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IMPACT OF BROOD DENSITY

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of the requirements for
Master of Science degree in Fisheries & Wildlife

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**SURVIVAL AND MOVEMENTS OF CANVASBACK DUCKLINGS--
IMPACT OF BROOD DENSITY**

By

Jerome Patrick Leonard

A Thesis

**Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of**

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ABSTRACT

SURVIVAL AND MOVEMENTS OF CANVASBACK DUCKLINGS-- IMPACT OF BROOD DENSITY

By

Jerome Patrick Leonard

Intensively-managed breeding areas might be of considerable value for increasing continental populations of canvasbacks (Aythya valisineria). However, little information exists on the carrying capacities of wetland complexes and the factors that limit production of canvasbacks. The purpose of this study was to document canvasback duckling survival and movement patterns and examine the influence of increased intra-specific brood density on survival and movement patterns. Individually marked female canvasbacks with ducklings were studied in 1988-89 in southwestern Manitoba. Duckling survival and movements of broods were compared between two 1560-ha study sites, one with an artificially dense breeding population. The 63-day duckling survival probabilities for 1988 treatment (0.54) and control (0.43) were different. Duckling survival rates in 1989 were much lower. Females with ducklings used an average of 4 different ponds and travelled an average total linear overland distance of 1.5 km.

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

LIST OF TABLES	v
LIST OF FIGURES	vii
INTRODUCTION	1
Objectives	4
STUDY AREA	6
METHODS	9
Survival	10
Movement	12
RESULTS	13
Survival	13
Movement	22
DISCUSSION	31
LITERATURE CITED	44
APPENDIX	49

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Early (hatch to 1 week) and late (2-9 weeks) survival of canvasback ducklings on the treatment and control areas at Minnedosa, Manitoba from 1988-1989.	17
2. Early (hatch to 1 week) and late (2-9 weeks) survival of canvasback ducklings in mixed (containing ≥ 1 parasitized redhead ducklings) and unmixed (with only canvasback ducklings) broods on the treatment and control areas at Minnedosa, Manitoba in 1988.	19
3. Daily survival rates and average brood sizes ($\pm$ SD) for age classes of canvasback ducklings on the treatment and control areas at Minnedosa, Manitoba for 1988-1989.	20
4. Survival probabilities of canvasback ducklings for the entire 63-day brood period for the treatment and control areas in Minnedosa, Manitoba for 1988-1989. Survival probabilities were derived from data on individual ducklings (Mayfield) and average brood size of observed broods (Apparent).	21
5. Number of overland moves and distance traveled by canvasback broods during early (hatch to 2 weeks) and late (3-9 weeks) time periods on the treatment and control areas at Minnedosa, Manitoba for 1988.	27

<u>Table</u>	<u>Page</u>
6. Duckling daily survival rates (week 1) for canvasback broods that were isolated and associated with other canvasback broods during the first week after hatch on the treatment and control areas at Minnedosa, Manitoba for 1988.	29

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Canvasback breeding pair density on the treatment and control areas in Minnedosa, Manitoba for 1983-1989 (Data from M.G. Anderson).	5
2. Location of the Minnedosa Prairie pothole region in southwestern Manitoba, Canada, and location of the experimental and control areas southeast of Minnedosa.	7
3. Number of canvasback ducklings hatched on the treatment and control areas in Minnedosa, Manitoba for 1983-1989 (Data from M.G. Anderson).	14
4. Mayfield survival probability curves for canvasback ducklings on the treatment and control areas for 1988 and the expanded study area for 1989 in Minnedosa, Manitoba.	16
5. Average number of duckling deaths per canvasback brood during each week of the 63-day brood rearing period in Minnedosa, Manitoba for 1988.	23
6. Average number of duckling deaths in canvasback broods that traveled overland and that did not travel overland during each week of the 63-day brood rearing period in Minnedosa, Manitoba for 1988.	24
7. Average number of overland moves made each week during the 63-day brood rearing period by canvasback broods in Minnedosa, Manitoba for 1988. Percentages account for broods making at least one move.	25

<u>Figure</u>		<u>Page</u>
8.	Average distance traveled overland each week during the 63-day brood rearing period by canvasback broods in Minnedosa, Manitoba for 1988.	26

INTRODUCTION

The prairie parkland breeding habitat of canvasbacks (Aythya valisineria) has been modified by agriculture and other forms of land use. For instance, in different parts of Manitoba, as much as 70% of the wetlands have been drained (Rakowski and Chabot 1983). This disruption of habitat has resulted in a decline of the populations of breeding canvasbacks since the 1950's. Hunting seasons have been closed periodically since the early 1960's. Studies designed to measure the size of canvasback breeding populations and to determine canvasback breeding habitat requirements (Olson 1964; Smith 1971; Stoudt 1971,1982; Kiel et al. 1972), indicate that the current trends of prime habitat loss and population decline will become more exacerbated in the future.

Anderson and Emery (1987) stated that future canvasback production will come from unmanaged areas of low productivity, and small intensively-managed areas where productivity is high. Although intensively-managed breeding areas might be valuable for increasing continental populations of canvasbacks, little information exists on the carrying capacities of wetland complexes and factors

limiting reproduction. Under higher breeding densities, food supply, behavior of breeding pairs, and duckling survival may be limiting; they must be evaluated so managers can understand the limits of production (Anderson and Emery 1987).

Duckling survival from hatch to fledging is probably the least understood component of recruitment (Cowardin et al. 1985). Traditionally, estimates of brood survival were based on counts of ducklings as a function of age, and loss of entire broods could not be included in these estimates. Ball et al. (1975), Talent et al. (1983) and Cowardin et al. (1985) followed radio-marked dabbling duck females with ducklings and found duckling survival from hatching to flight averaged around 40%. The variability in survival for mallard (Anas platyrhynchos) ducklings appear to be due to differences in areas and/or years (Cowardin and Johnson 1979).

About 60% of all canvasback nests in the prairie parkland (Stoudt 1982) are parasitized by redheads (Aythya americana). This significantly reduces clutch size and possibly the reproductive potential of canvasbacks. However, Smith (1968) suggests that under certain conditions it is actually advantageous for the host species to accept parasitic young. Nudds (1980) hypothesized that survival of canvasback ducklings in mixed broods may increase because the probability of a canvasback duckling being selected from

a brood by a predator may decrease.

Hochbaum (1944) stated that canvasback broods hatch on small temporary ponds and move overland to larger more permanent ponds soon after they leave the nest. Berg (1956) and Alison (1976) support this--broods are capable of frequent and extensive overland moves. As broods age, they move to larger and more permanent ponds. Natural chains of wetlands or drainage zones connected with thick cover may encourage brood movement. Hochbaum (1944) observed canvasbacks broods taking "paths of least resistance" such as roads and cattle trails for several miles instead of shorter direct routes through cover. Mallard broods moving overland between wetlands travelled in relatively straight lines oriented to the local topography (Talent et al. 1982). Information regarding brood movement patterns could have important implications on brood habitat management.

Stoudt (1982) stated that in a dry year when wetlands are shallow and less numerous, low water levels and/or inadequate food supplies may affect brood movements. Broods may congregate on permanent ponds and compete for the same food source. Constant brood mixing on crowded ponds can lead to orphaned young (Dzubin 1969). Increased competition and social aggression might cause broods to disperse overland to less favorable habitat, contributing to a higher-than-normal juvenile mortality rate. High densities might also cause an increase in parental stress and affect

young survival.

In 1983, M. G. Anderson, Delta Waterfowl and Wetlands Research Station, initiated a study to determine if canvasback philopatry, dispersal and breeding behavior are density-dependent. Since canvasback breeding density seldom exceeds 10 breeding pairs per square mile, factors controlling this limit were studied. He increased the density of canvasback breeding pairs by increasing nest success. Temporary fences were built to reduce nest depredation, and canvasback eggs were replaced in clutches with high numbers of parasitic redhead eggs to increase production. As a result, the density of canvasback breeding pairs on the experimental area was double that on the control area by 1988. A doubling in duckling production also occurred. In 1989 a severe drought lowered breeding pair density on the study site (Fig. 1).

This study developed as a part of M. G. Anderson's work to evaluate the impact of increased brood densities on brood behavior and duckling survival.

The objectives were:

- 1) to estimate canvasback brood and duckling survival rates,
- 2) to describe canvasback brood overland movement patterns, and
- 3) to evaluate how density of canvasback broods affects survival and movement patterns.

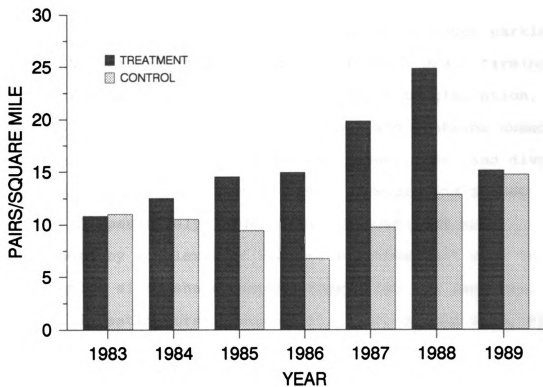


Fig. 1. Canvasback breeding pair density on the treatment and control areas in Minnedosa, Manitoba for 1983-1989 (Data from M.G. Anderson).

STUDY AREA

Field work was conducted in the Minnedosa prairie pothole region primarily on a 3500-ha area centered 9.6 km southeast of Minnedosa, Manitoba, Canada (50° 10'N, 99° 47'W) (Fig. 2). The area supported a native aspen parkland community prior to the development of small grain farming that now dominates (Rounds 1982). Shaped by glaciation, the landscape varies from flat to rolling, and contains numerous depressions with ponds (Trauger and Stoudt 1978) and diverse wetland complexes (Kiel et al. 1972, Trauger and Stoudt 1978). Comparatively large, permanent wetlands are surrounded by complexes of smaller wetlands that vary in permanency, size, shape, depth, vegetation and land use. Several investigators (Evans et al. 1952, Dzubin 1955, Kiel et al. 1972) have described the area and its use by waterfowl. The area is one of the most important waterfowl breeding areas in North America (Bartonek and Hickey 1969).

The Newdale till plain is the principal glacial landform in the Minnedosa area. It is characterized by an extensive ground moraine. Soils are black loam to clay loam, developed on medium-textured, moderately calcareous boulder till of mixed limestone, shale and granite rock origin (Ehrlich et al. 1957). Soils are imperfectly to

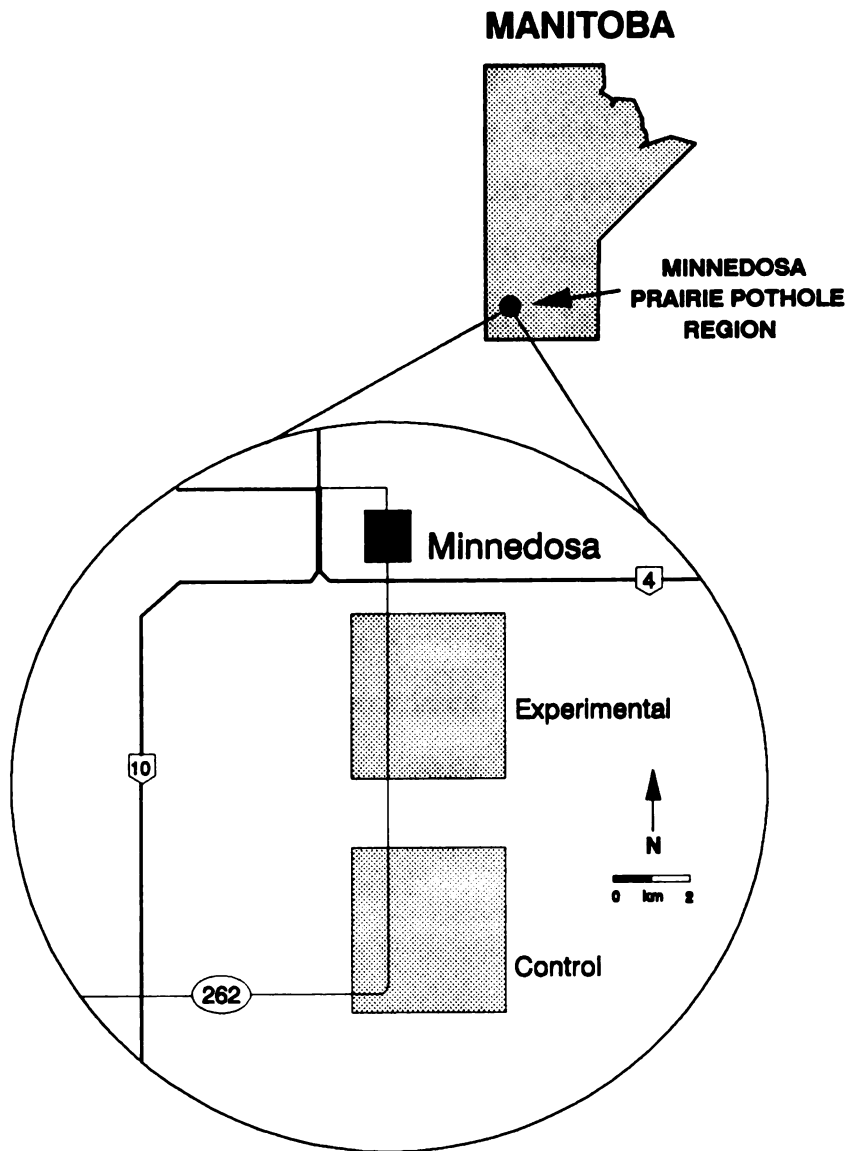


Fig. 2. Location of the Minnedosa Prairie pothole region in southwestern Manitoba, Canada, and location of the experimental and control areas southeast of Minnedosa.

poorly drained. The better drained Newdale soils are naturally fertile and well suited to production of grain and forage crops. These soils have good water retention capacity, are neutral to slightly alkaline in pH, and have high organic matter content (Stoudt 1982).

The midcontinental climate is characterized by extremes, with temperatures ranging from about -51° to 36°C . Strong winds are the rule, prevailing from the northwest. The long-term average precipitation for the Minnedosa area is 47.6 cm/year (Stoudt 1982).

Two study blocks were established in cooperation with local landowners, allowing investigators access to land with no changes in land use practices. The study blocks, an experimental and a control, were 2.4 kilometers apart with an area of 1560 hectares each (Fig. 2).

METHODS

Canvasback broods were monitored in 1988-89 for brood movement patterns and brood and duckling survival rates. Data collected by M. G. Anderson in 1983-1987 supplemented survival estimates.

All ponds on the study area were intensively searched twice during the nesting period for canvasback nests. A severe drought in 1989 necessitated a search of an additional surrounding 3120 hectares to increase sample sizes.

Female canvasbacks were captured on their nests (Weller 1957) and marked with colored nasal saddles with alpha and numeric symbols (Doty and Greenwood 1974, Greenwood 1977). Nests were revisited soon after hatch to determine the number of ducklings hatched. Each study area was searched every other week for broods. Females with ducklings were identified, location and time were recorded, and ducklings were counted 2-3 times per week on average until fledge. Hens began to abandoned their young, and brood mixing and separation began to occur soon after 6 weeks of age, making counts difficult.

A reduction in brood size between visits was assumed to represent mortality. Total brood loss was assumed when a brood was not seen after repeated searches and the brood hen was seen with other post- or non-breeding canvasback females.

Survival

Estimates of duckling survival were based on the Mayfield method (Mayfield 1975, Miller and Johnson 1978) using the computer program MICROMORT (Heisey and Fuller 1985). Daily survival rate (s_i) for any interval (i) was calculated as:

$$s_i = \frac{(x_i - y_i)}{x_i} ,$$

where x_i is the number of duckling-days of exposure and y_i is the number of mortalities observed during the interval. If a duckling disappeared from a brood, its age at disappearance was estimated as 40% of the interval between observations (Miller and Johnson 1978).

Use of the Mayfield (1975) method required the following assumptions: 1) reduction of brood size was indicative of mortality, 2) daily mortality was constant for the period under consideration, and 3) mortalities among brood members and between broods were independent events. Adoption was not observed among canvasback broods, and isolated ducklings were rarely recorded. These supported

the first assumption.

Mortality of young is greatest immediately after hatching, and then it decreases. This violates the Mayfield (1975) assumption of constant daily mortality. Therefore, since canvasbacks have approximately a 63-day rearing period (Dzubin 1959), MICROMORT was used to examine weekly survival patterns by comparing different models (pooling weekly rates) with likelihood-ratio tests (Heisey and Fuller 1985). The likelihood-ratio tests were also used to test for differences between the experimental and control 63-day survival probabilities. Differences in interval survival estimates of duckling survival were tested using z-statistics (Bart and Robson 1982). Survival of canvasback ducklings in broods that contained all canvasback ducklings was compared to canvasback duckling survival of broods with 1 or more redhead ducklings to evaluate if redhead ducklings, assumed to be present due to nest parasitism, had any effect on canvasback duckling survival.

The exponential growth model, $N_t = N_0 e^{rt}$ was used to determine duckling survival based on brood counts. In this model, r is a measure of duckling mortality (negative growth rate), and thus represents the daily mortality rate when t is in units of days. Therefore, $1+r$ represents the daily survival rate. Average brood sizes were determined at hatch and at the midpoints of age class I (14 days), age class II (37 days), and age class III (59 days).

Movement

Habitat components were quantified from aerial photographs using a Summa-graphics 12in X 12in digi-pad digitizer. The computer program AUTOCAD was used to determine overland movement distances. Calculations were made by measuring the shortest distance between the central points of the 2 ponds where females and their ducklings were observed.

Average overland distances traveled by females and their ducklings were determined for an early (0-14 days old) and late (15-63 days old) time period for the treatment and control areas. The null hypothesis that canvasback brood density has no effect on brood movement patterns was evaluated using a t-statistic (Steel and Torrie 1980).

RESULTS

Total numbers of canvasback ducklings were recorded for the treatment and control areas for all years of the Delta Canvasback Study, 1983-1989 (Fig. 3). Ducklings, hatched on the treatment area, increased from 101 in 1983 to 390 in 1987, but then decreased in 1988-1989 due to drought. Although the number of ducklings on the control area hatched after 1984 increased, the numbers remained well below those hatched on the treatment area.

In 1988, 48 canvasback nests hatched on the treatment area and 35 marked females with ducklings were observed. The control area had 32 successful nests and 28 marked females with ducklings. No canvasback ducklings hatched on either area during 1989, but 9 females with ducklings were observed in the surrounding Minnedosa area.

Survival

Analysis of weekly survival rates (Likelihood-ratio tests) revealed that survival data are best represented by early and late period survival rates. Based on these criteria, the early survival period had interval lengths of 7 days for 1988-1989 and 14 or 21 days for 1983-1987. The

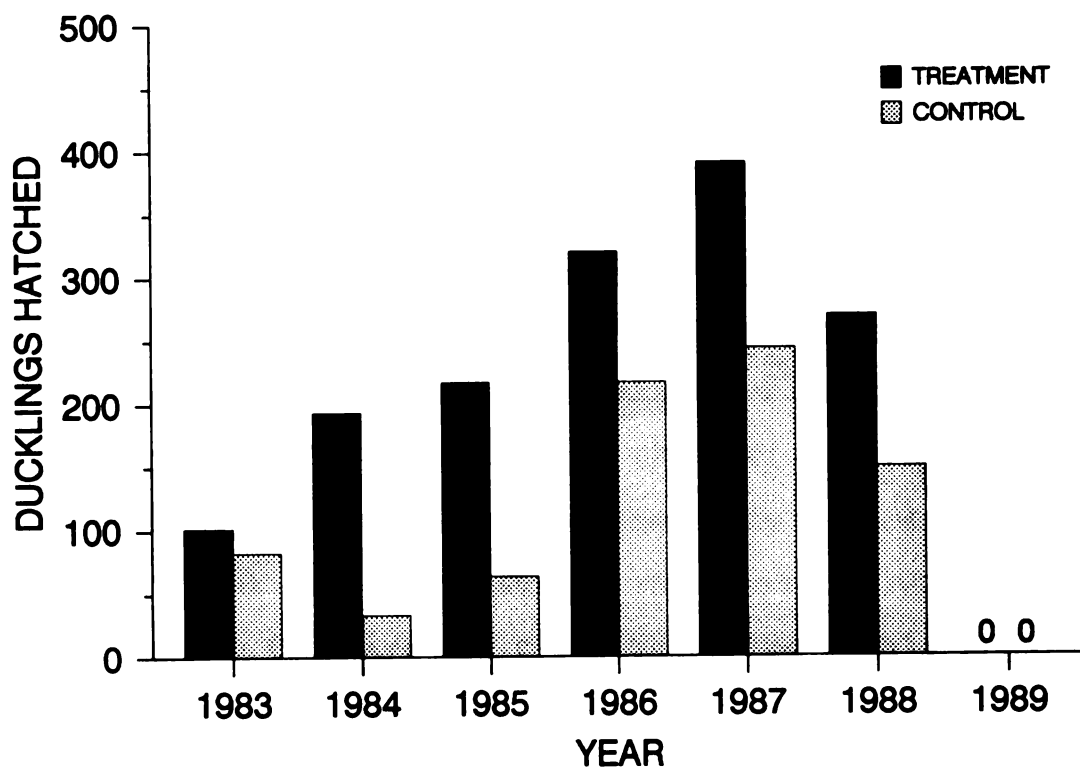


Fig. 3. Number of canvasback ducklings hatched on the treatment and control areas in Minnedosa, Manitoba for 1983-1989 (Data from M.G. Anderson).

frequency of brood locations during 1983-1987 (every 2-3 weeks/brood) was lower than in 1988-1989 (2-3 observations /week/brood) which accounts for the longer interval in the early years of the study.

No difference occurred for the probability of a duckling surviving the entire 63-day rearing period on the treatment and control areas from 1983-1986 (Appendix). In 1987 the treatment area had a significantly higher (Likelihood Ratio Test, $P < 0.05$) 63-day survival probability (0.62) than the control area (0.50). The 63-day survival probabilities for 1988 treatment and control were also significantly different (Likelihood Ratio test, $P < 0.05$). Equations derived from the Mayfield estimates of 1988 and 1989 were used to produce survival probability curves for the early and late brood periods (Fig. 4). Daily survival rate estimates of ducklings for the early period in 1988 were different between treatment and control ($z = 2.62$, $P = 0.0044$) but the same for the late period (Table 1). Survival rates in 1989 were lower.

Canvasback ducklings in broods with redhead ducklings for 1988 had 63-day survival probabilities that were lower for treatment (0.36, 95% CI=0.20-0.65) and control (0.37, 95% CI=0.24-0.55) areas than canvasback ducklings in broods without redhead ducklings on the treatment, (0.57, 95% CI=0.50-0.65) and control (0.56, 95% CI=0.45-0.69) areas. The difference in survival occurred because of a difference

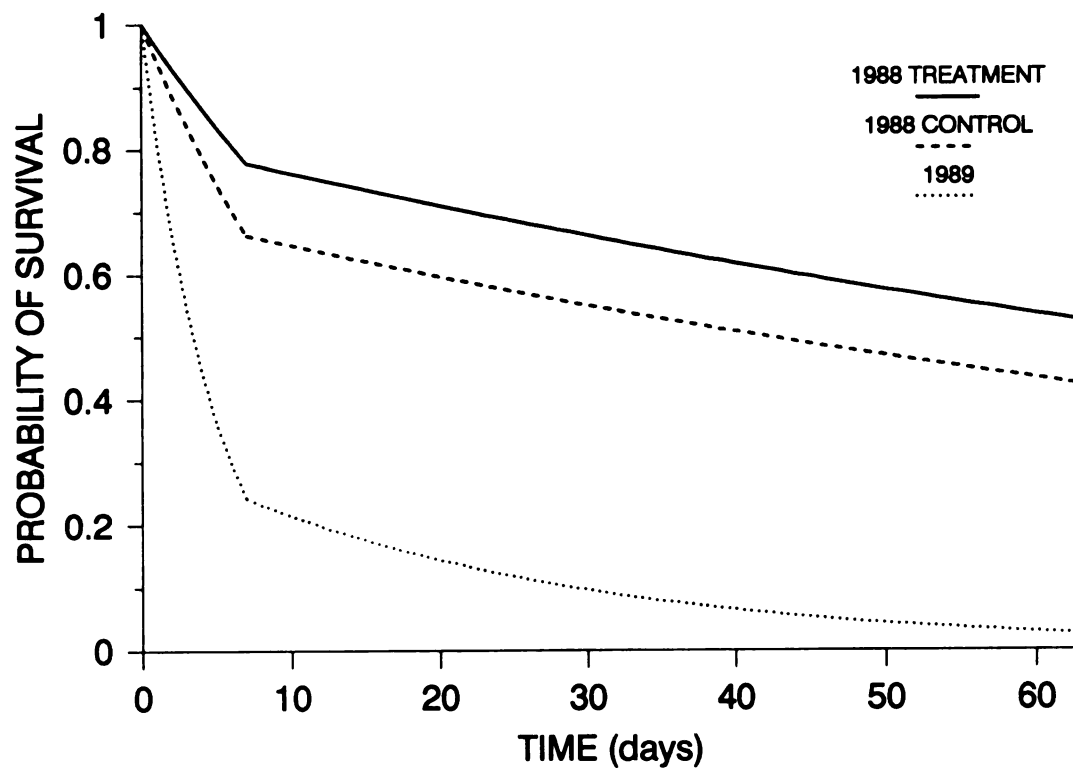


Fig. 4. Mayfield survival probability curves for canvasback ducklings on the treatment and control areas for 1988 and the expanded study area for 1989 in Minnedosa, Manitoba.

Table 1. Early (hatch to 1 week) and late (2-9 weeks) survival of canvasback ducklings on the treatment and control areas at Minnedosa, Manitoba from 1988-1989.

Year	Block	Early			Late		
		Duckling days	Daily survival		Duckling Days	Daily survival	
			($\hat{S}$)	SE		($\hat{S}$)	SE
1988	Treatment	1380	0.964*	0.005	6594	0.993	0.001
	Control	961	0.941*	0.008	4063	0.992	0.001
1989 ^a		138	0.797	0.034	202	0.960	0.014

* Significantly different rates ($z=2.61$, $P=0.0044$) within year.

^a Drought prevailed and study area was expanded to include the surrounding Minnedosa area.

in daily survival rates of canvasback ducklings in mixed and unmixed broods in the early period (Table 2).

Nests in 1988 hatched between May 31 to June 30. Only 16 nests out of 63 that hatched occurred after June 15. Survival of ducklings from late nests was significantly higher (Likelihood Ratio Test, $\chi^2=12$, 2 df, $P=0.005$) with a 63-day survival probability of 0.55 (95% CI=0.45-0.67), compared to the survival probability of ducklings hatched during the early period, 0.47 (95% CI=0.41-0.54).

Six canvasback females lost their entire broods within the first 10 days in 1988 while 54 (86%) of the 63 adult females fledged ≥ 1 duckling. The final fate of 3 broods was undetermined. Brood survival was much lower during the 1989 drought. Six entire broods were lost (67%) by 16 days post-hatch while the final fate of 2 other broods, presumably lost to predation, were undetermined. One duckling fledged in 1989.

Mean brood sizes decreased over time with the greatest decrease during hatch to Class I (Table 3). In 1988, canvasback brood size at time of fledging averaged around 4 ducklings. Total brood losses were not included for duckling survival estimates determined by average brood sizes. This method overestimated the probability of a duckling surviving the 63-day rearing period by 5-15% (Table 4).

Table 2. Early (hatch to 1 week) and late (2-9 weeks) survival of canvasback ducklings in mixed (containing ≥ 1 parasitized redhead ducklings) and unmixed (with only canvasback ducklings) broods on the treatment and control areas at Minnedosa, Manitoba in 1988.

Block	Broods	Early			Late		
		Duckling days	Daily survival		Duckling Days	Daily survival	
			$\hat{S}$	SE		$\hat{S}$	SE
Treatment	Mixed	123	0.902 ^a	0.027	362	0.995	0.004
	Unmixed	1203	0.971 ^a	0.005	5953	0.994	0.001
Control	Mixed	257	0.934 ^b	0.016	969	0.991	0.003
	Unmixed	536	0.959 ^b	0.009	2124	0.995	0.002

^a (z=2.49, P=0.006) within treatment

^b (z=1.42, P=0.068) within control

Table 3. Daily survival rates and average brood sizes ($\pm$ SD) for age classes of canvasback ducklings on the treatment and control areas at Minnedosa, Manitoba for 1988-1989.

Year	Block	Hatch	Class I	Class II	Class III
1988	Treatment (brood size)	6.5 $\pm$ 2.6	0.983 5.1 $\pm$ 2.6	0.995 4.5 $\pm$ 2.5	0.999 4.4 $\pm$ 2.5
1988	Control (brood size)	7.5 $\pm$ 2.6	0.962 4.4 $\pm$ 2.7	0.993 3.8 $\pm$ 2.2	0.998 3.6 $\pm$ 1.9
1989 ^a	(brood size)	5.8 $\pm$ 2.3	0.914 1.8 $\pm$ 0.5	0.993 1.5 $\pm$ 0.5	0.982 1.0

^a Drought prevailed and study area was expanded to include the surrounding Minnedosa area.

- Rates do not account for total brood losses.

Table 4. Survival probabilities of canvasback ducklings for the entire 63-day brood period for the treatment and control area in Minnedosa, Manitoba for 1988-1989. Survival probabilities were derived from data on individual ducklings (Mayfield) and average brood size of observed broods (Apparent).

Year	Block	Mayfield		Apparent
		S	95% CI	S
1988	Treatment	0.538*	0.472 - 0.613	0.676
1988	Control	0.425*	0.352 - 0.512	0.478
1989 ^a		0.021	0.004 - 0.113	0.172

* Significantly different rates (Likelihood Ratio Test, 9df, $P < 0.05$) within year.

^a Drought prevailed and study area was expanded to include the surrounding Minnedosa area.

The greatest mortality of ducklings occurred during the first week of life (Fig. 5). Travel increased the chance of death. Broods that remained sedentary during the first week lost 0.87 ducklings per brood. The death rate doubled to 1.76 ducklings loss per brood for females with ducklings that moved at least once during the first week (Fig. 6). The death rate of ducklings in broods that moved during weeks 5-6 was higher than those that did not move.

Movement

The movement pattern of females with ducklings varied over the 9-week observation period (Fig. 7). Sixty-eight percent of all females with ducklings made at least one pond change within 7 days after hatching and 92 percent within 14 days after hatching. Forty percent of all females with ducklings made at least 2 or more pond changes before 2 weeks old. After a decline in the frequency of moving in the third and fourth week of life, an increase in frequency occurred during the fifth and sixth week.

Average distance traveled by canvasback females with ducklings was greatest within 14 days of hatching (Fig. 8). After a decline in mean distance of movement in the third and fourth week, an increase during weeks 5 and 6 occurred.

Total linear overland distances, 1.5 km and 1.6 km for treatment and control respectively, traveled by broods were not significantly different (Table 5). Although there were

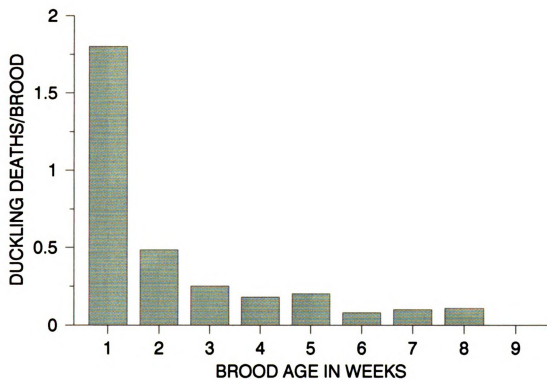


Fig. 5. Average number of duckling deaths per canvasback brood during each week of the 63-day brood rearing period in Minnedosa, Manitoba for 1988.

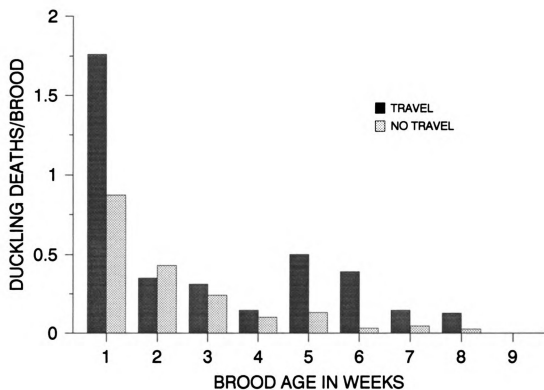


Fig. 6. Average number of duckling deaths in canvasback broods that traveled overland and that did not travel overland during each week of the 63-day brood rearing period in Minnedosa, Manitoba for 1988.

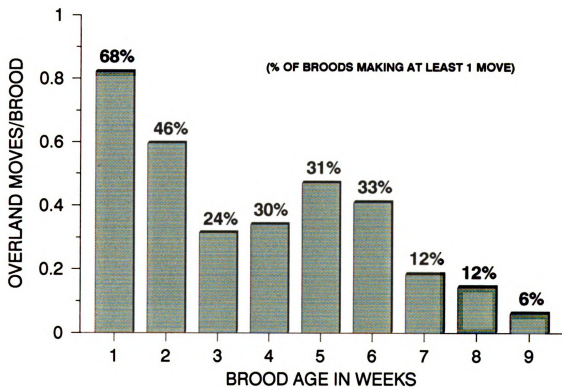


Fig. 7. Average number of overland moves made each week during the 63-day brood rearing period by canvasback broods in Minnedosa, Manitoba for 1988. Percentages account for broods making at least one move.

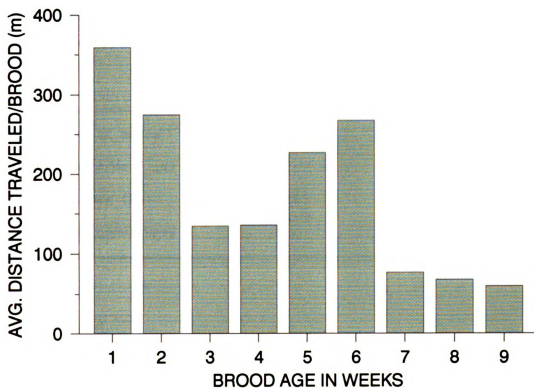


Fig. 8. Average distance traveled overland each week during the 63-day brood rearing period by canvasback broods in Minnedosa, Manitoba for 1988.

Table 5. Number of overland moves and distance traveled by canvasback broods during early (hatch to 2 weeks) and late (weeks 3-9) time periods on the treatment and control areas at Minnedosa, Manitoba for 1988.

	Treatment		Control	
	week 0-2	week 3-9	week 0-2	week 3-9
Avg. number of moves	1.6	1.7	1.4	1.7
Avg. distance/move (m)	417	479	483	553
Total distance (km)	1.5		1.6	
Avg. number ponds used	4.3		4.0	

no significant differences (t-test) in frequency and distance of moves between broods with young and older ducklings, broods with older ducklings tended to move further. Hens did not necessarily travel to the nearest or the largest wetlands for rearing, but often selected those within natural chains of wetlands connected by drainage zones. Females with ducklings used between 1-14 ponds, averaging 4 ponds, throughout the rearing period. Twenty-nine percent of all broods used ≤ 2 wetlands over the 9-week observation period.

Canvasback broods exhibited the highest levels of mobility during age Class I (hatch-22 days), moving to suitable rearing wetlands. During this period, broods have many opportunities to share rearing wetlands with other canvasback broods. Some 1988 canvasback broods within treatment and control areas remained "isolated", i.e., on wetlands without other canvasback broods. However, the majority of canvasback broods were observed at some point during the brood period on wetlands in "association" with other canvasback broods.

Weekly survival rates for age Class I ducklings were determined for the "isolated" and "associated" canvasbacks broods on the treatment and control area for 1988. Week 1 survival rates showed that broods associated with other canvasbacks broods during that week had higher survival rates (Table 6). "Isolated" 1988 control broods had the

Table 6. Duckling daily survival rates (week 1) for canvasback broods that were isolated and associated with other canvasback broods during the first week after hatch on the treatment and control areas at Minnedosa, Manitoba for 1988.

Block	Isolated			Associated		
	Broods (n)	$\hat{S}$	SE	Broods (n)	$\hat{S}$	SE
Treatment	24	0.962	0.006	11	0.969	0.008
Control	13	0.911	0.013	11	0.974	0.008

lowest 7-day duckling survival probability, 52%. "Isolated" broods in the treatment area had a 7-day duckling survival probability of 76%, slightly lower than the broods that were "associated" on the treatment and control areas. Duckling survival rates for weeks 2 and 3 suggested no difference between "associated" and "isolated" broods for the treatment and control areas. All broods (n=9) in 1989 remained isolated from other canvasback broods. These ducklings had only a 24% probability of surviving the first 7 days (Appendix).

Ducklings in isolated broods traveled on the average much less during the first 7 days than ducklings in broods that associated with other canvasback broods. During the first 7 days ducklings in "isolated" broods on treatment and control areas traveled an average distance of 282m and 230m, respectfully. Ducklings in "associated" broods traveled an average distance of 429m (treatment) and 384m (control) over land.

DISCUSSION

Most estimates of duckling survival for diving ducks have been based solely on Class II and Class III broods with no mention of an estimate for broods where all ducklings are lost (Stoudt 1971, Sugden 1978). Failure to account for losses of complete broods inflates production (Ball et al. 1975, Reed 1975, Ringelman and Longcore 1982b, Talent et al. 1983, Duncan 1986). Loss of all the ducklings in a brood varies for different species and different habitats. Ball et al. (1975) estimated survival of wood duck (Aix sponsa) and mallard broods in forest habitat in north-central Minnesota at 70-80%. However, the majority of their sample was derived from hens and ducklings captured within 2 days after hatch; consequently, their results could overestimate the actual survival rates. Mallard brood survival was estimated at 48% in the prairie pothole region of North Dakota (Talent et al. 1983) and 63% in north-central Montana (Orthmeyer and Ball 1990). Dzubin and Gollop (1972) examined mallard brood survival in the grassland and aspen parkland of Saskatchewan. Similarly, Duncan (1986) studied brood survival in grazed mixed grass prairie of Alberta. Both studies estimated that survival rate of dabbling broods in grasslands was less than 30%. Dzubin and Gollop (1972)

found brood survival in grassland to be substantially lower than in parkland.

Ring-necked duck (Aythya collaris) broods in Maine survived at a rate of 81% (McAuley and Longcore 1988) which equalled estimates for black duck (Anas rubripes) broods in Maine (Ringelman and Longcore 1982b). Survival of canvasback broods in this study is one of the highest estimates of brood survival (86%) reported. However, canvasback brood survival during a severe drought fell below 15%, which suggests that differing conditions of habitats dramatically affects success. Habitat (in terms of food and cover for broods) and predation would appear to be the most likely causes of any difference in brood survival (Duncan 1986).

Among studies of duckling survival where losses of complete broods were considered, estimates of duckling survival probability varied within species: 0.35 (Talent et al. 1983) to 0.44 (Ball et al. 1975) for mallards; 0.34 (Reed 1975) to 0.42 (Ringelman and Longcore 198b) for black ducks; and 0.41 (Ball et al. 1975) to 0.47 (McGilvrey 1969) for wood ducks. A 13-year study of eider (Somateria mollissima) ducklings in Scotland revealed an average estimate of duckling survival of 0.11, with a range of 0.01 to 0.55 fledging success (Mendenhall and Milne 1985). McAuley and Longcore (1988) showed yearly variations in ring-necked duckling survival ranging from 0.33 to 0.47. Canvasback survival rates in this study showed a similar

variation range: 0.42 to 0.62. However, during the severe drought of 1989 duckling survival dropped to 0.021. These studies document the need for determining duckling survival in different habitats and the role of yearly variations in habitat conditions (e.g., water levels, number of wetlands not dry during brood rearing, etc.) on duckling survival.

Mortality rates for young ducklings are higher than those for older ducklings in black ducks (Reed 1975, Ringelman and Longcore 1982**b**), wood ducks (McGilvrey 1969, Ball et al. 1975, Cottrell et al. 1988), mallards (Dzubin and Gollop 1972, Ball et al. 1975, Talent et al. 1983, Orthmeyer and Ball 1990), ring-necked ducks (McAuley and Longcore 1988) and even Canada geese (Branta canadensis moffitti) (Eberhardt et al. 1989). Several studies determined duckling survival over weekly intervals and suggested that the highest mortality occurs during the first 2 weeks. Mendall (1958) believed that juvenile mortality for ring-necked ducks was greatest immediately after hatching. When canvasbacks broods were intensively followed (located 2 to 3 times per week) duckling mortality was significantly higher the first 7 days after hatch. This seems logical when dealing with precocial, nidifugous young. Survival will be quickly enhanced by growth, development and experience.

However, when canvasback broods were not intensively followed (located once every 2 to 3 weeks) in years

1983-1987, duckling survival for week 1 was not different from week 2 and sometimes week 3. This revealed the importance of locating individual broods at least weekly. Weekly rates may then be partitioned accurately into intervals of reasonably stable rates (Bart and Robson 1982, Heisey and Fuller 1985). If daily survival rates for intervals are not different, such as age Class II and age Class III, they should be combined to accurately estimate survival probabilities of ducklings for the entire brood period (Heisey and Fuller 1985).

Higher densities of breeding canvasbacks seemed to attract greater number of redhead breeding pairs. Redhead nest parasitism of canvasbacks includes pre-hatch costs of 1) reducing clutch size because of disruption of normal laying patterns, 2) increase egg losses at the nest, and 3) increase nest desertion (Weller 1959). Post-hatch costs of parasites within a brood compounds pre-hatch disruptions. Canvasback duckling survival within broods with parasitic redhead ducklings have about a 20% reduction in the probability of survival from hatch to fledge.

Redheads tend to nest later than canvasbacks. Sugden (1980) and Stoudt (1982) showed that late nesting canvasbacks received more parasitic intrusions by redheads. Some may argue that canvasback duckling survival is lower in mixed broods because mixed broods hatch later, and late hatched ducklings may have a lower survival probability.

However, lower duckling survival resulted from nest parasitism, not hatch date, because late hatched broods had a significantly higher duckling survival probability. Further, redhead ducklings may have slight behavioral differences that make broods vulnerable to predation. Reasons for the reduction in canvasback duckling survival in mixed broods are unclear and need further evaluation.

Duckling density in an area is related to rearing success. Early duckling mortality might increase with higher brood density through a density-dependent increase in competition for resources and aggressive interactions between brood hens. Makepeace and Patterson (1980) showed a significant increase in shelduck (Tadorna tadorna) duckling mortality with an increase in brood density. Mallards in crowded conditions with supplemental food (Titman and Lowther 1975) showed more aggressive interactions between broods; this was considered a main contributor to the increase in duckling mortality. Crowding, due to the shortage of good brood rearing areas, has been shown to be the major bottleneck to mallard and other surface feeding duck production at Lock Leven (Newton and Campbell 1975).

In this study, canvasback ducklings subjected to higher duckling densities had a higher survival probability than those at a normal density level. Hill et al. (1987) stated that mallard duckling survival to 3 weeks of age was significantly higher for broods on an area with twice the

brood density of their other study area. They suggested that the increase in brood density and duckling survival may have been responses to higher food supplies. This study focused on 2 areas with homogeneous habitat containing numerous wetland complexes of different sizes, shapes and characteristics. The increase in duckling survival on the high density area suggested that there was no competition for food and/or cover resources.

Orians (1971) proposed that in avian species, with young mobile and capable of gathering their own food at an early stage, selection favors avoiding other groups, provided that food is uniformly distributed. He suggested that survival would be enhanced because of the advantages of not attracting predators. Further, capture rates of prey items should be higher on the average if another group has not recently foraged over the same area. In support, (Haland 1983) showed that young ducklings in mallard broods spaced themselves to mutually avoid other ducklings, possibly reducing interbrood competition for invertebrate foods during early stages of life. Ducklings in broods subjected to higher densities would have greater opportunities to associate with ducklings from other broods and less chance of avoiding or remaining isolated from conspecifics. However, ducklings in canvasback broods "associated" with other canvasback broods on the same wetland had higher survival rates.

Higher density levels must provide some benefits which increase early duckling survival . There are basic advantages in having conspecifics nearby. The more eyes and ears spread over a given area, the more likely that a predator will be detected. Females remaining with groups enhance survival of their own young by dilution into a larger group (Munro and Bedard 1977). Broods feeding may give out information about food sources, especially if food is distributed unevenly among different wetlands. Why disperse if the renewal rate of invertebrate prey in highly productive wetlands may be so high that temporal sharing of the pond can occur without reducing each other's feeding efficiency? Aggressive interactions to defend rearing areas require high energy output. This aggressive behavior pattern could have serious effects on the female's energy budget (Haland 1983) since her energy reserves are seriously depleted after the incubation period (Krapu 1981). Also the risk of splitting up the brood increases during these interactions, increasing the risk of predation and loss to exposure.

Female canvasbacks home precisely and use the same home ranges repeatedly. This implies that there should be a high degree of relatedness between females on wetlands. Kinship factors may then have a significant role in the observed spacing patterns and duckling survival rates. Presumably, females can identify their own siblings and may direct

aggression toward others. This would allow relatives to have the advantages of group living yet reduce nonrelative interbrood competition. Also, females with broods may provide younger siblings with broods important information that enhances duckling survival. The role of canvasback mother-daughter relationships and how they affect duckling survival, behavior and spacing patterns during the brood rearing period needs further evaluation. Research should continue with increases in density levels to determine when resources and/or space becomes limiting and duckling survival rates decline.

Prairie wetlands vary in their chemical characteristics, species, composition, structure, distribution, and productivity of plant and invertebrate communities (Swanson and Duebbert 1989). Overland travel to wetlands suitable for rearing presumably confers a survival advantage to ducklings despite the mortality often associated with such movements (Ball et al. 1975, Ringelman and Longcore 1982a). Some canvasback broods made extensive overland movements in search of rearing wetlands while others were sedentary. Although long overland movements may increase the probability of encounter with predators and other hazards, remaining on wetlands with poor foraging conditions reduces growth rates and prolongs the flightless period (Talent et al. 1982). Thus, both situations are undesirable in comparison to favorable habitat conditions

with little or no competition for the resources. Observations of canvasback broods subjected to a higher density did not suggest that competition for brood rearing habitat forced these broods to travel and disperse to surrounding habitat.

Mallards showed similar brood mobility patterns as canvasback broods in southwestern Manitoba. Talent et al. (1982) revealed that mobile mallard broods used 2 to 10 different wetlands, occupying an average of 4 different wetlands during the brood-rearing period. Mallard broods are capable of remaining highly mobile until they locate favorable habitat, i.e., good cover and an abundant source of invertebrates (Talent et al. 1982).

Canvasback broods did not always travel to the nearest or largest wetlands. This suggests that canvasback hens are selective in choosing wetlands for broods. Talent et al. (1982) and Cowardin et al. (1985) showed that mallard hens with broods favored seasonal ponds dominated by whitetop (Scolecchioa festucacea). Duncan (1983) described the overland movement pattern of a pintail (Anas acuta) hen with brood as well-oriented and directed toward a specific wetland. Black duck hens were highly specific in their selection of ponds for brood rearing; they moved to larger wetlands containing alder (Alnus incana), willow (Salix spp.) and herbaceous vegetation. This selection pattern reflected the food and cover requirements during brood

rearing (Ringelman and Longcore 1982a).

Previously successful canvasback hens usually moved their broods to their traditional rearing ponds. Hens were also often observed leaving their broods to intensively feed around other canvasback broods on nearby wetlands. These flights seemed to suggest hens were searching the surrounding area for highly productive brood-rearing ponds. Occasionally, hens moved their broods in the same direction, even to the specific pond, where they were observed feeding around other canvasback broods.

Brood mobility varies greatly between species and different habitats. However, broods tend to travel more during the early part of the brood-rearing period. Hepp and Hair (1977) showed that 67% of all wood duck broods were highly mobile during the first 24 to 48 hours after leaving the nest. All black duck broods monitored initiated overland movements before 3 days of age (Ringelman and Longcore 1982a). Talent et al. (1982) and Cowardin et al. (1985) found that mallard broods were mobile during week 1 of the brood period. Seventy-two percent of all overland moves occurred before broods were 1 week old (Talent et al. 1982). The majority of canvasback broods in this study traveled away from their nesting ponds during the first week. This suggests that hens are selecting a nest site primarily for characteristics increasing nest success. After hatch hens will take their broods to higher quality

rearing ponds.

Duckling mortality occurs whether or not they move. However, movement during this early period increases the potential of duckling mortality. Broods that traveled overland during the first week after hatch lost almost 1 duckling more per brood. Exhaustion, exposure, or scattering are logical explanations for the extra losses. However, it is difficult to determine whether mortality occurs before the brood leaves, after the brood reaches water, or during the overland move. Ball et al. (1975) reported a negative correlation between number of surviving ducklings and cumulative distance of overland travel, suggesting that some attrition within broods occurs during travel among wetlands. However, Talent et al. (1983) reported that overland movement did not significantly contribute to duckling mortality. Most of their mortality occurred within 24 hours after a mallard brood moved onto a new wetland. Several canvasback broods during this study moved to new rearing ponds soon after their broods were recorded with fewer ducklings. Also a few broods lost ducklings shortly after arriving on new rearing ponds.

Overland movements does not appear to be an extremely hazardous undertaking on the prairies because numerous upland nesting females select nest sites far from water (Duncan 1986). Also, many canvasback broods travel great distances between rearing ponds. Thus, the majority of

mortality would seem to take place on wetlands, on or near shore while resting. Arnold and Fritzell (1987) and Talent et al. (1982) recently provided evidence that mink predation may cause substantial duckling mortality in prairie potholes, especially on ponds where mink are denning. Duckling predation and/or disturbance by a predator may influence when a hen moves her brood to a new rearing wetland.

Stewart (1958), Prince (1965), and Ball (1971) observed a 2-stage movement pattern among wood duck broods which consisted of a primary move (from nest site to the first wetland used) and a secondary move (between wetlands). However, Hepp and Hair (1977) and Cottrell et al. (1988) did not observe this pattern. Black duck broods seldom undertook secondary movements (Ringelman and Longcore 1982a). Talent et al. (1982) recorded a mallard brood movement pattern similar to that of canvasbacks in this study.

Canvasback brood movement patterns may reflect hen selection for different wetlands as ducklings' dietary needs shift. Canvasback broods made a majority of their moves within the first 2 weeks and in weeks 5 and 6. Bartonek and Hickey (1969) reported that canvasback ducklings consumed 99% animal material at hatch to 5 weeks; but at 5 to 9 weeks of age animal material dropped to 86%. Cottam (1939) found similar results when 8 juvenile canvasbacks were examined.

Three older ducklings had fed almost entirely upon Potamogeton and Scirpus, while animal material comprised 56% of the food in the 5 younger ducklings. As juvenile canvasbacks grow older they rely less and less upon animal food. Movement patterns reflected this shift.

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APPENDIX

Appendix. Early (hatch to 1-3 weeks) and late (2-4 weeks to 9 weeks) survival of canvasback ducklings on the treatment and control areas at Minnedosa, Manitoba from 1983 - 1989.

Year	Block	Early				Late				63-day survival probability	SE	95% Confidence limits
		Days in interval ^a		Daily survival		Days in interval ^a		Daily survival				
		Days in interval ^a	Duckling days	$\hat{S}$	SE	Days in interval ^a	Duckling days	$\hat{S}$	SE			
1983	Treatment	14	1083	0.958	0.006	49	1253	0.994	0.002	0.420	0.057	0.321 - 0.548
	Control	14	1102	0.967	0.005	49	1192	0.994	0.002	0.471	0.063	0.362 - 0.612
1984	Treatment	14	2028	0.974	0.004	49	2430	0.995	0.001	0.535	0.047	0.449 - 0.636
	Control	14	153	0.954	0.017	49	291	0.996	0.003	0.438	0.131	0.243 - 0.789
1985	Treatment	21	3404	0.979	0.002	42	2588	0.996	0.001	0.530	0.042	0.457 - 0.615
	Control	21	1155	0.981	0.004	42	1307	0.998	0.001	0.606	0.062	0.496 - 0.741
1986	Treatment	21	4987	0.975	0.002	42	4090	0.998	0.001	0.532	0.031	0.475 - 0.595
	Control	21	3320	0.977	0.003	42	2877	0.998	0.001	0.548	0.038	0.479 - 0.627
1987	Treatment	14	4937	0.977	0.002	49	9394	0.997	0.001	0.623 [*]	0.026	0.575 - 0.675
	Control	21	5364	0.984	0.002	42	4125	0.992	0.001	0.503 [*]	0.035	0.439 - 0.577
1988	Treatment	7	1380	0.964	0.005	56	6594	0.993	0.001	0.538 [*]	0.036	0.472 - 0.613
	Control	7	961	0.941	0.008	56	4063	0.992	0.001	0.425 [*]	0.041	0.352 - 0.512
1989 ^b		7	138	0.797	0.034	56	202	0.960	0.014	0.021	0.018	0.004 - 0.113

^{*} Significantly different rates (Likelihood Ratio Test, 9 df, $P < 0.05$) within year.

^a Interval length was determined by pooling weekly rates (Likelihood Ratio test).

^b Drought prevailed and study area was expanded to include the surrounding Minnedosa area.

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