

OVERLAND TRAVEL, FOOD ABUNDANCE, AND WETLAND USE BY MALLARDS: RELATIONSHIPS WITH OFFSPRING SURVIVAL

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ABSTRACT.—We monitored wetland habitat use and inter-wetland moves of 52 Mallard (*Anas platyrhynchos*) broods near Yorkton, Saskatchewan. Brood-attending females were equipped with radio transmitters and their locations monitored daily. Duckling survival in the first two weeks after hatching was not related to distance traveled to the first wetland nor the total distance traveled overland in the 14-day period. Brood-rearing females were found on one to five wetlands in the first week after hatch (mode = 2), and most (17 of 32) remained on one wetland in the second week (range = 1–5). Broods were found most frequently (69–95% of days) on semi-permanent wetlands. Conductivity on most (>95%) of these wetlands was <2000 microsiemens/cm; such levels are well below those known to affect duckling growth or survival. For 12 broods for which we had data on food (chironomid) abundance, we were unable to detect a relationship between inter-wetland movements and brood use. Nor was there evidence that duckling survival was related to levels of chironomid abundance. Received 3 Sept. 1996, accepted 20 Feb. 1997.

Mallard broods typically use several wetlands during the brood-rearing period, but causes and consequences of these moves remain unresolved. Early studies of wetland use by Mallards (*Anas platyrhynchos*) relied on observational brood surveys (e.g., Berg 1956, Mack and Flake 1980, Monda and Ratti 1988, Mulhern et al. 1985). However, the secretive nature of brood-rearing females makes conclusions based on data collected from radio-marked birds more complete. The brood-rearing period for most dabbling ducks remains the least understood component of their annual cycle, despite the fact that natural mortality from hatching to fledging is higher than in later life stages (e.g., Johnson et al. 1992, Rotella and Ratti 1992a). Hence, evaluating factors that influence overland movements and wetland habitat use during the brood-rearing period, and their effects on survival, is crucial for a thorough understanding of waterfowl population dynamics.

Studies examining the impact of overland movements have yielded conflicting results. Two studies suggested that long overland moves reduced survival of Mallard ducklings (Ball et al. 1975, Rotella and Ratti 1992b), whereas Talent et al. (1983) did not find support for this hypoth-

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esis. Thus, further information is needed to evaluate whether offspring survival is related to overland movements.

Wetland use could be influenced by a variety of factors, including wetland conditions (vegetation characteristics and permanency of above-ground water) or water chemistry. Salinity of wetlands may affect habitat use, as it is known to negatively affect duckling growth and survival (Mitcham and Wobeser 1988, Swanson et al. 1984). Effects of wetland characteristics may act directly on duckling survival or indirectly through effects on predation risk and food availability.

Food abundance may also play a role in wetland selection by brood-rearing females. Dipterans, primarily of the family Chironomidae, are the most commonly reported animal food of young Mallard ducklings (Chura 1961, Sugden 1973, Krapu and Swanson 1977, Street 1977). Emergence patterns of chironomids typically show early summer peaks (e.g., Rasmussen 1984, Wrubleski and Rosenberg 1990), and diversity of the invertebrate fauna is related to wetland vegetation characteristics and water permanency (Driver 1977).

Our objectives were to (1) evaluate overland brood movements of Mallards and relate these moves to survival of ducklings and (2) examine wetland use by Mallard broods in terms of wetland type, water chemistry and food availability.

STUDY AREA AND METHODS

We conducted the study 40 km west of Yorkton (51°12'N, 103°7'W) in east-central Saskatchewan, Canada, from 1990 to 1993. The area consisted of five managed waterfowl nesting areas (63 ha each) that lie in the aspen parkland zone of the prairie pothole region of North America. The region is characterized by gently undulating topography, interspersed with aspen (*Populus tremuloides*) bluffs and has a moderate wetland density (range in mid-May, 27 to 49/km²). The primary land use in the region consists of cereal and oilseed crop production.

The number of wetland basins holding water was counted during weekly waterfowl surveys from early May until mid July. Wetlands were classified according to Stewart and Kantrud (1971). Class IV (semi-permanent) and class V (permanent) wetlands were grouped together and are referred to as semi-permanent wetlands. Class I (ephemeral), Class II (temporary), and Class III (seasonal) wetlands formed the second wetland category (hereafter referred to as seasonal wetlands). Most Class I and II wetlands were dry by the time broods appeared. Conductivity was measured in July each year using a hand-held conductivity meter. One reading was taken in shallow emergent, deep emergent, and open water zones; the average was taken as the measurement for the wetland.

Mallard nests were found by searching on foot or using cable-chain drags pulled between two all-terrain vehicles (Klett et al. 1986). Because nesting success of ducks in the prairie pothole region is so low (Greenwood et al. 1995), we protected nests with fences. Mallard nests that were not located in one of two 16-ha predator enclosure fences (Trottier et al. 1994) were surrounded by wire mesh fences if they survived to late egg-laying or early incubation stages (Sargeant et al. 1974, Greenwood et al. 1990). Females were captured at

about day 20 of incubation using hand-carried mist nests (Bacon and Evrard 1990) or automatic walk-in nest traps (Weller 1957). All females received leg bands, unique combinations of nylon nasal markers (Lokemoen and Sharp 1985), and radio transmitters. All females in 1990, half of the females in 1991, and one female in 1992 received 22-g harness-style transmitters (28 × 18 × 8 mm, model CHP2H, Telonics Inc., Mesa, Arizona, USA) using a criss-cross modification (Smith and Gilbert 1981) of the traditional Dwyer (1972) harness. The remaining brood-rearing females in 1991 and 1992, and all individuals in 1993, had a 21-g cylindrical transmitter (23 mm diam. × 53 mm, model IMP150, Telonics Inc.) implanted into their abdominal cavity (Olsen et al. 1992). Females were placed back on nests in a mild, methoxyflurane-induced state of anesthesia to reduce nest abandonment (Smith et al. 1980, Rotella and Ratti 1990). The use of different types of transmitters does not bias results presented here because offspring survival was not influenced by transmitter-type carried by the female (Dzus and Clark 1996).

Females were located one to four times daily, using either a truck-mounted or hand-held receiving system (White and Garrott 1990:47–75), and locations were plotted on aerial photomaps. Distances from nest to the first wetland used and inter-wetland distances were measured on photomaps (to the nearest 10 m). As the actual travel path of the brood was not known, we recorded linear distances. Logistic regression (PROC CATMOD, SAS Inst. Inc. 1990) was used to determine if brood fate at 14 days after hatching (response variable) was influenced by distance to the first wetland used. CATMOD was used because we had to control for annual differences and seasonal changes in nest to wetland distances, and to test for interactions among predictor variables: year, hatching date, and distance traveled (note: these variables were *not* divided into categories).

Observations to determine brood size were conducted at least every seven days after hatching until the young could fly (approximately 55 days, Bellrose 1976). Estimates of offspring survival were based on visual observations of broods attended by radio-marked females. Duckling survival (i.e., attrition within a brood) was calculated for each brood using a modified Mayfield technique (Flint et al. 1995). Brood survival estimates represent ≥ 1 ducklings surviving to 14 d. Because individual ducklings were not radio-marked, we could not determine causes of mortality. We restricted all survival analyses to the first two weeks after hatching because (1) it allowed us to maximize our sample of broods and because (2) duckling mortality is greatest in the first two weeks after hatching (e.g., Ringelman and Longcore 1982, Orthmeyer and Ball 1990).

Brood size was manipulated to $\pm 50\%$ of modal size from 1991 to 1993 as part of another study (Dzus and Clark 1997). Brood survival was lower for reduced broods ($P < 0.05$) but did not differ between control and enlarged broods ($P = 1.0$, Dzus and Clark 1997). Therefore, for analyses using brood fate, reduced broods were excluded, and data for control and enlarged broods were combined. Duckling survival in reduced and enlarged broods tended to be lower than control broods (Dzus and Clark 1997); therefore, analyses using individual duckling survival include only control broods.

We sampled aquatic invertebrates during the first two weeks after hatching using 1-m² emergence traps for a subsample of Mallard broods from 1991 to 1993 (Ross and Murkin 1989). Because of a limited number of emergence traps, broods could be included for invertebrate sampling only when traps became available. There is no reason to believe a bias existed in our selection of broods for invertebrate sampling, nor was there any indication of effects on brood movements from the placement of traps. The first 14 days were sampled because most duckling mortality occurs in this period (e.g., Orthmeyer and Ball 1990, Ringelman and Longcore 1982) and because young ducklings feed extensively on emerging invertebrates (Pehrsson 1979). Two traps were placed at randomly selected locations on wetlands used by broods; one trap was placed in emergent vegetation and the other in open

water one day after the brood arrived on the wetland. If one of the two zones was missing in a wetland, both traps were placed at random in the existing zone. If the brood moved, additional traps were placed on the new wetland. Samples were collected every seven days, stored in 70% alcohol and later sorted into chironomids and "others." Chironomids were classified by size class and subfamily: Chironominae (small, medium and large), Tanypodinae (medium), and Orthocladinae (small) and biomass conversions followed Lapointe (1986). We evaluated whether broods moved to wetlands with higher chironomid biomass by comparing chironomid biomass ($\log X + 1$) of the first wetland used to the last wetland used in the first two weeks of duckling life, using the Wilcoxon signed-rank test. We also compared chironomid availability between wetlands used by females that had young and those experiencing total brood loss using a Wilcoxon-Mann-Whitney test; chironomid biomass/wetland was weighted by the number of days the brood spent on the pond, and a weighted mean biomass was calculated for each brood.

All research methods employed during our study were approved by the Animal Care Committee, Univ. of Saskatchewan, on behalf of the Canadian Council on Animal Care.

RESULTS

Wetland density and initial nest-to-wetland moves.—There were substantial differences in wetland density between years, with 1990 having the greatest wetland abundance and 1993 initially having the lowest density until early summer rains refilled many dry wetlands (Fig. 1). Distances from Mallard nests to the closest wetland (regardless of permanency of water) and the closest semi-permanent wetland were significantly greater ($P = 0.05$, Bonferonni t -test) in 1993 than in 1990 and 1991 when wetlands were more abundant (Table 1).

Only 19 of 52 (37%) brood-rearing females moved from their nest to the closest wetland with standing water. The average distance from the nest to the first pond used was 211 m ($N = 26$, $SD = 183$) for broods surviving to 14 d and 310 m ($N = 9$, $SD = 206$) for broods experiencing loss of all ducklings (note: experimentally reduced broods excluded). Brood survival was not related to distance moved to the first wetland (logistic regression, $\chi^2 = 1.58$, $df = 1$, $P = 0.21$, two- and three-way interactions with year and relative hatching date were not significant, $P > 0.05$, and were removed from the model; Likelihood ratio: $\chi^2 = 34.3$, $df = 29$, $P = 0.23$).

Brood movements.—Of 40 Mallard broods for which we have reliable movement data (experimentally reduced broods excluded), most made two ($N = 14$) or three ($N = 10$) moves in the first seven days after hatching (range = 1–5). Sample size was too small to evaluate reliably survival consequences in relation to number of moves. Most (17 of 32) Mallard broods were sedentary in the second week after hatching, while other broods made one ($N = 6$), two ($N = 4$), three ($N = 2$), or five ($N = 3$) moves in the second week. For broods that fledged young ($N = 21$), there was a large degree of variability in the number of moves re-

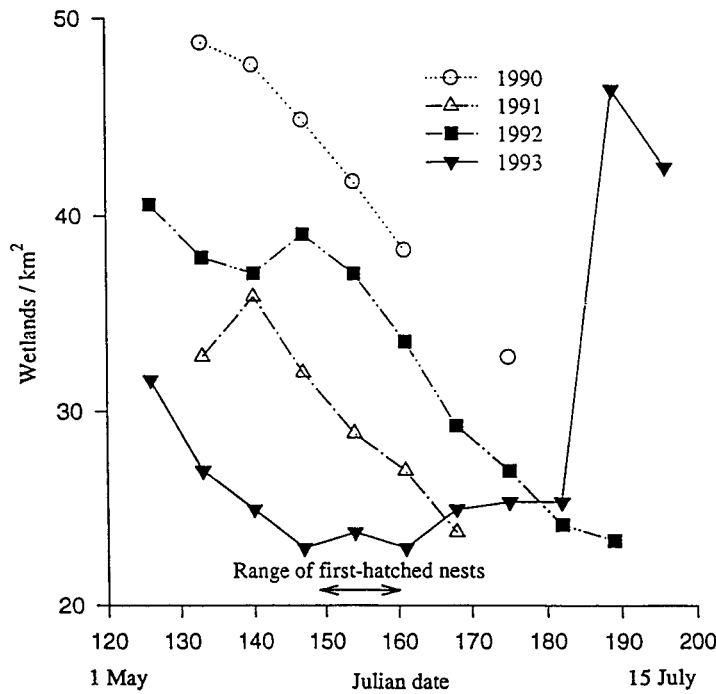


FIG. 1. Wetland density on managed nesting areas near Yorkton, SK, from 1990 to 1993.

TABLE 1					
ANNUAL VARIATION IN DISTANCES (m) FROM MALLARD NESTS TO THE CLOSEST WETLAND WITH STANDING WATER AND CLOSEST SEMI-PERMANENT WETLAND, FROM 1990 TO 1993 NEAR YORKTON, SASKATCHEWAN					
Year	Broods	Closest wetland ^a		Closest semi-permanent wetland	
		\bar{x}^b	SD	\bar{x}	SD
1990	16	75A	59	103A	93
1991	15	78AB	36	102A	53
1992	11	131BC	54	135AB	62
1993	11	183C	60	190B	54
F		11.83		4.36	
P		0.0001		0.008	

^a Closest wetland refers to a wetland basin with standing water, regardless of permanency.
^b Means with the same letter are not significantly different (Bonferonni *t*-test, *P* = 0.05).

corded during the period from 15 to 30 days after hatching. Six broods remained on the same wetland, four moved once, and the remainder ($N = 11$) made between three and 12 moves in this latter period.

Total distance traveled overland was similar (Wilcoxon 2-sample test, $P = 0.58$) between broods that had at least one duckling survive to 14 days ($N = 26$, median = 893 m) and those that did not ($N = 9$, median = 870 m). Similarly, duckling survival did not vary with total distance traveled (Spearman rank correlation, $r_s = -0.23$, $N = 27$, $P = 0.12$). A one-tailed test was used based on a predicted inverse relationship between duckling survival and distance traveled overland (Ball et al. 1975, Rotella and Ratti 1992b).

Brood use of wetlands as a function of wetland characteristics.—In all years of the study, broods used semi-permanent wetlands most frequently (69–95% of brood-days). Broods that fledged young seemed to spend more days in weeks 1 and 2 on semi-permanent wetlands than females that experienced total brood loss (Fig. 2). However, when examined on a per brood basis, there was no relationship between duckling survival and percent of days located on semi-permanent wetlands ($r_s = 0.20$, $N = 27$, $P = 0.29$, two-tailed).

Broods ($N = 37$) spent the majority of their time on wetlands with conductivity <2000 microsiemens (μS)/cm. Only seven of 247 (2.8%) brood-days in week 1 and 18 of 215 (8.4%) brood-days in week 2 were spent on wetlands with conductivity >2000 μS /cm, and the maximum conductivity recorded for a wetland used by a Mallard brood was 3633 μS /cm. On our study area, the highest value recorded was 3800 μS , and few wetlands had values greater than 2000 μS /cm.

There was no trend for the last wetland used by broods to have higher chironomid biomass than the first-used wetland (emergent and open-water samples combined) (Wilcoxon signed ranks test, $T^+ = 36$, $P = 0.43$, one-tailed test); this held true whether we used emergent ($T^+ = 44$, $N = 11$ broods, $P = 0.18$) or open-water samples ($T^+ = 32$, $N = 10$, $P = 0.35$). Furthermore, mean biomass of chironomids (weighted by the number of days the brood spent on the wetland) did not differ between wetlands used by broods with young surviving after 14 days and those that did not (Wilcoxon-Mann-Whitney test, $m = 5$, $N = 6$, $W_x = 31$, $P = 0.60$, Table 2).

DISCUSSION

Some previous studies have found a negative relationship between distance traveled overland and duckling survival (Ball et al. 1975, Rotella and Ratti 1992b). However, Talent et al. (1983) and this study did not detect a relationship between distance traveled and offspring survival. Differences between these studies may relate to wetland density, food

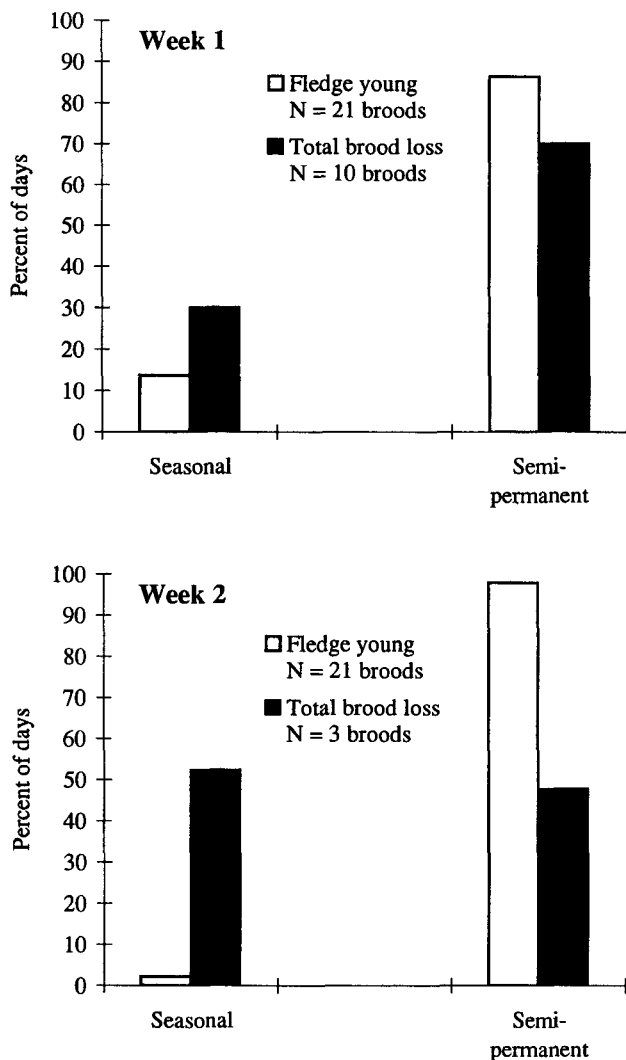


FIG. 2. Fate of Mallard broods in relation to wetland classification near Yorkton, SK, from 1990 to 1993.

availability, weather conditions, predator populations, or other factors. Wetland density on Rotella and Ratti's (1992b) study area ($\bar{x} = 11/\text{km}^2$, range 0 to $32/\text{km}^2$) was much less than our study (see Fig. 1), but greater than that of Talent et al. (1983: range 2– $14/\text{km}^2$). Rotella and Ratti (1992b) presented movement data for a 30-d period; if calculated for a

TABLE 2
CHIRONOMID BIOMASS IN WETLANDS USED BY BROODS THAT HAD YOUNG SURVIVING PAST 14 DAYS AFTER HATCHING AND THOSE THAT DID NOT (YORKTON, SASKATCHEWAN, 1991 TO 1993)

Brood fate Brood ^b	Number of wetlands used in first 14 d	Chironomid biomass ^a		
		First wetland ^c	Last wetland ^c	Mean ^d
Total brood loss by 14 days:				
2420/91	4	3.49	2.94	3.41
3260/91	3	8.72	11.15	8.94
2050/93	4	9.47	5.36	5.61
2070/93	3	9.11	8.22	8.48
2580/93	2	8.22	10.18	9.98
Duckling(s) survive > 14 days:				
3240/91	4	8.03	8.87	7.30
2620/92	3	7.86	9.19	8.35
2780/92	2	9.22	7.49	7.61
3200/92	5	5.68	5.10	4.79
3230/92	4	8.97	8.06	8.05
2030/93	2	5.38	12.64	12.12

^a Calculated as the sum of the emergence and open water traps per seven-day sampling period, expressed as \ln (mg/m²/week).

^b Identified by radio frequency and year.

^c First and last wetland used in the 14 days after hatching.

^d Mean chironomid biomass per wetland weighted by the number of days spent on the wetland.

14-d period, based on average distance moved per day, their broods would have moved 1204 m compared to an average of 875 m in our study. It is possible that there is some threshold of risk where distance traveled overland becomes a significant factor influencing mortality. Six of eight broods in our study that traveled >1200 m in 14 d had duckling survival probabilities lower than average. Whether such a relationship is related to wetland density is questionable. Talent et al (1983) suggested that brood movements and duckling survival may have been related to the presence or absence of mink on a particular wetland. Mink were not likely an important predator on our study area because their primary prey, muskrats, were not found on wetlands during our study (E. Dzus, pers. obs.). As such, without detailed information on movement and mortality events derived from radio-marked ducklings, discussion of the risks of overland travel will remain speculative.

Mallards consistently showed high use of semi-permanent wetlands, despite changing wetland conditions over the four years of study. Temporary wetlands were available to Mallards, especially in the wettest year (1990), yet brood-rearing females showed little use of these wetlands. Rotella and Ratti (1992b) studied Mallard brood habitat use in dry years in southwestern Manitoba and reported high use of semi-permanent wet-

lands. Preference for seasonal wetlands that exhibit extensive coverage of emergent vegetation was reported by Talent et al. (1982) and Mauser et al. (1994b). Thus, there appears to be geographic variability in wetland use by Mallard broods.

Little information is available relating brood use of wetlands to wetland conductivity. Most prairie wetlands have conductivity $<4000 \mu\text{S/cm}$ (Leighton and Wobeser 1994). The vast majority of wetlands used by Mallard broods in this study had very low conductivity values ($<2000 \mu\text{S/cm}$). Such levels were well below those shown to be fatal to young ducklings ($>20,000 \mu\text{S/cm}$) or known to affect growth (Mitcham and Wobeser 1988, Swanson et al. 1984). Conductivity did not affect selection of wetlands by brood-rearing American Black Duck (*A. rubripes*) females (Ringelman and Longcore 1982). Thus, wetland conductivity was unlikely to have had any effects on duckling growth or survival on our study area.

Food abundance may be an important, yet poorly-quantified, factor influencing wetland use. We found no relationship between the abundance of emerging chironomids and duckling survival. Talent et al. (1982) found some support for the hypothesis that brood-rearing females move to wetlands with higher chironomid abundance. A potential problem exists with the study of Talent et al. (1982); they sampled larval chironomids in the benthos, which may not necessarily reflect availability of emerging adults to young ducklings at or near the time of sampling. Talent et al. (1982) further suggested that seasonal wetlands support higher densities of benthic invertebrates (based on the work of Swanson and Meyer 1973). Contrary to this, Nelson (1989) found that semi-permanent wetlands supported higher densities of chironomid larvae than seasonal wetlands. Limited heterogeneity in plant species diversity and vegetation structure, in combination with total loss of surface water and low nutrient status, may operate in concert to limit the development of complex chironomid communities in seasonal wetlands (Driver 1977, Driver and Peden 1977, Wiggins et al. 1980). Thus it is not clear what the role of food is in influencing wetland movements of Mallard broods.

The period from hatching to fledging remains the least understood period of the Mallard's life cycle. To further our understanding of brood ecology, it will be necessary to study intensively individually radio-marked ducklings. However, before we begin examining the factors influencing duckling survival, we must be convinced by experimental studies with appropriate controls that there is no negative impact of the marking technique on such small animals. Once techniques have been refined, we can begin to examine relationships between invertebrates, habitat use by broods, age of female, hatching date, duckling survival, and causes of mortality in a comprehensive study with a large sample of broods.

ACKNOWLEDGMENTS

This research was funded by the Canadian Wildlife Service and postgraduate scholarships to EHD from the University of Saskatchewan, the Natural Sciences and Engineering Research Council, and the Isabel Lopez and Dennis Pattinson memorial scholarship funds. Ducks Unlimited (Canada) provided logistical support. We greatly appreciate the field assistance of S. Adams, C. Deschamps, C. Dzus, Z. Dzus, C. Friesen, T. Magus, J. G. Miller, D. Palmer, D. Reid, K. Warner, and R. Zaidan. The work would not have been possible without the cooperation many landowners. Comments provided by B. Dugger, J. Rotella, and an anonymous reviewer improved an earlier draft of this manuscript.

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