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VARIATION IN BODY MASS OF WILD CANVASBACK AND REDHEAD DUCKLINGS[1]

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Abstract. We assessed variation in body mass of ducklings in single- and mixed-species broods of wild Canvasbacks (*Aythya valisineria*) and Redheads (*Aythya americana*) 20–50 days old. Body mass of canvasback ducklings was not affected by year and season (early vs. late hatch date) despite changes in water conditions. Mean body mass of male and female Canvasbacks did not differ in Class IIA but did differ in older age classes. Within-brood differences in body mass tended to be higher in Class IIA ducklings (6–7% of mean body mass for Canvasbacks, 9–11% in Redheads) and generally declined to 4–6% in Class IIC and older ducklings. Some within-brood differences were as high as 20–30% of mean body mass. Tests to assess sources of within-brood variation (age, sex, and season) in body mass for Canvasbacks were inconclusive. Variation within broods was generally less than that among broods for both Canvasbacks and Redheads. The lack of differences in duckling body mass between single- and mixed-species broods for any age class, sex, or species suggests that mass was not affected by interspecific brood parasitism.

Key words: Aythya americana; Aythya valisineria; *duckling; brood; body mass; Canvasback; Redhead.*

INTRODUCTION

Body mass strongly influences duckling survival. Heavier ducklings generally are better able to withstand periods of food deprivation (Rhymer 1988b) and cold weather (Koskimies and Lahti 1964, Kear 1965, Samuel and Goldberg in press) and are less susceptible to predators in the first 10 days (Swennen 1989) than lighter ducklings. Factors affecting body mass and growth of ducklings include genetics (Prince et al. 1970, Rhymer 1988a), egg mass (Rhymer 1988b, Holmberg and Klint 1991), food availability (Street 1978, Hunter et al. 1984, Rattner et al. 1987), cold stress (Samuel and Goldberg in press), disease (Samuel and Goldberg in press), and contaminants (Swennen 1991, Cain and Pafford 1981, Hoffman et al. 1992). The effect of egg mass diminishes during the fist 1–3 weeks (Holmberg and Klint 1991, Rhymer 1988b). Sexual differences in body mass usually do not appear until near fledging (Greenwood 1974, Lightbody and Ankney 1984, Lokemoen et al. 1990).

Most studies reporting body mass, growth curves, or measurements of ducklings have used data from captive birds (e.g., Oring 1968, Rhymer 1988b, Lightbody and Ankney 1984). Variation in body mass among captive ducklings tends to be small (Rhymer 1988b), probably because of uniform environmental conditions and access to *ad libitum* food. Information on variability in body mass under natural conditions is sparse, however, and few researchers have assessed this variability within or among broods. Low variability in body mass within broods may be expected because brood mates are genetically similar and have encountered similar environmental conditions and foraging opportunities. However, two studies reporting within-brood variability found sizable differences in body masses. Dzubin (1959) reported within-brood differences of 5 g (11% of mean body mass) at hatch, 16 g (17%) in nine-day-old, and 120 g (12%) in 50-day-old wild Canvasback (*Aythya valisineria*) ducklings. In wild Gadwall (*Anas strepera*), Mallard (*Anas platyrhynchos*), and Blue-winged Teal (*Anas discors*) ducklings 19–41 days old, differences in body mass within broods ranged as high as 140 g for females and up to 95 g for males (Lokemoen et al. 1990).

Canvasback nests and broods in the prairie pothole region are often parasitized by Redheads

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(*Aythya americana*) (Stoudt 1982, Serie et al. 1992). The effect of interspecific brood parasitism on duckling growth and body mass is unknown, although some researchers have assessed its effect on survival to fledging. Canvasbacks reared in broods parasitized by Redheads had lower survival rates than Canvasbacks reared in unparasitized broods (Leonard 1990). In contrast, survival of Common Goldeneye (*Bucephala clangula*) ducklings was not affected by interspecific parasitism (Eadie and Lumsden 1985).

Data collected from Canvasback and Redhead ducklings during banding operations in the 1970s provided an opportunity to assess body mass of 20- to 50-day-old wild ducklings. Because Canvasback nests were commonly parasitized by Redheads (Serie et al. 1992), data included broods of both single and mixed (containing Canvasback and Redhead ducklings) species. My objectives were to (1) assess variability of duckling mass within and among broods of Canvasbacks and Redheads, (2) evaluate factors influencing duckling mass, and (3) determine whether ducklings raised in a single-species brood are heavier than ducklings in mixed-species broods.

METHODS

During 1974–1978, more than 1,100 Canvasback and Redhead ducklings were weighed in conjunction with a study of the breeding biology of Canvasbacks (Serie et al. 1992). The work was conducted in the prairie pothole region near Minnedosa, in southwestern Manitoba, Canada (50°15′N, 99°50′W). Wetlands, topography, vegetation, and densities of breeding waterfowl in the area have been described by Kiel et al. (1972), Adams and Gentle (1978), and Stoudt (1982).

Careful observations and notes made over several days before and immediately during the capture operation on each pond were used to locate broods and determine brood age (Gollop and Marshall 1954), size, and species composition. Usually only a single brood occurred on a pond; where several broods occurred on a pond, they usually could be distinguished by their different ages. In a number of cases, the brood hen was marked and the hatch date of the brood was known. Ducklings were caught in drive traps (Cowan and Hatter 1952, Trauger 1971) in late July and August. Ducklings were weighed immediately after capture, as soon as the down was dry. Mass was determined to the nearest gram using Pesola spring scales, the accuracy of which was regularly checked with known weights. Age of each duckling was determined in hand using plumage classes described by Gollop and Marshall (1954). Most captured ducklings were 20–50 days old (Classes IC–IIC). Some ducklings were classified only as Class III; because we were uncertain if they were Class IIIA or later, we separately delineated them as Class IIID. Statistical comparisons of body mass among and within broods were made only with data from broods which would be readily identified from others on the same pond. Within each identified brood, we determined mean and range of mass differences by comparing each possible pair of ducklings within the brood.

We used analysis of variance (ANOVA) to assess the effects of year, age class, sex, and season on mean duckling mass for Canvasbacks. Season refers to early- or late-hatching ducklings, where early-hatched ducklings are those hatched from nests initiated during the first 15 days of known Canvasback nest initiation each year (Serie et al. 1992). The design was a split-plot; broods within year-by-season-by-age class combinations were the whole plots, sex was the subplot level, and individual ducklings were the subsampling units. Mean separations following significant effects ($P \leq 0.05$) were done using Fisher's protected LSD values at the 0.05 level of significance (Milliken and Johnson 1984).

We assessed factors affecting variances of mass within Canvasback broods using a means model approach (Milliken and Johnson 1984) in an ANOVA. We first analyzed all testable hypotheses for yearly, seasonal, age class, and sex differences simultaneously in an unbalanced split-plot design. Broods served as the whole plot and sex as the subplot. We then tested individual hypotheses (contrasts) using single degree of freedom F-tests.

We used the following ANOVA model to estimate variance components attributable to within versus among broods and to compare between pure and mixed-species broods (brood type) for each species:

$$Y_{ijk} = \mu_i + b_{j(i)} + d_{k(j(i))},$$

where

Y_{ijk} = weight of duckling k in brood j of type i

μ_i = mean mass of ducklings of type i,

TABLE 1. Mean differences in body mass (g) of Canvasback and Redhead ducklings within broods by age class.[a]

Sex	Age class	Number of ducklings	Number of broods	Difference in body mass (g)			
				n[b]	$\bar{x}$	SD	Range
Canvasbacks:							
F	IIA	54	24	56	41.2	26.9	0–120
	IIB	111	47	114	49.9	42.2	0–230
	IIC	86	41	78	50.7	53.9	0–290
	IIIA	9	5	10	74.2	46.8	10–170
	IIID[c]	16	9	12	45.8	40.2	0–120
M	IIA	55	26	48	37.0	35.6	0–165
	IIB	102	55	77	39.0	34.5	0–145
	IIC	104	47	116	49.0	45.9	0–225
	IIIA	14	8	7	49.3	34.0	10–95
	IIID	22	8	21	63.2	86.8	0–325
F vs. M	IIA	98	25	103	51.5	43.4	0–250
	IIB	218	52	243	62.1	46.8	0–230
	IIC	153	37	192	77.1	54.2	0–290
	IIIA	60	6	24	90.0	64.1	5–245
	IIID	13	7	43	107.1	62.4	0–395
Redheads:							
F	IIA	36	21	23	51.5	40.0	0–110
	IIB	48	30	29	33.6	44.0	0–180
	IIC	30	20	17	46.5	36.0	5–115
	IIIA	6	4	2	37.5	31.8	15–60
	IIID	6	4	2	52.5	46.0	20–85
M	IIA	43	25	32	42.8	32.0	0–130
	IIB	53	29	38	50.0	36.6	0–145
	IID	19	13	7	35.0	48.8	10–145
	IIIA						
	IIID	10	7	4	15.0	10.8	5–30
F vs. M	IIA	61	16	67	46.9	37.5	0–135
	IIB	78	17	76	53.0	58.0	0–315
	IIC	32	11	36	57.5	31.5	0–120
	IIIA	9	3	4	37.5	18.5	25–65
	IIID	5	2	3	48.3	50.8	10–105

[a] Where broods contained ducklings of > 1 age class, the data were summarized for the dominant age class of that sex.
[b] Number of all possible comparisons within brood.
[c] Ducklings in Class IIID could only be aged to Class III.

$b_{j(i)}$ = random variable for brood j of type i, and
$d_{k(j(i))}$ = random variable for duckling k in brood j of type i

The variance of $Y_{ijk} = \nu_b^2 + \nu_d^2$, where ν_b^2 is the variance among broods and ν_d^2 is the variance within broods. Unbiased estimators of mean mass of ducklings in pure and mixed broods are given as least squares means (LSMEANS). All statistical tests were conducted using SAS (SAS Institute, Inc. 1989).

RESULTS

Most mean differences in body mass within broods were around 35–50 g (Table 1). When expressed as a percentage of mean body mass, differences tended to be highest in Class IIA ducklings (6–7% in Canvasbacks, 9–11% in Redheads) and generally declined to 4–6% in Class IIC and older ducklings.

Assessment of factors affecting mean body mass in Canvasback ducklings was complicated by the lack of data in Class IIC and in 1976. By excluding age class IIC and 1976 in the first ANOVA, we were able to balance the design to assess effects of age class, sex, year, and season. Of the 4 factors, age class (F = 38.39; df = 1, 69; P = 0.001) and sex (F = 14.89; df = 1, 46; P = 0.0004) were significant. All other main effects (year and season) and interactions were not significant. Because season did not seem to account for variation in mass, we conducted a second ANOVA including Class IIC and 1976 and ignoring sea-

TABLE 2. Mean body mass (g) of Canvasback ducklings, expressed as LSMEANS, by age class and sex.

Age class	Number of broods	Number of ducklings	Sex	$\bar{x}$[a]	SE
IIA	33	67	F	549.5A	14.81
	31	62	M	562.2A	18.05
IIB	56	129	F	697.9A	10.86
	62	113	M	739.1B	12.20
IIC	48	96	F	863.5A	10.39
	52	114	M	930.0B	12.35

[a] Means within age class followed by a common letter are not significantly different ($P > 0.05$) using Fisher's protected LSD value.

son. Effects of age class ($F = 168.75$; df = 2, 161; $P = 0.0001$), sex ($F = 56.75$; df = 1, 97; $P = 0.0001$), and sex-by-age class ($F = 3.75$; df = 2, 97; $P = 0.0271$) were significant. Within age classes, mean mass of male and female Canvasback ducklings did not differ in Class IIA but did differ in older age classes (Table 2).

Analysis of factors affecting variance of body mass within Canvasback broods was inconclusive. Although the overall test of no difference was significant ($F = 10.08$; df = 34, 25; $P = 0.0001$), when the main effects (year, season, age class, and sex) were analyzed separately, no effects or interactions were significant ($P > 0.35$).

Variance within broods was less than that among broods for both Canvasback and Redhead ducklings, except for Class IIC Canvasback females and Class IIA Redhead males (Table 3). Variance was highest among broods for Class IIIA female and IIID male Canvasbacks and IIID female Redheads, but sample sizes were small.

We found no significant differences in body mass between single- or mixed-species broods for any age class, sex, or species (Tables 4 and 5).

TABLE 3. Variance in body mass of Canvasback and Redhead ducklings among and within broods, by age class. Percent contribution to total variance is in parentheses.

Sex	Age class	Number of ducklings	Number of broods	Variance: Among broods (%)	Variance: Within broods (%)
Canvasback					
F	IIA	54	21	3,670 (75)	1,212 (25)
	IIB	111	36	6,432 (63)	3,784 (37)
	IIC	86	28	2,285 (42)	3,166 (58)
	IIIA	9	5	−90[a] (0)	3,738 (100)
	IIID	16	9	6,111 (79)	1,588 (21)
M	IIA	55	22	6,137 (82)	1,391 (18)
	IIB	102	39	6,051 (63)	3,502 (37)
	IIC	104	32	5,593 (59)	3,845 (41)
	IIIA	14	8	3,693 (69)	1,655 (31)
	IIID	22	10	794 (12)	5,953 (88)
Redhead					
F	IIA	36	18	3,912 (65)	2,115 (35)
	IIB	48	24	3,496 (57)	2,590 (43)
	IIC	30	18	2,668 (59)	1,825 (41)
	IIIA	6	4	—	—
	IIID	6	4	−661[a] (0)	1,906 (100)
M	IIA	43	19	3,596 (47)	4,023 (53)
	IIB	53	21	4,863 (60)	3,231 (40)
	IIC	19	13	4,733 (71)	1,890 (29)
	IIIA	3	3	—	—
	IIID	10	7	3,194 (94)	189 (6)

[a] Variance component not different from 0.

DISCUSSION

Differences in body mass within broods in this study were similar to those reported for wild Canvasbacks (Dzubin 1959) and wild Mallards and Gadwalls (Lokemoen et al. 1990). As expected, within-brood variation in body mass was generally less than that among broods. However, in some groups, the difference between within- and among-brood variation was very small. Some of these exceptions may have been due to intraspecific parasitism, which can be extensive in both species (Sorensen 1990). Tests to assess sources of within-brood variation in body mass for Canvasbacks, however, were inconclusive.

Comparison of variability among broods may be confounded by the use of plumage development for ageing, especially for ducklings around 2–3 weeks old. Lokemoen et al. (1990) suspected the high variation in body mass of Mallards, Blue-winged Teal, and Gadwall within the same plumage class was due in part to inaccuracy of ageing birds from plumage. Schneider (1965) found errors of more than two weeks within and among broods if age at which teleoptiles first emerge (2–3 weeks of age; Southwick 1953) was used for age classification. Once feathering began, the sequence and timing of emergence seemed to be constant. Retarded growth or poor body condition may be reflected in delayed plumage development. We were able to assess accuracy of ageing in this study by comparing 49 ducklings from 12 broods of known hatching date with age classes as outlined by Dzubin (1959). Of these, 14% had been misclassified: one was estimated as one week younger, five as one week older, and one as two weeks older than actual age.

Age class and sex were the only factors affect-

TABLE 4. Mean body mass (expressed as least squares means) of Canvasback ducklings by age,[a] sex, and brood type (mixed vs. pure species).

Sex	Age class	Mean body mass (g) Pure brood (n)[b]	Mixed brood (n)	P[c]
F	IIA	516 (19/8)	584 (35/15)	0.056
	IIB	694 (46/17)	705 (65/25)	0.646
	IIC	890 (40/14)	852 (46/20)	0.133
	IIIA	957 (6/2)	928 (3/3)	0.591
	IIID[b]	976 (7/4)	995 (9/5)	0.776
M	IIA	516 (19/9)	576 (36/15)	0.155
	IIB	739 (54/19)	739 (48/28)	0.996
	IIC	922 (66/21)	919 (38/17)	0.939
	IIIA	1,068 (4/3)	1,019 (10/5)	0.413
	IIID	1,077 (10/4)	1,124 (12/6)	0.289

[a] Age classes as defined by Gollop and Marshall (1954).
[b] Sample size = (no. canvasback ducklings/no. broods).
[c] H_0: $\mu_{pure} = \mu_{mixed}$.
[d] Classified only as Class III.

TABLE 5. Mean body mass (expressed at least squares means) of Redhead ducklings by age[a], sex, and brood type (mixed vs. pure species).

Sex	Age class	Mean body mass (g) Pure brood (n)[b]	Mixed brood (n)[b]	P[c]
F	IIA	415 (13/6)	480 (23/15)	0.094
	IIB	682 (22/8)	630 (26/22)	0.081
	IIC	797 (6/2)	741 (24/18)	0.159
	IIIA		867 (6/4)	
	IIID[d]	822 (3/2)	814 (3/2)	0.782
M	IIA	461 (23/8)	489 (20/17)	0.441
	IIB	708 (21/7)	660 (32/22)	0.229
	IIC	836 (5/2)	784 (14/11)	0.309
	IIIA		849	
	IIID	885 (2/2)	915 (8/5)	0.606

[a] Age classes as defined by Gollop and Marshall (1954).
[b] Sample size = (no. redhead ducklings/no. broods)
[c] H_0: $\mu_{pure} = \mu_{mixed}$.
[d] Classified only as Class III.

ing body mass in Canvasbacks. Sexual differences in mass became significant after Class IIA (about four weeks of age), somewhat earlier than reported for captive Canvasbacks and Redheads (Lightbody and Ankney 1984, Lightbody 1985). Canvasbacks were similar to Blue-winged Teal (Dane 1965) but differed from Mallards (Rhymer 1988b) in the lack of a seasonal effect on duckling body mass. The nesting period of Mallards is longer than that of Canvasbacks or Blue-winged Teal and provides greater opportunities for renesting and any associated changes in egg or duckling mass.

The lack of a year effect on duckling mass suggests habitat quality and food availability were not limiting, despite differences in water conditions among years (Serie et al. 1992). Canvasback broods moved extensively among ponds of various sizes and types (Austin and Serie 1991). The mobility of the broods allows broods to adapt to changing food availability and thus minimize the effect of food availability on growth and fledging.

In studies using captive ducklings, the greatest variability in duckling growth rates and body mass occurred at about 2–6 weeks after hatch, the period of most rapid growth (Schneider 1965, Prince et al. 1970, Brown and Fredrickson 1983). Brown and Fredrickson (1983) suggested that the high variability of body mass during this period may be related to high energy and nutrient demands and that stress would have its greatest effect on gains in body mass, and possibly survival, during this period. Certainly, one would expect that differences of the magnitude reported in this study (20–30% of mean body mass) could affect survival, particularly during periods of cold stress. Unfortunately, researchers investigating duckling thermoregulation have assessed cold stress only during the first 1–2 weeks after hatch (Untergasser and Hayward 1972, Rhymer 1988b); little information is available about the capabilities of older ducklings relative to body mass.

The lack of differences in body mass between ducklings in pure or mixed broods suggested that mass was not affected by interspecific brood parasitism. However, we do not know whether body mass differed relative to brood type in one- to two-week-old ducklings or whether such differences affected early survival. Leonard (1990) found that lower survival of Canvasback ducklings in mixed-species broods occurred during the first week after hatch; survival did not differ between pure- and mixed-species broods in 2–9 weeks after hatch, which coincides with the ages of ducklings in this study.

Although ducklings within a brood encounter the same environmental conditions and foraging opportunities, they can differ by as much as 34% of average body mass even within sexes. Such large differences cannot entirely be attributed to sex or size at hatch because these differences decline throughout development to nonsignificant levels after 3–4 weeks (Rhymer 1988b, Holmberg and Klint 1991). Other factors that may contribute to body mass variation within broods include behavior, injuries or disease, parasite loads, and different parentage (intraspecific parasitism [Sorensen 1990]). If ducklings differ, for example, in their ability to learn various feeding skills, they may develop differences in their foraging efficiency.

Few data are available to assess within-brood variability in body mass during the first two weeks (Dzubin 1959), when duckling mortality is greatest (Sargeant and Raveling 1992). The influences of low body mass in this early period on body mass and survival later in development are uncertain. Swennen (1989) found that during the first 10 days after hatch lighter ducklings were less alert and reacted more slowly to alarm calls than heavier ducklings; these lighter ducklings were most likely to be taken by gulls. Lighter ducklings in the first 1–2 weeks after hatch are more susceptible to cold stress than heavier ducklings (Koskimies and Lahti 1964, Untergasser and Hayward 1972, Rhymer 1988b).

Insight into the factors influencing body mass of ducklings and, in turn the influence of body mass on survival, would be valuable in our efforts to provide brood habitat and enhance wild duck production. A combination of experimental studies of ducklings in captivity and in the wild is needed to address these questions.

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LITERATURE CITED

ADAMS, G. D., AND G. C. GENTLE. 1978. Spatial changes in waterfowl habitats. Can. Wildl. Serv. Occas. Pap. 38.

AUSTIN, J. E., AND J. R. SERIE. 1991. Habitat use and movements of Canvasback broods in southwestern Manitoba. Prairie Nat. 23:223–228.

BROWN, P. W., AND L. H. FREDRICKSON. 1983. Growth and molt progression of White-winged Scoter ducklings. Wildfowl 34:115–119.

CAIN, B. W., AND E. A. PAFFORD. 1981. Effect of dietary nickel on survival and growth of Mallard ducklings. Arch. Environ. Contam. Toxicol. 10: 737–745.

COWAN, I. M., AND J. HATTER. 1952. A trap and technique for the capture of diving waterfowl. J. Wildl. Manage. 16:438–441.

DANE, C. W. 1965. The influence of age on development and reproductive capability of the Blue-winged Teal (*Anas discors* Linnaeus). Ph.D.diss., Purdue Univ., Lafayette, IN.

DZUBIN, A. 1959. Growth and plumage development of wild-trapped juvenile Canvasback (*Aythya valisineria*). J. Wildl. Manage. 23:279–290.

EADIE, J. M., AND H. G. LUMSDEN. 1985. Is nest parasitism always deleterious to goldeneyes? Am. Nat. 126:859–866.

GOLLOP, J. B., AND W. H. MARSHALL. 1954. A guide for aging duck broods in the field. Miss. Flyway Council Tech. Sec. Rep.

GREENWOOD, R. J. 1974. Reproductive aspects, growth, and development of Greenland Mallards. Condor 76:223–225.

HOFFMAN, D. J., C. J. SANDERSON, L. J. LECAPTAIN, E. CROMARTIE, AND G. W. PENDLETON. 1992. Interactive effects of arsenate, selenium, and dietary protein on survival, growth, and physiology in Mallard ducklings. Arch. Environ. Contam. Toxicol. 22:55–62.

HOLMBERG, K., AND T. KLINT. 1991. Growth in relation to egg weight and sex in Mallard ducklings, Chapter 5. *In* K. Holmberg [ed.], Mallard ducks: mate choice and breeding success. Ph.D.diss., Univ. of Stockholm.

HUNTER, M. L., JR., J. W. WITHAM, AND H. DOW. 1984. Effects of a carbaryl-induced depression on the growth and behavior of American Black Ducks and Mallard ducklings. Can. J. Zool. 62:452–456.

KEAR, J. 1965. The internal food reserves of hatching Mallard ducklings. J. Wildl. Manage. 29:523–528.

KIEL, W. H., JR., A. S. HAWKINS, AND N. G. PERRET. 1972. Waterfowl habitat trends in the aspen parkland of Manitoba. Can. Wildl. Serv. Rep. Ser. 18.

KOSKIMIES J., AND L. LAHTI. 1964. Cold-hardiness of the newly-hatched young in relation to ecology and distribution in ten species of European ducks. Auk 81:281–307.

LEONARD, J. P. 1990. Survival and movements of Canvasback ducklings—impact of brood density. M.Sc.Thesis, Michigan State Univ., Lansing, MI.

LIGHTBODY, J. P. 1985. Growth rates and development of Redhead ducklings. Wilson Bull. 97:554–559.

LIGHTBODY, J. P., AND C. D. ANKNEY. 1984. Seasonal influence on the strategies of growth and development of Canvasback and Lesser Scaup ducklings. Auk 101:121–133.

LOKEMOEN, J. T., D. H. JOHNSON, AND D. E. SHARP. 1990. Weights of wild Mallard *Anas platyrhynchos*, Gadwall *Anas strepera*, and Blue-winged Teal *Anas discors* during the breeding season. Wildfowl 41:122–130.

MILLIKEN, G. A., AND D. E. JOHNSON. 1984. Analysis of messy data. Vol. I: designed experiments. Van Nostrand Reinhold, New York.

ORING, L. W. 1968. Growth, molts, and plumages of the gadwall. Auk 85:355–380.

PRINCE, H. H., P. B. SIEGEL, AND G. W. CORNWELL. 1970. Inheritance of egg production and juvenile growth in Mallards. Auk 87:342–352.

RATTNER, B. A., G. M. HARAMIS, D. S. CHU, C. M. BUNCK, AND C. G. SCONES. 1987. Growth and physiological condition of ducklings reared on acidified wetlands. Can. J. Zool. 65:2953–2958.

RHYMER, J. M. 1988a. Geographic variation and genotype-environment interactions in avian growth and development. Ph.D.diss., Florida State Univ., Tallahasee, FL.

RHYMER, J. M. 1988b. The effect of egg size variability on thermoregulation of Mallard (*Anas platyrhynchos*) offspring and its implications for survival. Oecologia (Berlin) 75:20–24.

SAMUEL, M. D., AND D. R. GOLDBERG. In press. *Mycoplasma anatis* and cold stress on hatching of Mallard ducklings. J. Wild. Dis.

SARGEANT, A. B., AND D. G. RAVELING. 1992. Mortality during the breeding season, p. 396–422. *In* B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, and G. L. Krapu [eds.], Ecology and management of waterfowl. Univ. of Minnesota Press, Minneapolis.

SAS INSTITUTE, INC. 1989. SAS/STAT's user's guide, version 6, 4th ed. Cary, NC.

SCHNEIDER, K. B. 1965. Growth and plumage development of ducklings in interior Alaska. M.S. thesis, Univ. of Alaska, Fairbanks.

SERIE, J. R., D. L. TRAUGER, AND J. E. AUSTIN. 1992. Influence of age and selected environmental factors on reproductive performance of Canvasbacks. J. Wildl. Manage. 56:546–556.

SORENSEN, M. D. 1990. Parasitic egg laying in Redhead and Canvasback ducks. Ph.D. diss., Univ. of Minnesota.

SOUTHWICK, C. 1953. A system of age classification for field studies of waterfowl broods. J. Wildl. Manage. 17:1–8.

STOUDT, J. H. 1982. Habitat use and productivity of Canvasbacks in southwestern Manitoba. U.S. Fish Wildl. Serv. Spec. Sci. Rep. No. 248.

STREET, M. 1978. The role of insects in the diet of Mallard ducklings—an experimental approach. Wildfowl 29:93–100.

SWENNEN, C. 1989. Gull predation upon eider *Somateria mollissima* ducklings: destruction or elimination of the unfit? Ardea 77:21–45.

SWENNEN, C. 1991. Fledgling production of eiders *Sometaria mollissima* in the Netherlands. J. Ornithol. 62:427–437.

TRAUGER, D. L. 1971. Population ecology of Lesser Scaup (*Aythya affinis*) in subarctic taiga. Ph.D. diss., Iowa State Univ., Ames, IA.

UNTERGASSER, G., AND J. S. HAYWARD. 1972. Development of thermoregulation in ducklings. Can. J. Zool. 50:1243–1250.