior to 1978, no pairs counts were made at the refuge. From 1978 to 1987, pair counts during the breeding season ranged from 58 to 77. No distinction between total pairs, and territorial or nesting pairs, was made. In 1988, 25 to 40 pairs were present during the breeding season. From 1989 to 1993, number of nesting pairs ranged from 18 to 22. No pairs counts were done in 1994 or 1995. In 1996, we made 24 refugewide goose pair counts between 22 March and 5 May. Approximately 35 pairs became territorial; 26 (74%) of them nested.

In 1997, we made 19 counts of indicated pairs (pairs, plus pairs indicated by lone gander) from 21 March to 11 May. The total number of pairs ranged from 31 to 52, and averaged 41. Observations and territory mapping yielded about 43 territorial pairs. Of these, approximately 34 (79%) nested, producing 39 known nests. Thus, 5 pairs (15%) of 34 were responsible for 2 nests apiece. Our observations suggested that all renests were the result of continued laying. No first or second nests of the same pair contained more than 3 eggs or the eggshell fragments of more than 3 eggs.

Clutch Size

We calculated clutch size for all complete nests after full incubation had started. In 1996, average clutch size for artificial nesting platforms was 5.33 ± 0.71. Average clutch size for ground nests was 4.42 ± 1.51. When suspected renests were combined with their associated first nest to make one total clutch, the average clutch size for ground nests was 5.30 ± 0.82. Clutch size ranged from 2 to 6.

In 1997, average clutch size for artificial nesting platforms (n=10) was 5.70 ± 1.64. One nest contained 10 eggs, 5 of which were infertile. If the 5 infertile eggs are disregarded, average clutch size was 5.20 ± 0.63. Average clutch size for ground nests (n=19) was 4.68 ± 1.42. When suspected renests were combined with their associated first nest, the average clutch size for ground nests (n=17) was 5.29 ± 0.77. Clutch size ranged from 1 to 10.

We also calculated average clutch size for those nests that were successful (i.e., one or more eggs hatched). For this calculation, we considered nests that were abandoned when eggs were pipping due to our trapping efforts as successful. In 1996 and 1997, average clutch size for successful nests was 5.3 ± and 5.3 ± , respectively.

Nest Success

In 1996, we located 28 nests. Geese nested on 10 (58%) of 17 available artificial nesting platforms. We found 18 ground nests; 2 were abandoned due to human disturbance at the nest during laying, and the pairs renested. These 2 nests were not used in calculating nest success. We considered nests that contained pipping eggs that were subsequently abandoned due to our trapping efforts as successful nests for this calculation. Overall nest success (i.e., one or more eggs hatched) was 69%; i.e., 18 of 26 nests were successful. Nine (90%) of 10 platform nests were successful. Nine (56%) of 16 ground nests were successful.

In 1997, we located 36 nests. Twelve (70.5%) of 17 artificial platforms were utilized, 10 (83.3%) of which were successful. Ten (41.6%) of 24 ground nests were successful. Three ground nests were assumed to exist due to the appearance of broods otherwise unaccounted for, although they were not located. Thus, ground nest success may have been as high as 48.1% (13 of 27 successful). Overall nest success was 59.0% (23 of 39 successful). Since we did not find some successful nests, we probably did not find some unsuccessful nests as well. If these unsuccessful nests were present in the same ratio to successful nests as the ones we found or were indicated by brood presence, then there were 4 more nests at Fish Springs NWR. If we include these in our calculations, ground nest success was 41.9% (13 of 31 successful), and overall nest success was 54.5% (23 of 43 successful).

Fate of Unsuccessful Nests

Of the 28 nests found in 1996, 7 were depredated. Five were found already depredated, and 2 were in advanced stages of incubation when depredated. Nest visits by researchers may have caused abandonment in these 2 cases. Two other nests were abandoned after researcher visitation during the laying period and while the female was on the nest.

In 1997, 13 nests were depredated, 8 by an avian predator, probably the ubiquitous raven. At 2 of these we also discovered owl pellets. Three nests were probably depredated by coyote (*Canis latrans*). Three nests were depredated by an unknown predator. Of these 13 depredated nests, we do not know if abandonment came before or after the depredation. The majority were found depredated. However, one may have been abandoned due to harassment at the nest, first by a golden eagle (*Aquila chrysaetos*) and then by a researcher checking the nest. Another nest may have been abandoned due to harassment by conspecifics, as we observed aggressive interactions between geese in the nest vicinity both before and after the depredation.

In 1997, 2 nests were abandoned. One was abandoned after researcher visitation during the laying period and while the female was on the nest; the female renested within 25 m. The other was abandoned after researcher visitation. The eggs contained dead, normal embryos, approximately 9 days away from hatching.

Egg Success

In 1996, 18 nests were successful. We used 14 of these that had complete histories to compute egg success (Table 4-1). Seventy-five eggs were used in the calculations. Two (2.7%) were infertile, 1 (1.3%) was rotten, and 2 (2.7%) contained normal embryos that had not hatched. Overall, 5 (6.7%) did not hatch, for an egg success rate of 93.3%. We examined all of the eggs that did not hatch and found no evidence of physical deformities.

We calculated egg success for 20 of the 23 successful nests in 1997 (see Table 4-1). Of the 106 eggs laid, 21 (19.8%) did not hatch. Seven (6.6%) of the 106 were infertile, and 3 (2.8%) were rotten. Eleven (10.4%) contained developed embryos that had not pipped. Overall, 21 (19.8%) did not hatch, for an egg success rate of 80.2%. As in 1996, we examined all of the eggs that did not hatch and found no evidence of physical deformities. One egg contained twins; they were normal, but several days behind their nestmates in development.

Fledging Success

In 1996, 57 eggs hatched, and approximately 14 goslings (25%) survived to fledging. In 1997, 83 eggs hatched from 20 nests; 43 goslings (51.8%) survived to fledging. (Three nests containing a total of 13 eggs were counted as "successful" for nesting success estimation; however, they were abandoned as pipping eggs or hatchlings due to trapping efforts, so can not be used in fledging success estimation. Another 3 goslings from successful nests died immediately after hatching due to trapping efforts; they were not included in the count of 83 hatched eggs.)

In 1997, 37 goslings hatched in platform nests; 18 (48.6%) fledged. Forty-six goslings hatched in ground nests; 25 (54.3%) fledged. Platform and ground nest fledging success was not significantly different ($\chi^2 = 0.20$, $P = 0.66$)

Effect of Location

We examined number of gosling deaths per use-day on all brood-rearing impoundments (Table 4-2). One location, "Green Pond," was 800 m north of Harrison impoundment, and outside the refuge, and filled by runoff water from Harrison. Some broods moved from one pool to another. We counted deaths occurring during an overland move of more than 200 m as deaths in transit. Overland moves of <200 m were not considered in transit.Some deaths occurred during an interval when a brood was not located; these were recorded as unknown deaths. Ibis and South Gadwall were considered as one location because movement from one to the other entailed merely a trip over a dike, and South Gadwall was more similar in specific conductivity to Ibis than to North Gadwall.

We examined data from 17 broods. Seven of the broods had radio-collared females. In 5 of the 10 broods without radio-collared females, either one or both parents were collared. In the other 5 broods, neither adult was collared. We identified these broods by age of goslings and location. The 17 broods hatched 75 goslings. We counted the day the goslings hatched as day 0. By the end of day 1, all broods had left the nest. By the end of the 15th day following hatching there were 42 goslings (56%) left. Thirty-three goslings (44%) had died. The average number of deaths per use day (DPUDs) during this period was 0.042-0.045. Four locations had below average DPUDs: Harrison, Ibis/S. Gadwall, Pintail, and Shoveler. The range for "Unknown," 0.032-0.058, spans the average. Two locations, Mallard and Green Pond, had DPUD numbers that ranged from 0 to above average. Four locations had above average DPUDs: Egret, Curlew, N. Gadwall, and In Transit.

Breeding Experience

We collared five females in 1996. All incubated their clutches to pipping. We consider them all successful nesters, although 3 abandoned their nests due to our trapping efforts. All 5 of these females returned to the same general nesting vicinities with mates in 1997, and became territorial. At least 4 of them nested, and one successfully hatched a brood and raised 2 goslings to fledging. Another 5 pairs are suspected to be returning pairs because they nested early and utilized artificial nesting platforms that were used last year (or, in one case, the placement of a ground nest next to a platform that was used in 1996). We suspect another 7-8 pairs of having prior breeding experience at Fish Springs due to a combination of clues, including nest placement and behavior. One collared male and a mate were present on the refuge in 1996 without becoming territorial. In 1997, this male and a mate successfully raised 3 goslings to fledging.

Gosling and Adult Female Size

Means comparisons (SAS GLM, Least Squares Means) of the measurements for goslings showed significant pairwise differences between any 2 of the 3 groups in body mass and wing length (Table 4-3). Fish Springs wild goslings were the lightest and smallest and Cutler wild goslings were the heaviest and largest. In culmen length, Fish Springs wild goslings were significantly smaller than both caged goslings and Cutler wild goslings. Caged and Cutler wild goslings did not differ significantly in culmen length..

All of the Cutler females were captured with goslings on 18 June 1997 and we assumed them to be primarily successful nesters. We also captured the Fish Springs females while doing a gosling roundup on 2 July 1997. We know that at least 6, and possibly 8, were successful nesters. Two others were positively identified as failed nesters, and the remainder most likely were failed nesters. Nonbreeding geese begin molt earlier than nesters (Bellrose 1980). Because the vast majority of geese had completed their molts by the day of the roundup and could fly, we suspect that none of the Fish Springs females captured were nonnesters.

The Cutler and Fish Springs females were not significantly different in wing bone length (w1), body length (total body length minus tail length), tail length, or total wing length (w3) (Table 4-4). The 2 groups were significantly different in body mass at an alpha level of 0.10 (P

= 0.07), with the Fish Springs females weighing slightly less than the Cutler females.

DISCUSSION

Our results show that limitations on reproductive success occur in at least 3 parts of the reproductive cycle. First, the number of pairs present on the refuge is lower than has occurred there in the past (i.e., pre-1988). This may be due to low recruitment; however, we have no data to address that question. Secondly, nesting success for ground nests is low. Thirdly, fledging success is low.

In both 1996 and 1997, nests on platforms had greater nesting success than ground nests. There are several possible explanations for this. First of all, females take recesses from incubating the eggs. The gander, instead of guarding the nest, accompanies the female as she recesses (Bellrose 1980). Thus, the nest is vulnerable to predation during this time, particularly from an avian predator, such as the ubiquitous common raven at Fish Springs NWR. A platform nest is more visible to the gander at a distance, because it is elevated. If an avian predator approached the nest, the pair could return swiftly to protect the eggs.

Secondly, it may be that pairs with more breeding experience are utilizing platforms. This is suggested by the earlier nest initiation dates for successful platforms versus successful ground nests. First-time breeders may need more time to develop and strengthen their pair bond on wintering grounds, thus arriving later on the breeding ground. Once on the breeding ground, they will find the best territories already occupied, and will have to search for and defend a new territory. If platforms are considered higher quality territory, then older, more experienced pairs would be better at defending them. More experienced breeders may begin incubation with more body reserves, and need to spend less time off the nest feeding. However, Aldrich and Raveling

(1983) showed that first-time breeders lay smaller clutches than experienced breeders. Our analysis of clutch size, if renesting is taken into account, shows remarkably similar clutch sizes for platform and ground nests in both 1996 and 1997. This suggests that platform nesters and ground nesters have similar amounts of experience.

In addition to being vulnerable to avian predators, ground nests are at risk from mammalian predators. At the refuge, the most common mammalian predator is the coyote; however, red fox (*Vulpes fulva*), and striped skunk (*Mephistis mephistis*) are also present.

Females on ground nests may react more strongly to perceived threats at the nest leading to abandonment. In 1996 and 1997, we unintentionally flushed laying females off their ground nests of 1-2 eggs while conducting nest searches. In all cases (2 each year), the females abandoned their ground nests. In 1996, we checked 4 platform nests before the clutch was completed. In no case did we flush the female from the nest, although in at least 2 cases, the pair was in the vicinity. In 1997, we checked 4 platform nests with incomplete clutches, flushing females from 3 of these nests. In all cases, there were 3 eggs and down in the nest, indicating the start of at least some incubation (Cooper 1978). No females abandoned platform nests during laying due to checking. Perhaps, they react less strongly to perceived threats, did not perceive the action as a threat, or because the clutches were 3 eggs apiece, felt a stronger fidelity to them due to the investment.

No females abandoned platform nests later in incubation due to nest-checking in 1996 or 1997. In 1996, one ground nest may have been abandoned because of checking later in incubation. At another ground nest, the female abandoned her peeping (but not yet pipping) eggs after she was flushed for a nest check. In 1997, one ground nest was abandoned after a nest check; the eggs were approximately 9 days away from hatching. Another 2 ground nests with clutches under incubation were probably abandoned before being depredated, one due to conspecific harassment and the other due to a combination of harassment by a golden eagle (*Aquila chrysaetos*) and nest visitation.

The general wariness of Fish Springs nesting females as compared to other populations may have significance. In 1996, 3 of 5 collared females abandoned due to capture; and, 1 female of 6 where a trapping effort occurred, but was not successful, abandoned her pipping eggs. Four of the other 5 females would not return until the trap was removed. Other researchers who had trapped nesting female geese found this unusual (J. Sedinger, Univ. of Alaska, pers. commun.; T. Aldrich, Utah State Division of Wildlife Resources, pers. commun.). Eberhardt (1987) trapped 41 nesting females for radio-tagging. Of these, only 7 (17%) abandoned. Abandonment late in incubation, or while eggs are hatching, suggests that female geese on the nest are responding to a proximate condition (i.e., low body reserves) more dramatically than females on nests at other locations, and that natural selection through predation on less wary ground nesters has taken place (Sherwood 1966). Fish Springs NWR nesting females did weigh less than Cutler marsh nesting females.

Possible Reasons for Low Fledging Success

We found fledging success low for this species. We documented fledging success at 25% in 1996. We cannot unravel the causes of this low survival rate because of the potential effects of our research on goose behavior. Our trapping efforts caused many abandonments, decreasing the number of eggs that hatched. The low density of goslings may have had an effect on survival. Our trapping efforts, which resulted in abandonments, occurred on the nests initiated earlier in the season, since we discontinued this process due to poor results. It may be that earlier hatched goslings survive better because of timing (Wang 1982) or because of location and that we biased survival by eliminating many of these broods.

In 1997, we quantified survival to fledging as 51.8%. Thirty-five (81.5%) of the 40 mortalities occurred in the first 15 days following hatching. We were able to follow broods accurately because we had many of the parents marked with collars and some with radio-transmitters as well, and few broods on any one impoundment. Uncollared parents that we followed had broods of differing ages, or were on different impoundments. We knew of 2 cases of adoption. We never observed one brood, until their 6 goslings were approximately 41 days old. Some broods of unmarked adults disappeared, and we assumed they died. It is possible that they were on the refuge; however, we consider it unlikely that we would never have viewed these broods again if still alive, since the other broods congregated in the more open northern parts of the refuge, on Pintail (8-9 broods), Harrison, and Ibis/S. Gadwall.

We found that the number of DPUDs was higher than average at 4 locations (see Table 4-2). One location, Curlew, had only 6 use days and the death was on day 1 following hatching. We offer no particular explanation for this death other than to note sample size is low.

Geis (1956) in her study of *B. c. moffitti* in Montana found significant mortality during the first few days following hatch as broods trekked overland from nesting areas to brood-rearing areas. She attributed most of the mortalities to predation. We speculate that this is what happened to the goslings disappearing in transit at Fish Springs NWR, too. We can surmise by the timid behavior of nesting geese that defense against predators is small. Another possible explanation is that weaker or smaller goslings were not able to keep up with the rest of their brood during these arduous treks through saltgrass or upland desert. Wary parents may have abandoned these slower young in favor of getting the others to safety as quickly as possible. This also suggests pressure from predation.

Egret impoundment had a very high number of DPUDs in 1997. In 1996, only one brood hatched or spent time there. The female was collared, and we watched as over the first 16 days her brood gradually decreased from 5 to 1. One week later the diminished brood left Egret impoundment. We also suspect predation in these mortalities. In both years, we often observed broods grazing to the east of Egret dike, outside the impoundment. When we approached slowly in the truck, many times adults and young would run into the upland desert far away from the safety of the water. We examined the area and found coyote tracks interspersed with goose tracks, and a coyote path along a low (4 m high) ridge that paralleled the dike, and the grazing area. J. Engler, past assistant refuge manager, also reported high loss of goslings in this area in 1989, and attributed it to the easy access to coyotes (J. Engler, Goose Production, Fish Springs NWR, 1989). Additionally, in 1997, water levels were low enough to allow easy access by mammals to the islands and peninsulas within the pool.

In 1996, one of our technicians observed a juvenile coyote with a dead adult goose in its mouth on Pintail impoundment (K. Jenkins, Fish Springs NWR, pers. commun.). We also saw coyotes apparently stalking geese, and adults teaching young to do this. Actual predations by coyote on Pintail were probably low for three reasons. First of all, in both years broods congregated on this pool, and several adults were always alert. Thus, it was more likely that potential predators would be seen. Also, the impoundment is large and open, so visibility is good. Thirdly, if broods are feeding on the north or south dikes, they can go either north or south if startled and find water, either in Pintail or the adjacent impoundments. If broods fed on the eastern or western edges of the pool, they were unlikely to be startled by the approach of our truck because these areas are not next to the dikes. Broods feeding in these areas would often become alert at our approach, but could get to the water without crossing in front of our vehicle, or going up and over a dike. They did not run into the upland desert.

Nutrition

Since the early days of the refuge, refuge personnel have been concerned with the quality of the forage available to the geese. In 1961, then refuge manager Lynn A. Greenwalt, in a report about the proposed captive Canada goose flock and reintroduction of geese, wrote: "Native forage, consisting primarily of Inland Saltgrass (*Distichlis stricta*), (sic) will ultimately be replaced by a suitable forage grass, while arable soils will be planted to forage crops suited to the soil type." This did not prove feasible (J. Banta, Fish Springs NWR, pers. commun.). Identifying and quantifying types of plants used for forage was beyond the scope of this project; however, our observations indicate broods fed in areas consisting primarily of saltgrass and annual samphire. These plants may not provide adequate nutrition for growing goslings.

Our results from weighing and measuring goslings from 3 different groups (Fish Springs wild, Cutler wild, and Cutler caged) may be a reflection of nutritional quality available to the different groups. We expected wild goslings to weigh less and be smaller than their caged counterparts, which were provided with a nutritionally balanced feed *ad libitum*, and protected from environmental stresses. This was the case when we compared Fish Springs wild goslings to Cutler caged (see Table 4-3). However, Cutler wild birds were not significantly different in body mass nor measurements from Cutler caged birds.

To check for possible population differences in size, we compared measurements of 12 Cutler adult females to 13 Fish Springs adult females. The only significant difference was that Fish Springs females weighed less. This may give weight to our hypothesis that nutritional quality is poorer at Fish Springs; however, it may be a result of other environmental stresses, or more interruptions during feeding.

MANAGEMENT IMPLICATIONS

We can divide the refuge into successful locations and unsuccessful locations, both for nesting success and fledging success. This does not require absolute understanding of the mechanisms causing success or failure. In terms of nesting success, platforms were much more successful than ground nests in both years, and northern platforms more successful than southern ones. There are 5 platforms in the southern half of the refuge. Only one was utilized in 1996, and it was depredated. Three were used in 1997, and 2 were depredated. In neither year were the 2 platforms in S. Curlew used. Our observations revealed much use of the Curlew platforms by ravens as perches, and even by short-eared owls (*Asio flammeus*), and occasionally other raptors. We found duck parts and eggshells on and around these platforms.

In terms of fledging success, broods reared on Harrison, Pintail, and Ibis/S. Gadwall survived better than those reared on Egret or N. Gadwall. Broods hatched in Curlew, Avocet, and Mallard left these impoundments or "disappeared." There was no difference in fledging success between platforms and ground nests.

The refuge can take advantage of these facts by installing more platforms in the northern impoundments, and removing the platforms in S. Curlew, so the ravens do not have such a good vantage point to observe the comings and goings at nests in the area. We also suggest removing transect poles from all over the refuge. Because the refuge is basically flat with low vegetation in the nesting areas, without these artificial constructs the ravens will have fewer viewing perches.

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Table 4-1. Egg success for eggs from successful nests of Canada geese at Fish Springs NWR, Juab County, Utah, 1996 and 1997.

Year	No. nests	Total no. eggs	Average clutch size	Number infertile eggs	Number rotten eggs	Number normal[a] eggs	Total hatched (egg success)[b]	Average hatch per nest
1996	14	75	5.4	2 (2.7%)	1 (1.3%)	2 (2.7%)	70 (93.3%)	5.0
1997	20	106	5.3	7 (6.6%)[c]	3 (2.8%)	11 (10.4%)[d]	85 (80.2%)	4.25

[a] We use "normal" to designate unhatched eggs with normal embryos that did not begin pipping.

b Pipping eggs from nests that were abandoned due to trapping efforts and subsequently did not hatch are counted as hatched for this calculation.

[c] Five of the infertile eggs were from one nest that also contained 5 fertile eggs.

[d] Our activities at the nest may have caused broods to leave earlier than they would have normally, abandoning unhatched eggs; as many as 7 eggs may have been affected by this.

Table 4-2. Number of Canada goose gosling deaths per use day from day 1 through day 15 after hatching at various locations at Fish Springs NWR, Juab County, Utah, 1997.

Location	No. of use days[a]	No. of deaths[b]	Deaths per use day
Ibis/S. Gadwall	143-144	2	0.014
Harrison	184-187	2-3	0.011-0.016
Pintail	162-163	3	0.018
Shoveler	43	1	0.023
Unknown	69-95	3-4	0.032-0.058
Green Pond	10-12	0-1	0-0.100
Egret	75-104	10-12	0.096-0.160
Curlew	6	1	0.167
N. Gadwall	12	3	0.250
In Transit	17-19	1-8	0.053-0.471
Mallard	6	0-3	0-0.500
TOTALS	**727-791**	**33[c]**	**n.a.**
AVERAGE	**n.a.**	**n.a.**	**0.042-0.045**

[a] Ranges in number of use days resulted from days when we located a brood but were unable to make an exact count of goslings.

[b] Ranges in number of deaths at a specific location resulted from us pinpointing mortality to one of 2 locations, rather than to the exact location.

[c] Exact number of mortalities.

Table 4-3. Pairwise comparisons for group means for Canada goose goslings, at Fish Springs NWR, Juab County, Utah, 1997. Group 1 = Cutler caged goslings, aged 58 days. Group 2 = Fish Springs wild goslings, aged 58-60 days. Group 3 = Cutler wild goslings, aged 59 days.

Body Mass

Group	n	mean	SD	1	2	3
1	9	2367	287	.	p=0.0376**	p=0.0175*
2	14	2069	340	t=2.21	.	p=0.0008**
3	2	3000	141	t=2.57	t=3.91	.

Wing Length

Group	n	mean	SD	1	2	3
1	9	134	6.8	.	p=0.0002**	p=0.0482**
2	14	116	10.9	t=4.47	.	p=0.0001**
3	2	150	0	t=2.10	t=4.81	.

Culmen Length

Group	n	mean	SD	1	2	3
1	9	46.5	2.96	.	p=0.0003**	p=0.7835(ns)
2	14	41.7	2.42	t=4.28	.	p=0.0129*
3	2	47.1	2.47	t=0.28	t=2.71	.

* $P \leq 0.05$
** $P \leq 0.01$
ns Not significant

Table 4-4. Means for 5 measurement variables for adult female Canada geese at Fish Springs NWR, Juab County, Utah, and Cutler marsh, Cache County, Utah, 1997.

		w1		w3		Body length		Tail length		Body mass	
Location	*n*	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Fish Springs	13	139.4	5.2	334.2	39.8	673	27	147	8.6	3069*	281
Cutler	12	139.6	5.4	333.8	54.1	679	22	149	9.1	3258*	215

*Significant at $p \leq 0.10$. Actual p-value for t-test is 0.07. All others not statistically significant.

CHAPTER 5

TECHNIQUES FOR DETERMINING GOSLING SURVIVAL

Abstract: There are 5 major techniques used for determining gosling survival: average brood size, total gosling count, meta-analysis, marked adults, and marked goslings. I describe each technique and possible inherent errors. I discuss implications for my study at Fish Springs National Wildlife Refuge (NWR) in 1997 when we used the marked adults technique. I suggest managers and researchers refrain from comparing gosling survival rates to those based on average brood size or the meta-analysis of Krohn and Bizeau (1980), because these are likely to be overestimations.

INTRODUCTION

Estimates of gosling survival for the western Canada goose (Branta canadensis moffitti) and the giant Canada goose (B. c. maxima) range from 49-95% (Geis 1956, Steel et al. 1957, Martin 1963, Dey 1964, Brakhage 1965, Sherwood 1966, Hanson and Eberhardt 1971, Glasgow 1977, Knight 1978, Krohn and Bizeau 1980, Ball et al. 1981, Zicus 1981, Wang 1982, Warhurst et al. 1983, Eberhardt et al. 1989) (Table 5-1). Most gosling mortality occurs in the first 2 weeks following hatching (Steel et al. 1957, Martin 1963, Brakhage 1965, Zicus 1981, Eberhardt et al. 1989), and thus many researchers use survival to a certain time (e.g., 3 weeks, 7 weeks) as a surrogate for survival to fledging. Several techniques have been used to measure gosling survival. Eberhardt (1987), Eberhardt et al. (1989), Wang (1982), and Zicus (1981) provide succinct discussions of many of these techniques. I will describe the techniques, and comment on the accuracy of the technique I used, and the implications of my results at Fish Springs National Wildlife Refuge (NWR) in Juab County, Utah, in 1997.

THE TECHNIQUES

Average Brood Size

The least accurate estimation technique involves comparing average hatch per nest with average brood size at some later date. Estimates of gosling survival using this technique range from 86-93% (Steel et al. 1957, Dey 1964, Hanson and Eberhardt 1971). This technique will consistently overestimate gosling survival as it does not take into account families that lose all goslings (Krohn and Bizeau 1980, Zicus 1981, Sargeant and Raveling 1992). Some researchers have found average brood size to be greater than average number of goslings hatched per successful nest (Williams and Marshall 1938, Steel et al. 1957, Martin 1964). Eberhardt (1987) using radio-marked females found that 12 (44%) of 27 families lost their entire broods. I found that 6 (30%) of 20 families lost their entire broods. If I had used the average brood size technique to estimate survival, I would have overestimated survival by 44%. Brood mixing may also complicate matters (Sargeant and Raveling 1992).

Total Gosling Count

Another technique employs a total gosling count (Geis 1956, Brakhage 1965). This is determined by counting total number of goslings hatched and comparing that number to the number of survivors counted at a later date. This technique may be biased by mobility of broods, i.e., broods leaving from or coming to the area under observation, as well as personnel and visibility (Ball et al. 1975). Overestimation is possible if broods immigrate to the area or if very mobile broods are counted more than once without the observer realizing it. Underestimation might occur if broods emigrate from the area under observation, or if poor visibility due to inclement weather or natural obstructions hide broods from view. Additionally, personnel vary in their skill at and dedication to finding and observing broods. Estimates of gosling survival using total gosling count range from 64-86% (Geis 1956, Brakhage 1965).

Meta-Analysis

The accuracy of a meta-analysis relies on the accuracy of the individual studies. Krohn and Bizeau (1980) in a much cited meta-analysis combined the results of 10 studies to arrive at an average of 92-95% gosling survival for the Rocky Mountain population of the western Canada goose. While warning readers of the bias inherent in using the technique I call average brood size, they included 7 studies (of a total of 10) in their meta-analysis that used this technique. Thus, survival was almost certainly overestimated.

Marked Adults

The use of individually coded plastic collars to identify adults has been applied to estimating gosling survival; researchers have arrived at estimates ranging from 56-95% survival (Martin 1963, Sherwood 1966, Glasgow 1977, Zicus 1981). Survival estimates based on the change in brood size of marked adults are potentially more accurate than both average brood size, or total gosling count. The results of counts on different days may be combined, since each brood can be followed individually. Cases of adoption, or brood aggregation may bias results. Errors in estimation may also be made if marked adults are not located since the fate of the goslings will be unknown. However, the use of homing-telemetry can help to overcome this problem.

Eberhardt et al. (1989) tracked 31 radio-marked females to calculate a fledging success rate of 49%. They trapped females on the nest to put on radio transmitters. The disturbance at the nest may have caused a lower survival rate due to interference with the normal imprinting of goslings on their mother (Eberhardt et al. 1989). Additionally, it may have made females more wary and apt to abandon slower goslings when disturbed during the days and weeks that followed.

Marked Goslings

The various methods of marking goslings have yielded survival estimates ranging from 56-84% (Glasgow 1977, Wang 1982, Warhurst et al. 1983). Several researchers injected dye into eggs to color-mark the young waterfowl (Evans 1951, Glasgow 1977) so they could be monitored at a distance or to study hatching sequence (Wang 1982). However, this technique can kill embryos if not done properly (Evans 1951, Glasgow 1977). Color-marked young may also be at a disadvantage in avoiding predation. Wang (1982) and Warhurst et al. (1983) used colored patagial tags to mark goslings. By combining different colors, Warhurst et al. were able to identify goslings to their brood. Glasgow (1977) also could identify goslings to brood; in his case he used one dye color per brood. Inaccuracies may result in this technique if tags fall out, or if tagged goslings emigrate. Monitoring radio-marked goslings has the potential to be a very accurate method of estimating gosling survival.

IMPLICATIONS FOR THE STUDY AT FISH SPRINGS NWR

I monitored radio-collared females, collar-marked adults, and unmarked adults with broods to determine Canada goose gosling survival at Fish Springs NWR in 1997. I identified the broods of unmarked adults by plumage class of goslings and location. I followed every brood that hatched. There was no possibility of immigration or emigration due to the location of the spring-fed marsh within upland desert and salt flats. This gave me the opportunity to very accurately assess gosling survival. Forty-three (52%) of 83 goslings survived to banding at 5.5 to 10.5 weeks. This survival rate is low compared with rates from studies using all techniques (see Table

5-1). However, it is comparable to the only other study using the same technique of radio-marked females; Eberhardt et al. (1989) arrived at the rate of 49% gosling survival in their study.

Eberhardt et al. (1989) considered the possibility that the disturbance they caused at the nest contributed to lower gosling survival. This was probably not the case at Fish Springs NWR where, since at least 1989, gosling survival has been very low, about 36% (Table 5-2). Gosling survival at Fish Springs NWR was higher in 1997 than was documented in the previous years. Eberhardt et al. (1989) reported that coyotes (Canis latrans) were common in their study area, were implicated in nest predation, and were observed attempting to catch goslings. Coyotes were also ubiquitous at Fish Springs NWR and were seen stalking geese. However, for both studies, the actual impact of coyote predation on goslings is unknown. The similarity of my results to that of Eberhardt et al. (1989) deserves further investigation.

I suggest that researchers and managers refrain from comparing gosling survival rates to those based on average brood size or the meta-analysis of Krohn and Bizeau (1980) because these are likely to be overestimations. Estimates of gosling survival rates of B. c. moffitti and B. c. maxima based on other techniques range from 49-89%, and may be a better reflection of the actual gosling survival.

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Table 5-1. Estimates of gosling survival and estimation technique used for studies done on *B. c. moffitti* and *B. c. maxima*.

Authority	Location	Subspecies	Percent Survival	Estimation Technique
Brakhage (1965)	Missouri	*maxima*	64-80	total gosling count
Dey (1964)	Utah	*moffitti*	89	average brood size
Eberhardt et al. (1989)	Washington	*moffitti*	49	radio-marked females
Geis (1956)	Montana	*moffitti*	80-84	total gosling count
Glasgow (1977)	Alberta	*moffitti*	56	marked adults and goslings
Hanson and Eberhardt (1971)	Washington	*moffitti*	86[a]	average brood size
Krohn and Bizeau (1980)	RMP[b] area	*moffitti*	92-95	meta-analysis
Martin (1963)	Utah	*moffitti*	95	marked adults
Sherwood (1966)	Michigan	*maxima*	75[c], 16[d]	marked adults
Steel et al. (1957)	Idaho	*moffitti*	93[e]	average brood size
Wang (1982)	Ohio	*maxima*	62-84	marked goslings and roundup
Warhurst et al. (1983)	Ohio	*maxima*	74	marked goslings
Zicus (1981)	Wisconsin	*maxima*	61-71[f]	marked adults

[a] Survival to third week
[b] Rocky Mountain population
[c] Average for 1963 and 1965
[d] 1964, disease outbreak
[e] Survival to two-thirds grown
[f] Over 3 years

Table 5-2. Fledging success for Canada goose goslings at Fish Springs NWR, Juab County, Utah, 1989-1995.

Year	Goslings Hatched	Goslings Fledged	Percent Survival
1989	63	22	35
1990	55-65	33	51-60
1991	67	18	27
1992	95	31	33
1993	99	34	34
1994	69	no data	no data
1995	no data	17	no data
1996	57	14	25
1997	83	43	52
AVERAGES	**74-75**	**27**	**36**

CHAPTER 6

CONCLUSION

Numerous factors determine Canada goose (Branta canadensis) production at a particular location. I identified 3 factors that are limiting production of the western Canada goose (B. c. moffitti) at Fish Springs National Wildlife Refuge (NWR) in western Utah: low fledging success, low nesting success for ground nests, and low number of breeding pairs.

Canada geese generally experience high fledging success; usually 60-95% of those goslings that hatch survive to fledge (Geis 1956, Steel et al. 1957, Martin 1963, Dey 1964, Brakhage 1965, Sherwood 1966, Hanson and Eberhardt 1971, Knight 1978, Krohn and Bizeau 1980, Ball et al. 1981, Zicus 1981, Wang 1982, Warhurst et al. 1983). At Fish Springs NWR, I documented fledging rates of 25 and 52% in 1996 and 1997, respectively. I researched the factors contributing to the low survival rate. I first studied the effects of saline drinking water, because young waterfowl can die or suffer from serious sublethal effects on growth, feathering, and other physiological processes if not given access to relatively fresh water during their first few weeks of life (Ellis et al. 1963; Swanson et al. 1984; Mitcham and Wobeser 1988a,b). The water available for goslings to drink at Fish Springs NWR ranges from 3-25+ μS/cm.

I conducted an experiment on captive wild-strain goslings. On day 1 following hatching, I assigned each gosling to one of 3 drinking water treatments: a control on tap water (treatment 1), 12 μS/cm (treatment 2), and 18 μS/cm (treatment 3). I monitored survival and growth (as measured by body mass, wing length, and culmen length) on a daily basis through day 28. I found that saline drinking water of the chemical composition found at Fish Springs NWR caused mortality, as well as growth depression of captive wild-strain goslings at the specific conductivity of 18 μS/cm. At 12 μS/cm, growth was depressed, but the differences in daily treatment means were not statistically significant on most days.

I also monitored free-ranging wild goslings on the refuge through observations of collar-marked and unmarked adults, and radio-tracking adults. Broods under the age of 16 days were not found on impoundments measuring over 11.9 μS/cm. Using an arbitrary classification system, I divided broods into those located on high (≥ 8.2 μS/cm) and low (<8.2 μS/cm) conductivity impoundments. I found that mortality from day 1-15 was independent of conductivity classification of gosling location.

I then analyzed mortalities from day 1-15 according to location. I found that certain locations had much higher numbers of deaths per gosling use-day than others. My observations suggest that predation and human disturbance contributed to many of the mortalities at these locations. Some mortalities occurred while broods were in transit from one location to another. These may be due to predation (Geis 1956), or other environmental factors particularly within the first few days following hatching.

I found and monitored ground nests, and monitored artificial nesting platforms. In 1996, nesting success was 56% and 90% for ground nests and platform nests, respectively. In 1997, nesting success was 42% and 83% for ground nests and platform nests, respectively. Clutch size was lower for ground nests than for platform nests in both years, probably due to continuation nesting after depredation of the first ground nest.

Historically, Fish Springs NWR has reported greater gosling production and larger numbers of nesting pairs. This is partly due to errors in estimation, such as using the average brood size technique for estimation of gosling survival, and not taking into account pairs that become territorial but do not nest. However, it does seem that the number of nesting pairs is lower than it was during the last 2 decades. My study was not designed to detect the causes of this, however, the low number of nesting pairs is almost certainly contributing to the limitation on production.

To put the gosling survival rates at Fish Springs NWR into perspective, I examined the techniques used in other studies to estimate survival. The technique of comparing average brood size at a certain age (i.e., 6 weeks) to average number of goslings hatched per successful nest usually overestimates the survival rate because it does not take into account families that lose all goslings (Krohn and Bizeau 1980, Zicus 1981, Sargeant and Raveling 1992). Researchers using this technique have estimated gosling survival from 86-93% (Steel et al. 1957, Dey 1964, Hanson and Eberhardt 1971). A study done, as this one was in one of the 2 years, using radio-marked females yielded a gosling survival rate of 49% (Eberhardt et al. 1989). While Fish Springs NWR's 8-year average (1989-1997, excluding 1994) of 36% survival is unusually low, it may not appear as dramatic when compared with the results of studies done using techniques more accurate than average brood size. It is possible that my results from 1997, when I used radio-marked females, are a better reflection of actual gosling survival. Or, 1997 may have been a slightly better year than average for gosling survival. The weighted average for gosling survival to fledging for the 2 years of my study was 40%.

The results of my study lead me to make 3 specific management suggestions for Fish Springs NWR personnel, if increasing gosling production is a goal:

1. Monitor specific conductivity of brooding impoundments on a weekly basis. Take steps to decrease salinity if levels will rise above 12 μS/cm during the early part of the brood rearing season.
2. Encourage geese to rear their broods on successful impoundments (viz., Harrison and

Pintail) by installing more platforms within them.

3. Minimize human disturbance of broods by closing the northern half of the refuge to vehicular and other traffic from 15 April (when the first broods hatch) to 15 July (when most goslings are fledged or close to fledging) every year.

When the refuge was established in 1959, the emphasis of the U.S. Fish and Wildlife Service (USFWS) was on producing surplus waterfowl, particularly ducks and geese, for harvest by hunters. In recent years, the mission of the USFWS has been modified to include a more diverse fauna with increasing attention given to non-game species. Fish Springs NWR supports breeding populations of such sensitive species as the white-faced ibis (Plegadis chihi), snowy plover (Charadrius alexandrinus), and sandhill crane (Grus canadensis). It has several large rookeries of ibis, snowy egret (Egretta thula), great blue heron (Ardea herodias), and black-crowned night-heron (Nycticorax nycticorax), and provides habitat for migrating songbirds. Since the western Canada goose has healthy breeding populations in many other wetlands in Utah, and other parts of its range, Fish Springs NWR may wish to concentrate its efforts on other avian species.

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