MALLARD DUCKLING CARE AND SURVIVAL AT A WILDLIFE REHABILITATION CENTER

by

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ABSTRACT

Birds are by far the largest group of wildlife cared for by wildlife rehabilitators in British Columbia, Canada. Of this group, mallards (*Anas platyrhynchos*) are the fifth most common species brought into care. 41% of these mallards are uninjured orphans and require only supportive care until they begin to develop their flight feathers. Although these birds are precocial, and although heat and *ad lib* food and water are provided, deaths are common in the period between admission and release.

An analysis of 937 individual ducklings representing 6 years of data from the Wildlife Rescue Association of British Columbia showed that these deaths are concentrated in the first week after birds are admitted. Logistic regression analyses showed that ducklings that were lighter, admitted with fewer siblings, and that spent longer with the individual who found them were more likely to die in the rehabilitator's care than other individuals.

In an experiment, a single, older bird was added to novice broods to act as a "mentor" during the first week of care. Nine novice broods were split at admission and reared in two groups: one housed with a mentor and the other acting as a control. Body size metrics were collected at admission and again at the end of the first week in care, and ducklings in both groups were weighed twice daily during this time. There was no significant difference in mean growth or body condition between treatment and control groups and no experimental ducklings died during the first week. Treatment groups did, however, have less spread in final body weights, mainly because the final weight of the least-thriving individual in each treatment group was significantly greater than in corresponding control groups. The fact that no deaths occurred among the experimental broods in the first week indicates that the experimental housing was better for novice broods than standard facility housing. However, as low growth rates are associated with greater risk of death, the provision of mentors to new broods may reduce the number of birds dying in care where housing is less favorable.

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LIST OF ABBREVIATIONS

AEC - Vancouver Animal Emergency Clinic

BCSPCA - British Columbia Society for the Prevention of Cruelty to Animals

WildARC - British Columbia Society for the Prevention of Cruelty to Animals Wild Animal Rescue Center

WRA - Wildlife Rescue Association of British Columbia

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CHAPTER 1: INTRODUCTION

GENERAL OVERVIEW

Mallards (*Anas platyrhynchos*) are the most abundant wild duck species in North America (Anderson and Henny 1972). Compared to other duck species, mallards are highly tolerant of humans (Greer 1982) and are the most common waterfowl species in many suburban environments and parks (Figley and Vandruff 1973, Heusmann and Burrell 1974). The species is also capable of forming "synurbic" populations (Luniak 2004) that show some adaptation to urban and suburban environments. Within this shared habitat, human encounters with mallards are frequent, and injuries and deaths are often anthropogenic (Burton and Doblar 2004). It is not surprising, then, that orphaned mallard ducklings are commonly brought to North American wildlife rehabilitation centers by members of the public.

Alaska, British Columbia and the Yukon have between 3 and 6% of the mallard breeding population on the continent (Anderson and Henny 1972). In British Columbia, orphaned mallard ducklings compose 2.5 to 5% of the birds admitted to wildlife rehabilitation facilities per year (*derived from* Dubois 2003). At the Wildlife Rescue Association of British Columbia (WRA) in Burnaby, Canada, where the following studies were conducted, uninjured mallard ducklings accounted for 10% of the total individuals admitted to the facility (>150 individuals/year), and mallard broods accounted for 3.4% of the admission events from 2000-2006.

As precocial birds, mallard ducklings require relatively little time investment by the rehabilitator. At the WRA, these birds are initially group-housed in heated brooders with fine mesh flooring. This caging is cleaned with water, and birds are given fresh food and water twice daily. Feed and water are topped up throughout the day. Once the mallards have begun to molt into adult plumage they are moved into larger, gravel-bottomed duck runs with access to artificial ponds in which they can swim. They are released onto local lakes when they have, or are within 24 hours of having, molted into their primary flight feathers. Generally, the period from admission to release is 52 days. Unfortunately, during this period, the facility experiences high mortality rates (in excess of 28%), with the vast majority of deaths occurring within the first week of care.

While such deaths suggest welfare concerns associated with rearing and housing practices, several other factors should be taken into account before assuming that deaths are the result of the facility or care protocols. Mallards may have intrinsically high early mortality rates, they may suffer from disease, and they experience inappropriate treatment prior to admission. These are factors over which the rehabilitator has very little control and therefore deserve review.

BASELINE MORTALITY

Mallards experience high juvenile mortality rates in the wild. Field studies in North America generally estimate 30-day post-hatch survival to be below 60%. Survival estimates are 46% in Southern Ontario (Hoekman *et al* 2004), 40% in north-central Montana (Orthmyer and Balland 1990), 60% in south-central Saskatchewan (Gendron and Clark 2002), 44% in New Brunswick (Petrie *et al* 2000) and 22% in southern Quebec (Maisonneuve *et al* 2000). In northeastern California, 50-day post-hatch survival has been estimated to be only 37% (Mauser *et al* 1994).

Mortality rates are highest within the first week of hatching (Dzubin and Gollop 1972; Hoekman *et al* 2004). The majority of deaths occur within the first 14 days (77% at 8 days (Hoekman *et al* 2004), and 85% within 14 days (Talent *et al* 1983)).

Under natural conditions, factors known to contribute to deaths include predation (90.7% of fatalities in one study (Mauser *et al* 1994)), exposure in poor weather conditions (Kear 1965), and food availability (Gunnarsson *et al* 2004; Cox *et al* 1998), which, in turn, is influenced by temperature (Cox *et al* 1998; Johnson *et al* 1992) and wetland availability (Krapu *et al* 2000). This suggests that in rehabilitation, where these factors are removed or controlled, the number of deaths should be reduced and perhaps fall in line with those of farmed mallards.

Domestic mallards (*Anas platyrhynchos f. domesticus)* that are reared for commercial purposes, like rehabilitated animals, are protected from extrinsic sources of mortality such as predation and exposure. In Canada, commercial mortality is approximately 5% within the first 6 weeks, with the majority of deaths occurring within the first 2 weeks (Pajor 2007). This is notably lower than mortality rates for rehabilitated birds and may be associated with the uniform care ducklings receive before they are moved into grow-out housing and efforts to minimize dehydration after hatching. Commercial birds are also vaccinated (or received passive immunity from the vaccination of breeder ducks) against common waterfowl diseases.

DISEASE

Waterfowl are susceptible to numerous viral, bacterial, and non-contagious diseases. Among those that commonly and specifically affect young birds are Duck Hepatitis Virus (DHV), *Pseudomonas sp*. bacteria, and illness related to environmental factors.

DHV is primarily a disease of domestic ducklings (Hess and Paré 2004), but is capable of infecting wild mallards (Friend and Trainer 1972) and has been reported in wild mallard ducklings (Bourne WildPRO). The disease results in high mortality rates for birds less than one week old but rarely affects birds at ages greater than four weeks (Hess and Paré 2004; Morishita 2004). Affected ducklings have hemorrhaged and enlarged livers and may lie on their sides and paddle their legs before dying (Morishita 2004). DHV is relatively stable in the environment and easily spreads among ducklings via physical contact, feces, and shared housing, feed and equipment (Bourne WildPRO). Commercial operations are able to eliminate the problem by producing maternally immune ducklings through the vaccination of breeder ducks (Kahn 2006).

Pseudomonas bacterium can infect ducklings in the egg or at hatching. Symptomatically, birds are lethargic, have inflamed navels, and die suddenly. Necropsies show egg yolk infections (Morishita 2004).

Aflatoxin poisoning is another cause of deaths in ducklings. Aflatoxins are produced by fungi *Aspergillus flavus* or *A. parasiticus* growing in grain that has a high moisture content and is stored at temperatures greater than 21ºC. Ducklings have low tolerance for these toxins (Creekmore 1999) and will appear lethargic and become ataxic. Lesions include an enlarged and often pale yellow liver and swollen kidneys (Morishita 2004).

Finally, rehabilitators and breeders anecdotally report two non-infectious conditions - hypoglycemia and staggers - that result directly from food and water deprivation respectively. Hypoglycemia is thought by some rehabilitators to be responsible for deaths that occur shortly after admission. The symptoms include lethargy and lack of coordination and may be relieved by giving oral or subcutaneous dextrose to symptomatic birds (Tavenner 2004).

Staggers is triggered by dehydrated ducklings consuming too much water over a short period of time; it results in birds becoming uncoordinated and, in many cases, dying (Horton 2004). Providing small amounts of warm water over an hour is believed to prevent the condition (Horton 2004). Staggers has been reported to kill domestic ducks (Agriculture Canada 1977) although a physiological explanation does not appear in the literature. The condition may simply be hyponatremia, as seen in humans, where excessive water consumption after a loss of electrolytes results in a sodium imbalance which, in turn, can lead to cerebral edema (Adrogué and Madias 2000).

PRE-ADMISSION TREATMENT

Birds in rehabilitation do not receive uniform care before admission and may be subjected to high levels of stress before and during capture and through handling. Birds may also have been deprived of food and water before and after capture or have received inappropriate foodstuffs (*WRA records*). Temperature stress when the birds are transported to rehabilitation facilities may compound prior dehydration or energetic deficits. These factors likely contribute to deaths in care and make it difficult for rehabilitators to assess the effectiveness of care protocols. Data records on rates and patterns of mortality for ducklings in care could provide information on pre-admission treatment from which mortality correlates might be identified. The contribution of pre-admission treatment to mortality is assessed in Chapter 2.

HUSBANDRY

Unlike birds in the wild, mallard ducklings in rehabilitation facilities are exposed to a suite of captivity-specific factors including handling stress, unnatural sources of food and water, and the absence of a hen mallard.

Wittner (2003) reported a case where duckling survival improved when veterinary hospital cages with towel flooring were replaced by indoor mesh-floored brooders with running water drinkers. This success was attributed to improved drinking water access, and ducklings staying dry, overnight (Wittner 2005). However, similar, heated, mesh-floored housing is used at the two largest rehabilitation facilities in British Columbia, but survival rates do not match those reported by Wittner (2003), and running water does not appear to influence duckling growth or survival (Drake, *unpublished data*). This indicates that, while housing is important, other factors are strongly affecting survival. Often housing changes at rehabilitation facilities are accompanied by other modifications that make causal relationships difficult to determine. Reduced mortality may result from design changes, management changes, or reduced disease load in the new environment when compared to the older housing. Isolating and identifying factors that improve survival are important, as rehabilitation facilities have limited resources to spend on facility changes and need to make cost- and time-effective decisions. With this in mind, targeted, controlled experiments may be the best approach. One such experiment is described in Chapter 3.

Wildlife rehabilitators' primary interest is in improving the welfare of the animals in their care. Their code of ethics includes a duty to work constantly to improve the quality of care given to wild animals undergoing rehabilitation (Miller, 2000). Part of this improvement involves increasing our knowledge of species-specific needs as well as our knowledge of the differing needs of individuals. In Chapter 2, I use one facility's records to investigate the link between pre-admission treatment and duckling survival. This kind of analysis can be used to identify high-risk birds and allow rehabilitators to give them special attention. Chapter 3 describes an experiment intended to test a single husbandry variable: the addition of an older "mentor" duckling to novice broods. While rehabilitators can meet the physical needs of birds in care, it is often difficult to create an adequate social environment, particularly for young birds. This husbandry change was an attempt to mimic the presence of a hen mallard and to bring the captive environment more in line with the natural circumstances under which ducklings are reared.

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CHAPTER 2: ADMISSION TRENDS AND MORTALITY CORRELATES FOR MALLARD DUCKLINGS AT A WILDLIFE REHABILITATION FACILITY[1]

INTRODUCTION

Orphaned mallard ducklings make up 2.5 to 5% of the avian admissions to rehabilitation facilities in British Columbia (*derived from* Dubois 2003). One-week-old birds spend an average of 52 days in care before they fledge their flight feathers and can be released. During this period, the average mortality rate for these birds at the two largest facilities in the province is 35%. Although changes in care protocols may reduce some of this mortality, pre-admission treatment of mallards by the individuals who find them likely also has an impact on whether the birds survive in the rehabilitator's care.

Rehabilitation facilities keep records (case sheets) for animals in care. These forms provide information collected at the time the animal is admitted to the facility, and a record of treatments received by, and assessments of, this animal for the duration of time it spends at the facility. Often these records also include a questionnaire completed by the individual who found the animal ("the finder") and contain information on what happened to the animal before it arrived in care. When pooled, these records can provide information on admission numbers and patterns over time, common pre-admission treatments and events, mortality rates, and common diagnoses.

[1] A version of this chapter will be submitted for publication in the *Journal of Wildlife Rehabilitation* published by the International Wildlife Rehabilitation Council.

The objective of this study was to combine mortality data with the information provided by the finder and by staff on the day of admission, to identify important pre-admission effects. Defining relationships between pre-admission treatments and duckling survival may enable rehabilitators to identify ducklings that are at risk of dying in care, and allow care protocols to be adjusted accordingly.

Rehabilitators in B.C. have stated an interest in seeing data records used "as an educational tool, for research, and analyzed further to produce statistics" (Dubois 2003). Therefore, statistics were also compiled on admission trends, why ducklings are brought into care, and how ducklings are handled by the individuals who find them.

MATERIALS AND METHODS

Pre- and post-admission data from the Wildlife Rescue Association of British Columbia (WRA) in Burnaby, Canada, were collected from the original admission sheets for "uninjured ducklings" (as assessed by a staff person at admission), spanning 6 years (2001-2006). Data collection was limited to mallards that came in between April 1 and July 31 of each year, as this was the peak admission period. The data included "brood" data consisting of pre-admission information on groups of ducklings that were admitted together, and the "individual" data specific to each bird, such as admission weight and outcome.

Where data are reported at the individual level, the data set was limited to those birds that weighed less than 60 grams at admission. Where data are reported at the brood level, the dataset was limited to broods that had a mean weight of less than 60 grams. This cut-off was based on weight distributions and the fact that birds at or below this weight are less than one week old (Lokemoen *et al* 1990), this being the age range of interest. The majority (94.7%) of uninjured ducklings admitted to WRA fell below this weight. In total, 305 broods accounting for 937 individual ducklings were included in the final dataset.

Additional information on mortality was compiled using electronic data records from 1998-2004 at BC SPCA WildARC (WildARC) in Victoria, Canada. This dataset did not always contain specific staff assessments of bird condition at admission; hence, it was difficult to determine "uninjured" status. As a result, all birds that were described at admission as "critical", "lethargic", "injured" or as having been attacked by a cat, were not included. Excluding this last category is conservative as, at WRA, ducklings described as being attacked by a cat are not always injured. Admission weights were not included in WildARC records, therefore only uninjured birds described as "juveniles", "immature", or explicitly listed as being less than a week old were included. The final dataset contained 499 individuals.

Pre- and Post-admission Data

Pre-admission data were provided by the individuals who brought animals to the WRA. From this information it was recorded: whether the duckling/s received pre-admission food (y/n), water (y/n) and handling (y/n), how long ducklings were cared for by the finder before being admitted, and the reason why the animal had been captured. This information was less standardized and complete than information provided by staff. For example, no pre-admission information existed for animals that were admitted by the local humane organization (BCSPCA) or in other instances where the admitting party was not the finder. It is also likely that these data are less reliable than information provided by staff. Finders may be motivated to adjust their responses to match what they perceive would be acceptable to staff. As a result, the responses reported for such questions as “how long did you keep the animal before bringing it in?” or “was the animal handled a lot?” should be treated with caution.

Post admission data were collected by a staff person or by an experienced volunteer. The data included: admission date, brood size (the number of birds admitted together including those that were dead on arrival), individual weight (to the nearest gram), and survivorship (the date of death or the date of release).

Descriptive Statistics

Data were compiled on the number of broods admitted per year, the pattern of admissions over the season, the amount of time a brood spent with the finder, and the reason why birds were admitted.

The time broods spent with their finder was recorded in seven categories: (0) hatched at the center, (1) kept ≤ 1 h; (2) kept 1-5 h; (3) kept 5-12 h; (4) kept 12-24 h including birds described as “kept overnight”; (5) kept ≥ 24 h or one day; (6) kept ≥ 1 week. If the brood was transferred to the Vancouver Animal Emergency Clinic (AEC) prior to being brought to WRA (which occurred in approximately 3% of cases), the time spent at AEC was not included under the assumption that birds receive similar care at AEC as they do at WRA and that the pertinent information was the amount of time the bird spent with an inexperienced handler.

The reasons why broods were captured were divided into 5 categories, and then further divided into common sub-categories (Table 2.1). Information on whether the broods were fed, watered or handled was tabulated as ‘yes’ or ‘no’ responses. Correlations between pre-admission treatments and between treatments and admission weight were calculated.

From individual data, post-admission deaths were plotted against time in care using a subset of the WRA and the BC SPCA WildARC data sets. Analyses excluded all birds that were dead on arrival, euthanised in care, missing outcomes, and (at WRA) all birds used in the care protocol experiments in 2005 and 2006. The resulting data consisted of 795 individuals for WRA and 484 individuals for BC SPCA WildARC.

Dates of admission and death were used to calculate “days survived in care”. Birds that died on the day of admission were recorded as surviving 0 days, and those that died overnight were recorded as surviving 1 day. All descriptive statistics were tabulated in Microsoft Excel for Mac (2004, Version 11.2.3, Microsoft Corporation).

Mortality Correlates

Correlations between pre-admission factors and mortality in care were calculated from the above WRA release/mortality subset. The pre-admission

Table 2.1. Categorical breakdown of reasons for duckling admission and their description

Category	Sub-Category	Description
1. Unknown	**Without hen**	Where ducklings were found without a hen in any situation other than on a road. Includes birds found in backyards, parks, parking lots and lumber-yards.
2. Road-related	**Alone on road**	Where ducklings were found on a road or sidewalk without a hen and the finder had no knowledge of what had happened to the hen.
	Hen fled	Where the hen was seen crossing a road and then abandoning her ducklings when they unable to mount the curb or because she was frightened by traffic or people.
	Hen hit by car	Where the hen was run over while crossing a road and surviving young were caught up.
3. Predation	**Domestic**	Where ducklings were collected when attacked by a dog or a cat.
	Wild	Where ducklings were collected when attacked by a wild animal. The majority of reported attacks were from northwestern crows and bald eagles but there were also coyote and mallard attacks on broods
4. Trapped	**Storm Drain**	Where ducklings were described as being found trapped in a storm drain, vertical pipe, manhole or sewer
	Man-made water source	Where ducklings were found alone in manmade ponds, pools or fountains: presumably unable to climb out while the hen could
	Structure	Where ducklings were found trapped in a manmade structure. Includes parkades, warehouses, buildings, and one instance where ducklings were trapped by a fence
5. Other	**Hen injured**	When ducklings and an injured hen were brought in together
	Human interference	Where a person deliberately takes a duckling from a brood or harasses/attacks broods such that the hen flees
	Hen dead, cause unknown	Where the hen was found dead but the cause was unknown

factors tested were: whether birds received food and water, whether birds were handled, the amount of time birds spent with the finder, admission weight, brood size, and when in the breeding season the birds were admitted. Because the response variable was categorical and binary (died/survived) a multiple logistic regression analysis was used (Hosmer and Lemeshow 1989; Dohoo *et al* 2003; Schwarz 2006).

Patterns in post-admission mortality indicated two distinct trends: increasing deaths with time with the finder for birds that remained with the finder for up to 24 h, and decreasing deaths with time with the finder for birds that remained with the finder for more than 24 h. As few birds were kept for more than 24 h, a multiple logistic regression could not be done using these birds and only the first trend was analyzed using this technique. A series of single-variable logistic regressions of pre-admission factors against deaths were done for birds that were kept for more than 24 h.

≤ 24h with the finder

Separate analyzes were run for deaths that occurred within the first 2 days after admission and for deaths that occurred after 2 days, but within the first week. Preliminary tests had shown no correlation between deaths after the first week in care and any pre-admission factor and so this period was not analyzed.

To eliminate a strong correlation between feed and watering, both were merged into a single categorical variable as follows: (0) given no food or water,

(1) offered food only, (2) offered water only, (3) offered food and water. If one field had been filled and the other left blank, the data was recorded as (1) or (2).

Finally, birds that were with the finder for longer than 5 h but for less than 24 h were merged into a single category because few birds were kept between 5 h and 12 h.

Each bird was considered to be an independent data point for the purposes of the analyses despite more than 49% being admitted into care as members of a brood of 2 or more individuals. Birds admitted as broods are not truly statistically independent of each other given that they are likely related (although large variations in weight indicated possible brood mixing in some admission groups) and share pre-admission treatment. However, the observed probability of mortality did not differ across broods making it acceptable to treat each bird as an independent data point. This conclusion was reached by looking at the models' dispersion values (Goodness-of-Fit Pearson χ^2/df) and finding that none were over- or under-dispersed (Schwarz 2006).

Important variables were identified by independently testing their relationship to mortality using logistic regressions and contingency tables (Sall *et al.* 2001). Contributing variables and their interactions were then entered into a multiple logistic model and a stepwise procedure, with P to enter or leave of 0.25, was used to identify the variable subset that best predicted the observed mortality. Backward-stepwise analysis was then used to remove any remaining variables that did not notably contribute to the final models (P>0.10). The overall model evaluation, Goodness-of-fit measures, variable effects, and odds ratios for continuous variables were then recorded. Independent contrasts were run for categorical variables in order to accurately calculate their odds ratios (Schwarz 2006). Because deaths were common in the data set, the reported odds ratio overestimate the more intuitive risk ratio (Zhang and Yu 1998). For categorical variables, the risk ratio was estimated from the odds ratio using an approximation formula created by Zhang and Yu (1998).

All models showed a large overlap in predicted probability-of-death values for birds that did not die and those that did. Best probability cut-offs (such that false positives and false negatives were minimized) were determined using receiver operating characteristic (ROC) curves (Dohoo *et al* 2003). As rehabilitators are more interested in accurately identifying birds at risk of death, I increased the models' sensitivity by shifting the probability threshold for identifying a bird as "predicted to be dead" down to the point where at least 75% of the observed deaths were identified correctly. This shift reduces the specificity of the models (i.e. the accuracy of identifying birds "predicted to live") but errs on the side of caution. The predictive powers for each model are reported. All analyses were done using JMP Statistical Package (Version 6, 2005, SAS Institute Inc.).

RESULTS

Descriptive Statistics

An average of 156 ducklings from an average of 51 independent admissions (broods) were admitted per year. This constituted 10.0% of the total individuals and 3.4% of the independent admissions brought to the Wildlife Rescue Association during the April 1 – July 31 period (Table 2.2). Admission numbers rose exponentially through April, and more than half of all broods arrived in May. After this peak, there was a more gradual decline towards August (Figure 2.1). More than half of admissions (51.5 %) were single birds, although groups of 2-5 were relatively common. The largest single group admitted over the 6 years consisted of 13 ducklings (Table 2.3).

One-half of the admissions were related to roads or other human structures (Table 2.4). 37% of birds were found on roads, and 13% in other man-made structures. Predation and direct human intervention were less common reasons cited for collecting birds.

The majority of birds were admitted within 5 h of being found (Figure 2.2). Most were not offered food or water, and less than one-half were described as handled “a lot” while in the custody of the finder (Table 2.5).

Broods that were given food were more likely to receive water: 29.2% were given both and 58.0% were given neither (Likelihood ratio χ^2 107.41, P< 0.0001, n=195). As would be expected, ducklings kept by the finder for a longer period of time were more likely to receive water and/or food. Of the broods that were brought to the center within 5 h, only 17.1% were offered water and 12.8% were offered food, but this increased to 66.7% offered water and 74.6% offered food for birds brought in within 5-24 h (Likelihood ratios: χ^2 65.00, P< 0.0001, n=176 for water; χ^2 102.34, P< 0.0001, n= 188 for food).

Table 2.2. Yearly count and % of total cases/individuals admitted to the Wildlife Rescue Association of BC that are mallards. Each case may consist of a brood or litter of several animals.

Year	Duckling Cases	Total Cases (All Animals)	Individual Ducklings	Total Individuals (All Animals)
2001	41 (2.5%)	1659	115	*
2002	56 (3.3%)	1703	148	*
2003	64 (4.4%)	1463	181 (10.5%)	1717
2004	57 (3.9%)	1462	209 (11.3%)	1846
2005	43 (3.0%)	1412	133 (7.8%)	1685
2006	44 (3.5%)	1245	151 (9.9%)	1524
Mean	51 (3.4%)	1491	156 (10.0%*)	1693

*Data not available

Table 2.3. Brood size distribution (count and %).

Birds per brood	Number of broods	Percentage of broods
1	157	51.5%
2	32	10.5%
3	19	6.2%
4	16	5.2%
5	22	7.2%
6	10	3.3%
7	14	4.6%
8	8	2.6%
9	11	3.6%
10	10	3.3%
11	3	1.0%
12	2	0.7%
13	1	0.3%

Table 2.4. Reasons for admission (n= 225 broods).

Reason for Admission	%
1) Unknown	
Found without hen, not by road	**38%**
2) Road related	
Found without hen, reason unknown	23
Hen hit	10
Hen fled	4
Total	**37%**
3) Trapped	
Storm drain	5
Building	5
Pool/fountain	3
Total	**13%**
4) Predation	
Domestic	4
Wild	4
Total	**8%**
5) Other	
Human interference	2
Hen found dead/injured, cause unknown	2
Total	**4%**

Table 2.5. Pre-admission treatment of mallard broods as described by the finder.

Treatment	YES	NO
Provided Food	80 (37.6%)	133 (62.4%)
Provided Water	75 (37.5%)	125 (62.5%)
Handled “a lot”	61 (31.1%)	135 (68.9%)

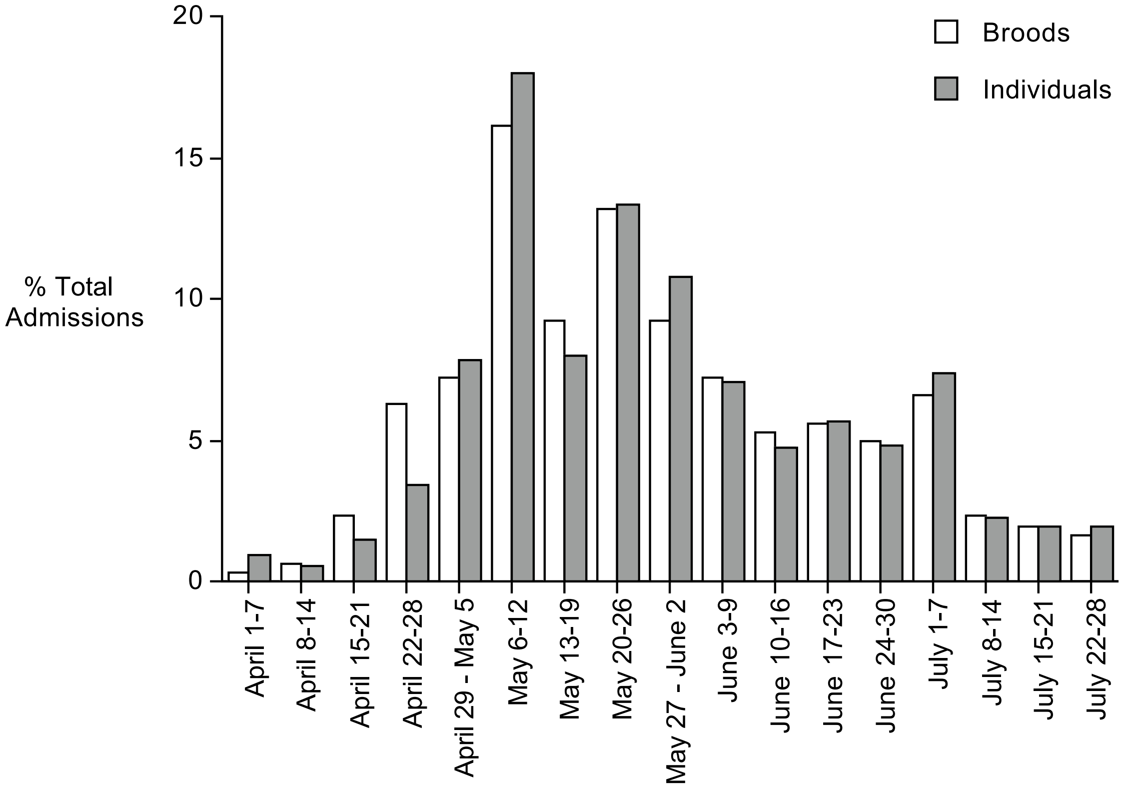

Figure 2.1. Percent of total broods (n=305) and individuals (n=937) admitted by 7-day intervals for April1-July 28 (2001-2006).

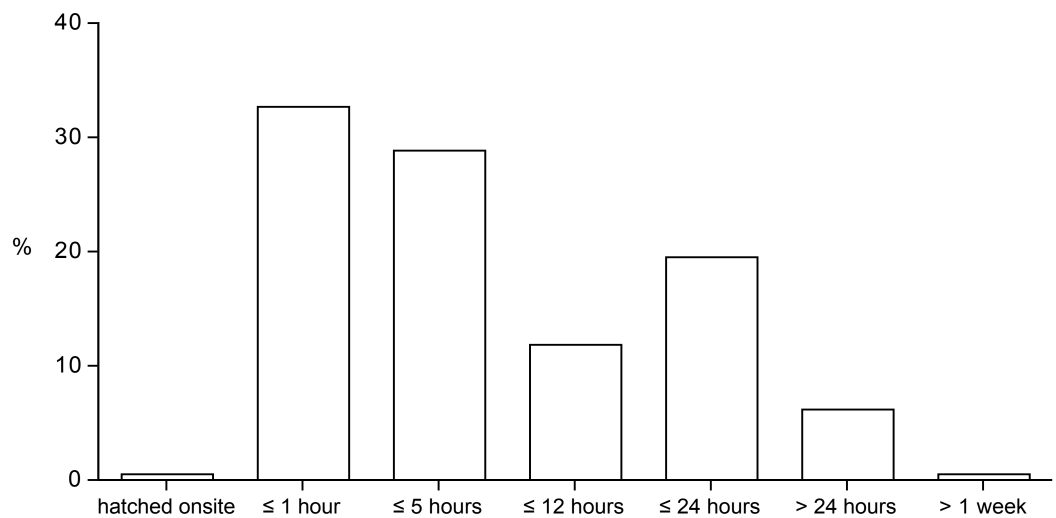

Figure 2.2. Percentage of independent cases by time with finder (n= 211 broods)

The likelihood of being handled was not related to whether broods received food, or water, nor to the length of time in the finder's care.

Mean brood admission weight was slightly higher for birds that were fed or watered, but the effects were small: birds that received food weighed about 1 g more than those that did not, and birds that received water weighed about 2 g more than those did not. Effects of feeding and watering, tested by Wilcoxon/K-W χ^2 approximations (*df*=1 and n=197 for feeding and n=184 for watering) showed $P<0.05$ for feeding and $P<0.01$ for watering. Weight showed no relationship with brood size or handling.

The mean weight of birds in the dataset was 31 g (range: 16 g – 60 g). This matched the mean hatch-weight for the species of 31.8 ± 3.4 g (range: 27.2 g - 40.6 g, n=27) (Nelson 1993). Many birds were light however: 19% of individuals fell below 28 g and 7% fell at or below 24 g. 38.1 % of the 577 birds that fell within one standard deviation of the literature's mean hatch-weight (i.e. between 28 g and 35 g) died, while 58.1% of the 160 birds that fell below this range died.

The mean survival of ducklings was 58.2% at WRA and 71.4% at WildARC. Deaths were much more common during the first few days after admission, with 15.0% and 14.3% of all ducklings dying on the day of, and the day after, admission at WRA and WildARC, respectively. At WRA, 86.1% of all deaths had occurred by the end of the first week, and 91.3% by the end of the second. WildARC mirrored this trend with 84.1% of deaths having occurred by the end of the first week and 86.4% by the end of the second week (Figure 2.3).

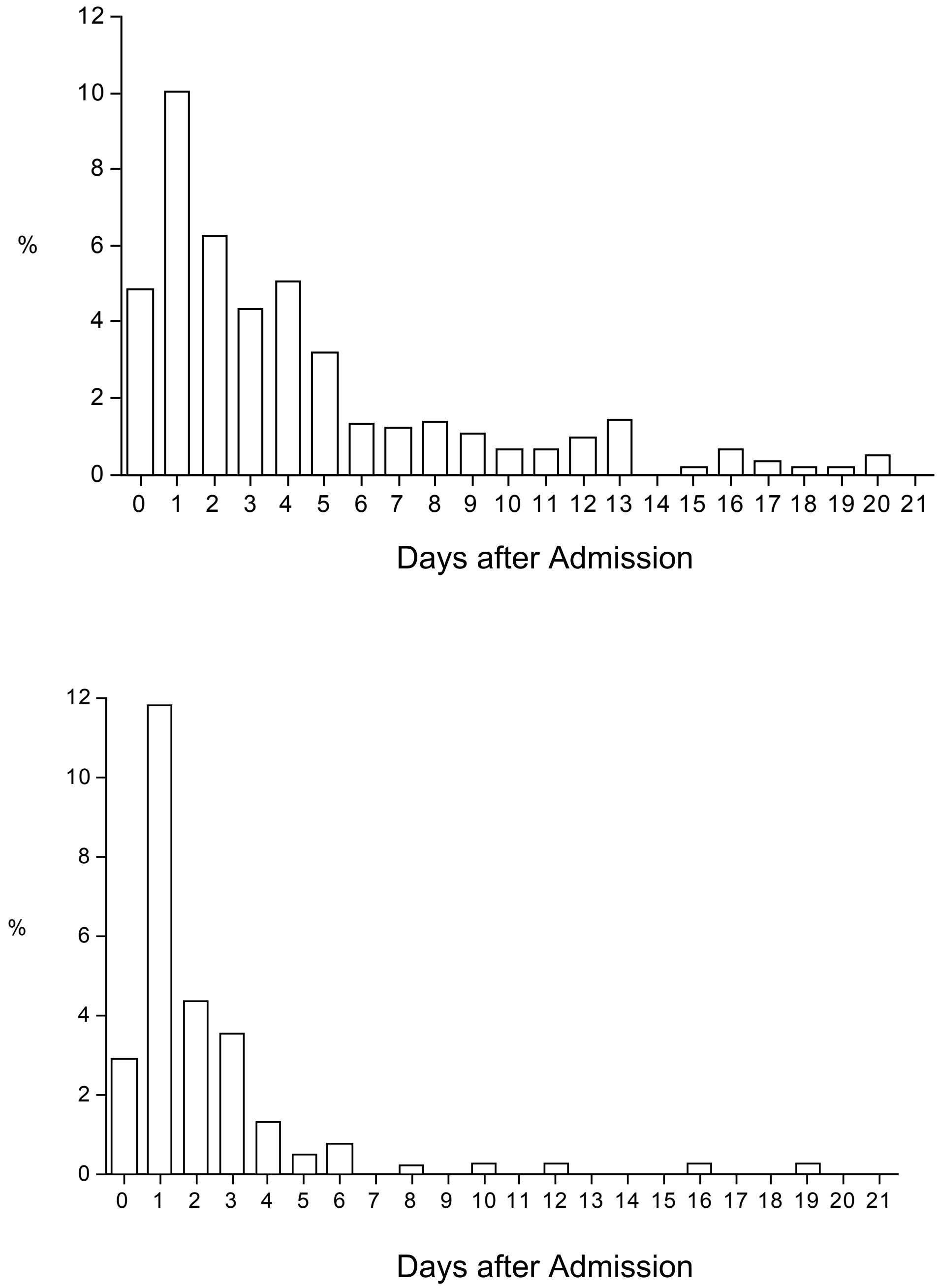

Figure 2.3. Adjusted percentage of ducklings that died during the first 3-weeks after admission. The bars show the number of birds that died on a given day, expressed as a percentage of the number of birds that survived to that day.

Above: Wildlife Rescue Association of BC, (n=795 birds, 313 deaths).

Below: BC SPCA WildARC (n=484 birds, 136 deaths).

Mortality Correlates: ≤ 24 hours with the finder

2-day mortality

The final model included admission weight, time with the finder, brood size and the interaction of brood size and time with the finder (Table 2.6). This model was a significantly better predictor of the outcome than the intercept alone ($\chi 2$ = 60.46, *df* = 6, P<0.0001, n=423), but gave a relatively poor overall fit to the data ($R^2(U)$ =0.14).

Birds brought in within 1 h of being found did not fare any better than those brought in within 5 h; however, birds brought in after 5 h had double the probability of death than those brought in after a shorter time period. Individuals in larger broods were more likely to survive than those in smaller groups. The significant interaction between the time spent with the finder and brood size was driven by a significant difference in the effect of brood size on survival between birds kept for 1-5 h and those kept for 5-24 h. Increased brood size was strongly associated with improved survival for ducklings kept for 1-5 h, but for birds kept for 5-24 h brood size no longer improved survival. Heavier birds had a tendency to fare better than lighter animals regardless of other factors. Effects tests, odds ratios, and independent contrasts are summarized (Table 2.6) and the percentage of birds that died in the dataset are reported for these significant pre-admission factors (Table 2.7).

The overall model was adjusted for sensitivity such that birds with a predicted probability of dying greater than 0.16 were considered to be “at risk”. With this threshold, the model identified 81.6% of the 87 birds that died as at risk and

Table 2.6. Effect of variables, unit odds ratios (OR), and whole model evaluation for logistic model predicting duckling deaths occurring within 2 days of admission. Sub-categories of "Time with finder" describe independent contrasts and were not entered as variables in the original model.

Predictor		***df***	**Wald $\chi 2$** (L-R $\chi 2$)	***OR***	**P**
Time with finder (*overall model test*)		**2**	**35.27**	.	**<0.0001**
≤1h vs.1-5h		1	(0.02)	0.94	0.88
≤5h vs. 5-24h		1	(37.55)	5.05	<0.0001
Brood size		**1**	**8.13**	**1.14**	**0.0043**
Admission weight		**1**	**3.19**	**1.06**	**0.0743**
Brood size x time with finder		**2**	**18.62**	**.**	**<0.0001**
Model Test		***df***	**$\chi 2$**		**P**
Overall model evaluation					
Likelihood ratio test		6	60.43		<0.0001
Goodness-of-fit test					
Pearson $\chi 2$		416	388.70		0.828
R^2 (U)	0.14				
Overdispersion (Pearson $\chi 2/df$)	0.93				

Table 2.7. Observed percentage of birds that died within 2 days broken down according to significant pre-admission factors (n=423)

Factor		**n**	**% died**
Time with finder			
	< 1h	146	12.3
	1-5h	158	13.9
	5-12h	71	29.6
	12-24h	47	55.3
Admission weight			
	16-25g	41	43.9
	26-30g	256	19.1
	31-35g	97	13.4
	36-60g	28	25.0
Brood size: ≤ 5h with finder			
	1	62	24.2
	2 to 3	34	29.4
	4 to 6	89	11.2
	7 or more	119	4.2
Brood size: 5-24h with finder			
	1	34	38.2
	2 to 3	28	28.6
	4 to 6	9	44.4
	7 or more	47	46.8

identified 61.6% of the 336 birds that survived as not at risk. Mortality thresholds based on this model are presented as a function of weight and brood size for different times ducklings have spent with the finder (Figure 2.4). This figure offers a way of identifying, at admission, birds that are most at risk of dying within the first 2 days of care.

Mortality between 3 and 7 days

The final model for predicting duckling deaths after 2 days and within the first week of care contained the following variables: whether birds were given food or water, how long they were kept by the finder, and admission weight (Table 2.8). Again, the model was significantly better at predicting mortality than the intercept alone ($\chi 2$ = 32.87, *df* 4, P<0.0001, N=310), but was a poorer fit than the 2-day model (R^2(U)=0.10).

Birds that were not given food and/or water had a 2.4 times greater probability of dying than those that were. Birds kept by the finder for 5-24 h had 1.8 times higher probability of dying as those kept for ≤ 5 h. Finally, higher admission weight was associated with increased likelihood of survival. Effects tests, odds ratios and independent contrasts are summarized (Table 2.8) and the percentage of birds in the original dataset that died are reported for these significant pre-admission factors (Table 2.9).

Mortality Correlates: > 24 hours with the finder

Only 36 birds (14 broods) in the mortality data set were kept for longer than 24 h by the finder. The overall death rate among these birds (36.1%) was lower than that of those kept ≤ 24 hours (46.8%). All of these birds were

Table 2.8 Effect tests for variables, unit odds ratios (OR), and whole model evaluation for logistic model predicting duckling deaths occurring on days 3-7 in the rehabilitator's care. Sub-categories of "Given food and/or water" and "Time with finder" describe independent contrasts and were not entered as variables in the original model.

Predictor		***df***	**Wald $\chi2$** (L-R $\chi2$)	***OR***	**P**
Given food and/or water *(overall model test)*		**1**	**12.32**	**.**	**0.0004**
Food and/or water vs. nothing		1	(15.16)	5.13	<0.0001
Admission weight		**1**	**8.00**	**1.15**	**0.0047**
Time with finder *(overall model test)*		**2**	**6.68**	**.**	**0.0354**
≤1h vs.1-5h		1	(2.21)	0.60	0.14
≤5h vs. 5-24h		1	(4.54)	2.38	0.033
Model Test		***df***	**$\chi2$**		**P**
Overall model evaluation					
Likelihood ratio test		4	32.87		<0.0001
Goodness-of-fit test					
Pearson $\chi2$		305	295.35		0.644
R^2(U)	0.10				
Overdispersion (Pearson $\chi2/df$)	0.97				

Table 2.9. Observed percentage of birds that died within 3-7 days broken down according to significant pre-admission factors (n=310).

Factor		**n**	**% died**
Time with finder	< 1h	121	26.4
	1-5h	122	16.4
	5-12h	44	27.3
	12-24h	21	14.3
Admission weight			
	16-25g	17	41.2
	26-30g	194	26.3
	31-35g	78	7.7
	36-60g	19	15.8
Food and/or water			
	Yes	78	11.5
	No	209	27.8

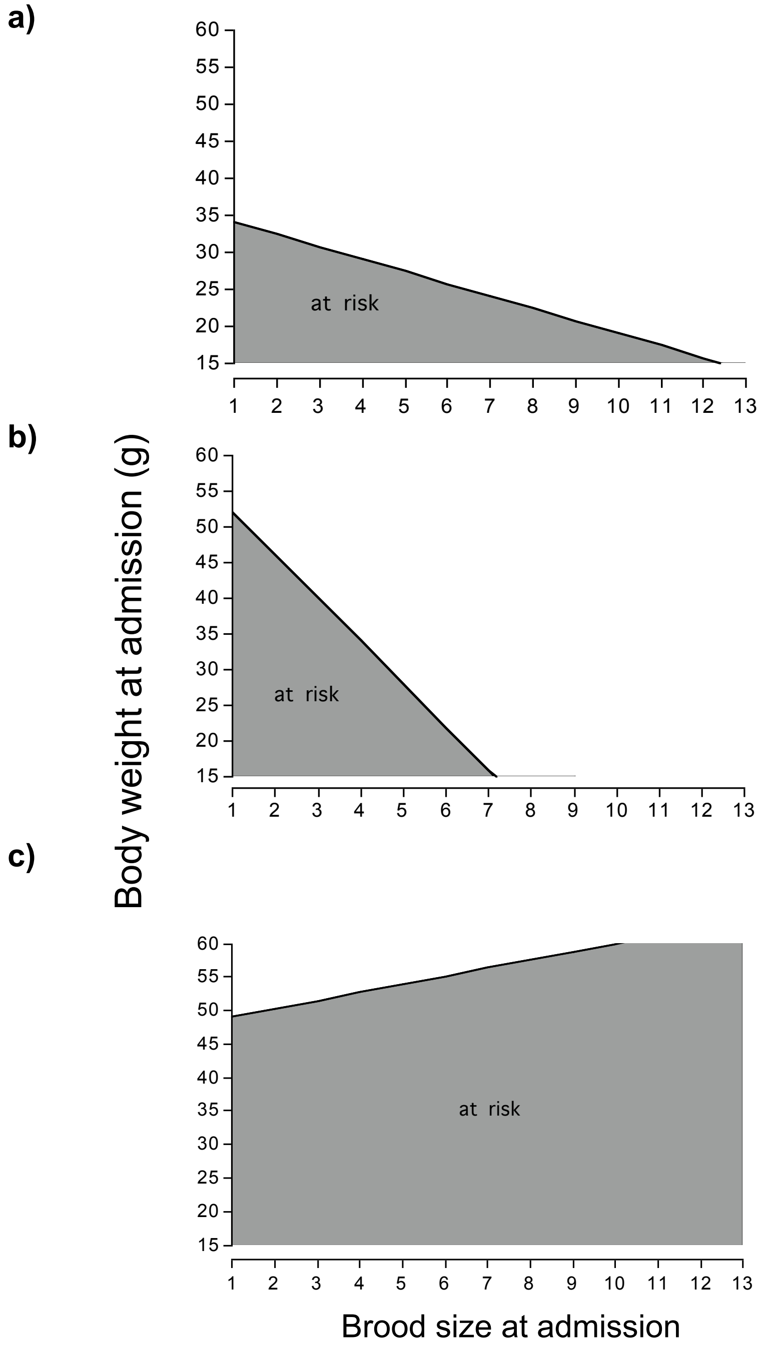

Figure 2.4 Predicted 2-day mortality thresholds for brood size, duckling body weight at admission, and time kept by the finder. Birds that fall into the shaded region of the graph are predicted to die in the model and should be considered at risk. a) Birds kept for ≤ 1h, b) Birds kept for 1-5h, c) Birds kept for 5-24h

described as being fed, and all but one were described as being offered water. Although this subset was too small to produce a meaningful predictive model, independent logistic regressions identified birds that arrived late in the breeding season and those with low admission weight as significantly more likely to die within 2 days of admission ($\chi 2 = 7.76$, df =1, $P<0.01$ for admission day, $\chi 2 = 8.99$, df =1, $P<0.01$ for admission weight).

DISCUSSION

Admission Trends

The peak admission period for the WRA coincides with the peak hatch period for mid-latitudes of the mallard breeding range (Drilling *et al* 2002). This pattern, coupled with the low mean weight of birds brought into care, would indicate that the majority of ducklings are orphaned shortly after hatching, probably after leaving the nest (which typically occurs 13-16 h after hatching (Drilling *et al* 2002)) but before reaching water. The observation that the largest known source of admissions was road incidents, and that 38% of these involved a hen leading her brood across the road, offers support for this argument. However, in prairie wetlands hens may move their broods additional 2-3 times within the first week making it possible that some broods may have been older when they were collected off roads (Dzus and Clark 1997). Periods of overland movement are considered a more dangerous time for mallard ducklings than periods spent on water as the risk of predation and of separation from the hen is thought to increase when broods are on the move (e.g. Ball *et al* 1975, Rotella and Ratti 1992 but see Dzus and Clark 1997 for conflicting results). The large proportion of birds in this study that were collected during overland travel (i.e. trapped, on roads, and possibly a large number of the birds found alone), coupled with the predominance of very young birds, would appear to support the assumption that periods of travel are more dangerous than stationary periods for young ducklings.

As road-related abandonment and entrapment appear to be the most common known reasons for admissions, they would be the most logical issues to address within a community. Road incidents are likely to be concentrated where roads divide nesting and pond sites; birds may be regularly trapped in specific areas (such as public fountains) as well. Having finders identify the locations where birds are found on a posted area map may locate such "hot spots" in the rehabilitator's area.

Landscape changes might be used in urban areas to discourage nesting in problem sites and/or encourage nesting in more appropriate locations. Areas can be made less attractive to nesting mallards by reducing dense vegetation less than 1 m in height and removing overhanging, concealing cover (Drilling *et al* 2002). The provision of artificial nest structures in areas where safe routes to water exist will encourage birds to choose these areas, as mallards readily use such structures when they are available (Drilling *et al* 2002)).

Artificial water bodies that consistently cause entrapment may be fitted with duckling ramps. Such ramps have been successfully used in Golden Gate Park, San Francisco in the USA and Holland Point Park, Victoria in Canada. Ducklings seeking a way to mount roadside curbs will trace the road edge, which may be why they frequently fall through storm drain gratings. Reducing road crossings would, in turn, reduce this problem. Alternatively, drains fitted with finer gratings (even temporarily during the hatching season) would prevent ducklings from falling through.

Mortality Patterns and Correlates

Deaths were concentrated in the first few days after admission at both centers. This trend could possibly indicate that: 1) many ducklings are in poor heath at admission, 2) many ducklings are unable to adapt to the captive environment, or possibly 3) that Duck Hepatitis Virus exists in the captive environment (as the virus causes early mortality, but rarely affects ducklings after 4 weeks of age (Hess and Paré 2004)). Post-mortem analysis is needed to eliminate disease as a cause of early mortality. The analysis of pre-admission factors identified several traits that were linked to post-admission survival. For birds brought to the center within the first 24 hours of being found, rapid admission was associated with higher survival rates in the first week in care. In addition, large brood sizes improved the chances of survival when birds were brought into care rapidly and reduced the critical weight at which birds were considered at risk even though lighter birds fared worse than heavier ones overall. This beneficial effect of large brood size may be due to increased thermoregulation or decreased stress for larger groups. Small birds expend substantially more energy on thermoregulation than larger birds (Rhymer 1988) and, if birds are kept without heat by the finder, the body heat of brood mates may prevent an ultimately fatal loss of energy. Alternatively, larger groups are more likely to be housed as a single brood unit by the rehabilitator, which may limit social stress. Singletons and pairs are likely to be mixed with unrelated broods already in care and experience aggressive interactions where lighter body sizes would place individuals at a disadvantage and could result in increased deaths.

Overall, heavier birds were probably more likely to survive than lighter animals because weight reflects both age and body condition. Birds that weighed less than 28 g likely had little in the way of energy reserves, given that the mean hatch-day weight of a mallard is 31.8 ± 3.4 g (Nelson 1993). Mallards retain their yolk sac in their abdomen after hatching. This provides them with the energy needed to move overland from nest to water (Baldassarre and Bolen 2006). Mallards rely on these energy reserves for the first 3 days after hatching (Sediger 1992) and as a result their weight may decline during this period. Two birds admitted to WRA weighed only 16 grams at admission: a dramatic decline from expected hatch weight that suggests that some of the mallards admitted to WRA never fed in the wild.

Birds were less likely to die between days 3 and 7 of care if the finder provided them with “food and/or water” before admission. Oddly, this variable was not significant in the 2-day mortality model. The reason for this appears to be that, among birds that were kept by the finder for more than 5 h, individuals that were offered food and/or water were more likely to die within the first 2 days than those that were offered nothing. As described in the results, whether birds were offered food and/or water was strongly correlated with the amount of time the birds spent with the finder. This meant that "time with finder" alone was enough to explain deaths in the 2-day mortality model. It is questionable then, that the offering of "food and/or water" has a positive effect. The advantage it conferred in days 3 to 7 may simply be an artefact of the larger number of deaths for fed and/or watered birds within the first 2 days of care. Specifically, the initial disadvantage created by offering ducklings food and/or water may have meant that only the hardiest of these birds survived into the 3-7 day period where they did better than those birds that had been given nothing. The pooling of all first-week mortality data indicates that this is the case. Forty percent of the ducklings given nothing and 38% of the ducklings given food and/or water died within the first week. Although food alone might be beneficial, offering water to birds kept for more than 5 h appears to be associated with a greater number of deaths (Figure 2.5). It may be that these birds were offered water in the form of a pool and lost body heat as a result.

The provision of food and water to animals by the finder is often discouraged by rehabilitators because inappropriate feed may be harmful and water may be a drowning hazard to weakened animals. According to this data set, offering food and/or water has little effect on bird survival.

It is unclear why fewer birds died when they were kept with the finder for longer than 24 h than when kept by the finder for less than 24 h. It is possible the early deaths seen within the first few days of the rehabilitator's care occur in the finders' care in these situations. If so, many duckling deaths would happen "off the record" when birds were kept by the finder for more than 24 h and this would explain the reduced death rate for these animals after admission.

This information has several practical applications. Body weight and brood size are not within the rehabilitator's control, but special care can be given to birds that are considered "at risk" to reduce deaths. Practical recommendations would include: 1) Assuming that energy loss is the root cause of death in "at risk" birds, these birds should be housed at higher temperatures (32ºC is the maximum temperature suggested for domestic ducklings) and provided with highly energetic and palatable food in order to encourage rapid feeding may reduce deaths; 2) Close attention should be paid to the practice of mixing small broods in case stress arising from aggression contributes to deaths; 3) Rapid admission of animals should continue to be encouraged as this is clearly beneficial.

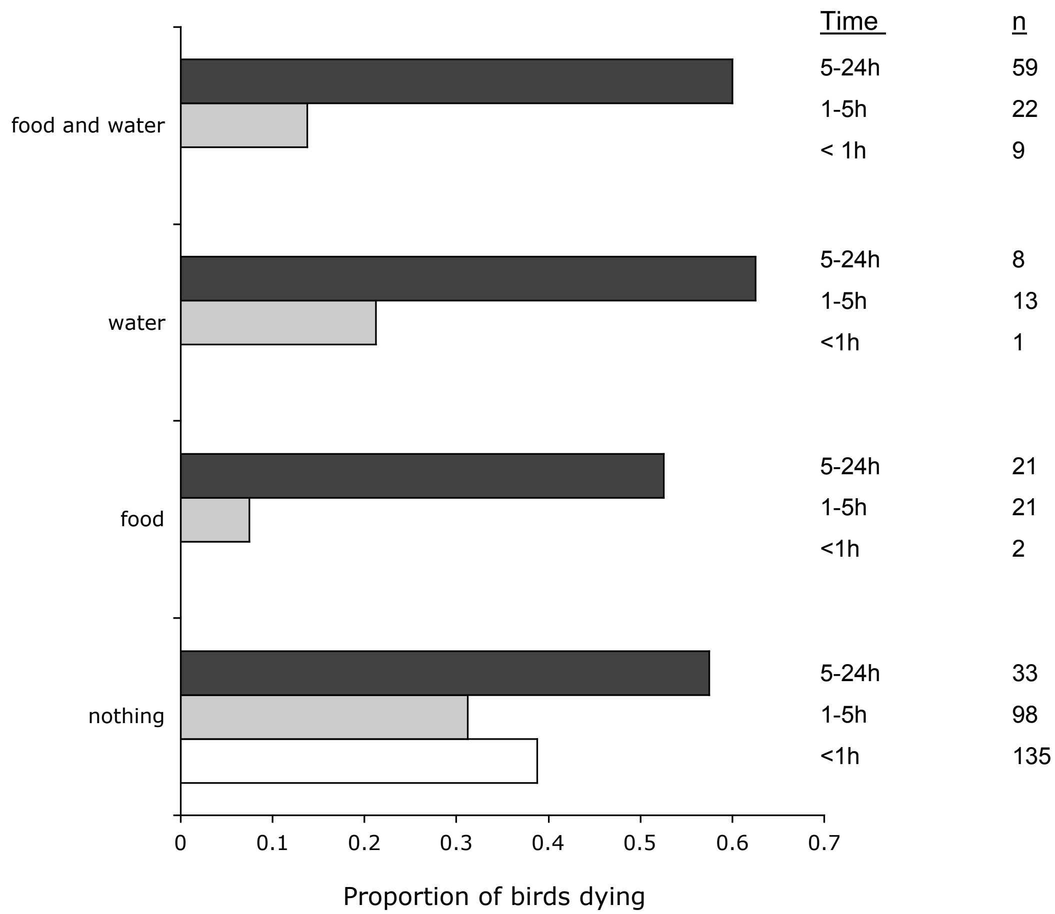

Figure 2.5. Proportion of birds dying within the first week of care broken down according to food and water treatment. Bars represent different periods of time the birds were kept by the finder. The number of individuals per category is listed next to each bar. Overall 40.5% of ducklings offered nothing died while 37.8% of those offered food and/or water died.

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CHAPTER 3: THE EFFECT OF PROVIDING "MENTOR" BIRDS TO MALLARD DUCKLINGS AT A WILDLIFE REHABILITIATION FACILITY[2]

INTRODUCTION

In contrast to the helpless nestling birds that flood rehabilitation facilities during the summer months, precocial birds such as ducks often require the rehabilitator to provide only a clean environment, the appropriate temperature, and ample food and water. Despite this apparent self-sufficiency, many ducklings die in care. At the two largest rehabilitation facilities in British Columbia, Canada, the six-year average mortality rates for uninjured mallards brought in when less than one week old was 29% and 42% respectively. Because many (35-48%) of these deaths occur within the first 2 days after admission, they are likely due to the inability of some individuals to adapt to captive circumstances.

The above mortality rate is similar to that occurring in the wild: field studies in North America generally estimate 30-day post-hatch survival to be below 60% (Hoekman *et al.* 2004; Orthmyer and Balland 1990; Gendron and Clark 2002, Petrie *et al.* 2000; Maisonneuve *et al.* 2000) with the majority of deaths occurring within the first few days after hatching (Dzubin and Gollop 1972). However, deaths in the wild are often attributed to environmental stressors (food limitation, extreme temperatures) and predation. Orphaned mallard ducklings raised in

[2] A version of this chapter will be submitted for publication in the *Journal of Wildlife Rehabilitation* published by the International Wildlife Rehabilitation Council.

wildlife rehabilitation facilities experience no predation and limited environmental stresses. Rather, unlike their wild counterparts, they are exposed to a suite of captivity-specific factors including handling stress, unnatural housing, unnatural sources of food and water, and the absence of the hen mallard. Deaths might be reduced in captive conditions if a means of reducing the impact of these potential stressors could be devised.

The use of a surrogate hen is a potential way to reduce stress in captivity. Hens likely induce rest periods in young birds and assist them in regulating their body temperature (Dzus and Clark 1997; Krijgsveld *et al* 2003). Hens also transfer waterproofing onto down which in turn reduces heat loss when ducklings are wet (Rodenburg *et al* 2005). In addition, hens cue feeding behaviour (Todd 2007) and may decrease separation distress. The use of surrogate mothers to raise fowl is common in bird husbandry. Breeders have traditionally used broody domestic chickens to rear various kinds of fowl including geese, pheasants and ducks. Foster offspring are generally kept with the hen for 3-6 weeks after hatching. Recently, exotic ground-bird species such as the South American curassow (*Pauxi* sp.), Blue crane (*Anthropoides paradisea*), and the Ocellated turkey (*Meleagris ocellata*) have been successfully reared in captivity by domestic hens (Todd 2007). In other studies, domestic turkey poults have been seen to adopt more normal behavioural patterns when fostered by wild turkey hens (Duncan *et al* 2004). Interestingly, these adoptive hens did not encourage feeding but instead induced rest periods which, the authors suggest, allow poults to conserve energy during development and could serve to reduce "starveout" in commercial operations (Duncan *et al* 2004).

Despite these potential advantages, the use of domestic broody hens to rear wild ducklings is not desirable. Disease transmission is a major concern, as ducklings will eventually be released and mix with wild, migratory populations. Many rehabilitators do not retain non-releasable wild birds in captivity (Dubois 2003), and thus could not use non-releasable mallard hens for duckling care. As an alternative to surrogate hens, young birds may be used as companions or "mentors". These mentors are young birds that have adapted to captivity, and that exhibit healthy behaviour patterns that the ducklings can imitate. The Cochrane Ecological Institute (an endangered species breeding and wildlife rehabilitation facility in Alberta) uses poultry chicks for this purpose (Cochrane Ecological Institute 2005). These chicks feed readily in captivity and encourage ducklings to do the same (Cochrane Ecological Institute 2005). The Houston Zoo has housed domestic chicks with young pheasants, Ruddy ducks (*Oxyura jamaicensi*), curassow (*Pauxi* sp), and Guinea fowl (*Numida* sp) as a means to encourage feeding and reduce imprinting on staff (Todd 2007). Studies on domestic turkey poults provide further support for the concept by showing that young birds can be stimulated to feed by housing them with broiler chicks (Savory 1982). Similarly, the use of mallards as "tutors" for other mallards, scoters (*Melanitta* sp.) Harlequin ducks (*Histrionicus histrionicus*), and Long-tailed ducks (*Clangula hyemalis*) has been suggested as a way to prevent starveout in young birds (Bourne WILDPro).

The use of one-week-old mallards to mentor very young duckling broods is a practical option for rehabilitators. Such birds do not introduce novel diseases into the care facility and, as they themselves will eventually be released, their use does not require keeping non-releasable birds. Personal experience at the Wildlife Rescue Association of British Columbia (WRA) in 2005 indicated lower mortality among novice ducklings provided with a single duckling that had been at the facility for at least one week and had adapted successfully to captive rearing. As a result, a formal test was conducted in 2006 to assess the impact of this practice. It was anticipated that mentors would reduce brood deaths, encourage rapid weight gain, and produce broods with better body condition by the end of the first week in care.

MATERIALS AND METHODS

General Care

Sixty-six ducklings (9 broods) were included in the study between May 7 and June 29, 2006. All were admitted to WRA by members of the public. Upon admission ducklings were housed in cardboard boxes placed on an electric heating pad set at “low” until they were banded and assessed, generally 20-60 min after admission. Birds that were in visibly poor or critical condition, had physical injuries, or weighed more than 60 grams were not included in the study. Additionally, birds admitted as singletons or in pairs were not used. As a result, all 66 birds were uninjured orphans of less than 1 week in age. Birds that did not meet the experimental criteria were placed in regular facility care.

Ducklings were housed during the experiment in standard stacked commercial poultry brooders with wire mesh flooring (Petersime Brood-unit Model 25D20, Petersime Incubator Company, Gettysburg, Ohio). Each level of the brooder was separated into two cages by a central partition. Each cage contained a heated section separated from the rest of the cage by a plastic curtain (Figure 3.1). The temperature within the heated section was set to 31 ˚C to reflect the recommended temperature of 30-32 ˚C for raising commercial ducklings in their first week (Clauer and Skinner Raising Waterfowl; Hamre 1994; Dean and Sandhu 2001). Heat was produced by an overhead resistor coil (whole brood-unit: 1040W, 115V) located in a vent 20 cm above the floor. Actual temperature within the brooder varied throughout the day, and along with humidity, was measured twice daily. Perforated rubber matting (Magic Stop, generic cupboard lining) was used to reduce temperature fluctuations and make movement easier for smaller birds by reducing the mesh size (Figure 3.1).

Water troughs were provided and held approximately 3L of water when full. *Ad libitum* Gamebird Starter (Pro-form Feeds, (26% protein) Unifeed Chilliwack, BC) and mixed shredded greens (primarily romaine lettuce and carrot in a 3:1 ratio) were provided. Feed and water were completely replaced twice daily during cleaning.

Brooders were cleaned twice daily when birds were removed for weighing. Mats were removed and hosed off, and mesh was scrubbed with a bristle brush

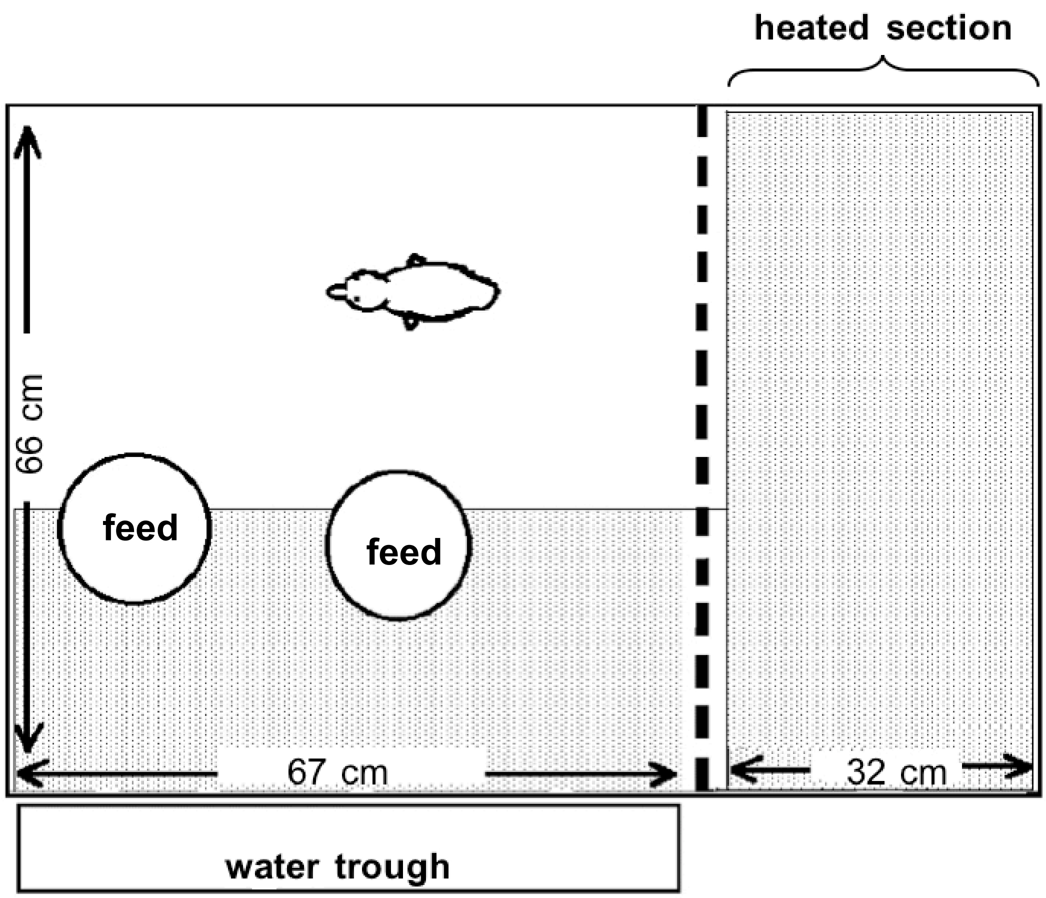

Figure 3.1. Cage layout. Shaded areas indicate perforated rubber matting, clear areas are wire mesh flooring. The dashed line indicates a plastic curtain dividing heated and unheated sections.

and water to remove feces. Between broods, brooders and matting were cleaned thoroughly with 1:16 diluted Peroxigard (accelerated hydrogen peroxide (7.0%), Bayer Inc. Toronto, Ontario) and a bristle brush.

Experimental Design

Broods were split at admission, and randomly allocated into “mentor” or “control” groups. Split broods were placed on one level of the stacked brooder, separated from each other by the central partition. Birds assigned to control groups were raised with their siblings. Birds assigned to mentor groups were also reared with their siblings but, in addition, were given an older bird as a “mentor”. The mentor bird had spent at least 1 week at the facility and was in good health and showing normal weight gain. Mentors integrated well with the novice groups except for one bird that was replaced within the first 5 min because it was aggressive towards the group. The average weight of these birds was 134.6 g (range: 68.5-215 g) or approximately 4 times heavier than the novice ducklings with which they were placed. The addition of a mentor meant that groups with mentors had one more bird in their cage in even-numbered broods; in odd-numbered broods the extra sibling was always assigned to the control group so that group size would be the same.

Four measures of condition were made at admission: weight, tarsus length, culmen length and head length (Proctor and Lynch 1993). Birds were then weighed twice daily for the duration of the experiment, between 07:30 h and 09:00 h and between 18:30 h and 20:00 h, before the diets were replaced. At the end of the experiment, culmen, head and tarsus measures were again taken. All weights were measured on a MP-2000 electronic scale (±0.5g) (WAS MP-2000, Western Scale Co. Ltd., Port Coquitlam, British Columbia) and all body metrics were taken using standard calipers (± 0.1 mm).

Data Analysis

Because individual birds could not be treated as independent of their group members, the experimental unit was the brood. Treatment effects were tested by group means for weight gain and body condition at the end of 1 week in care.

To compare growth rates between treatments, individual weight values were log transformed and the growth curves were then analyzed as linear functions by the use of least squares regression analysis. During the first week of development, the assumption of exponential weight gain fit the observed growth patterns very well (mean $r^2 = 0.96$) as none of the birds was approaching its asymptotic weight. The regression slope for each bird was used to calculate mean growth rates for each group within each treatment. The effect of treatments on mean growth rate was then tested by a paired t-test.

During analysis it was noted that the standard deviation of the mean growth rate differed markedly between mentor and control groups. In order to describe this difference, the data were analyzed in two ways. First, the coefficient of variation (%CV) for the growth rates and final weights (excluding groups 5 and 9 which did not contain enough individuals) for each group was calculated and compared across treatments by a paired t-test (Sokal and Rolf 1994). Secondly, in replicates where there were more than two individuals per treatment, individual growth rates were used to identify the fastest and slowest growing individual in each group. The growth rates of these animals were compared between the mentor and control groups by a paired t-test.

Body condition was calculated by taking normalized distributions of final body measures for the entire dataset and producing a unit-less index of "body size" for each bird through principal component analysis (Proctor and Lynch 1993, Rising and Somers 1989, Freeman and Jackson 1990). The resulting PC1 index was: body size = [0.343(tarsus length (mm))+0.306(head length (mm))+0.449(culmen length (mm))-35.75].

Final body weight was plotted against the body size index for each bird, and the residuals of a least-squares regression ($r^2 = 0.66$, *df*=53, $P<0.0001$) were used as a measure of body condition (i.e. whether birds were heavy or light for their body size) (Pelayo and Clark, 2003). Body condition values for each bird were used to calculate mean body condition for each replicate and treatment group, and the effect of treatments was tested by a paired t-test.

Five birds were removed from the data set as outliers. Four of these birds came from brood 6 which were noticeably larger than the other broods, while the fifth came from brood 2 and had an abnormally short culmen length that may have been the result of a measurement error. Removing these birds did not qualitatively change the data fit in the principal component analysis or, when calculating body condition, the significance and direction of the regression fit.

Growth rate regression analyses were done by SAS PROC reg (SAS 9.1, 2002, SAS Institute Inc). Body size and condition calculations and all treatment comparisons were done using JMP 6.0 (2005, SAS Institute Inc.). Tests of the stated hypotheses were one-tailed, while those that had no *a priori* assumptions about the expected outcome were two-tailed. Because eight tests of effect were run on the same data set, a Bonferroni correction was applied to critical values to reduce the chance of Type I errors (Sokal and Rolf 1994). The corrected P value for significance was 0.006.

RESULTS

There were no deaths over the course of the experiment although two birds were euthanised because of injury. A defective heating system (subsequently repaired) led to the removal of brood 5 halfway through the study period.

General observation of the ducks indicated that mentor birds were notably less active than newly admitted birds. They spent more time resting than moving and moved mainly to obtain food and water. Ducklings foraged independently but tended to cluster while resting or when disturbed. Often individual birds in the novice brood would rest next to the mentor bird while their broodmates were active. With the exception of the one individual as noted, mentors integrated well with the groups and did not show aggression in the form of chasing or grabbing the younger birds.

Neither mean growth nor mean final weight differed between groups with mentors and those without (growth: $t = 0.48$, *df*=7, $P = 0.64$, *two-tailed*; final

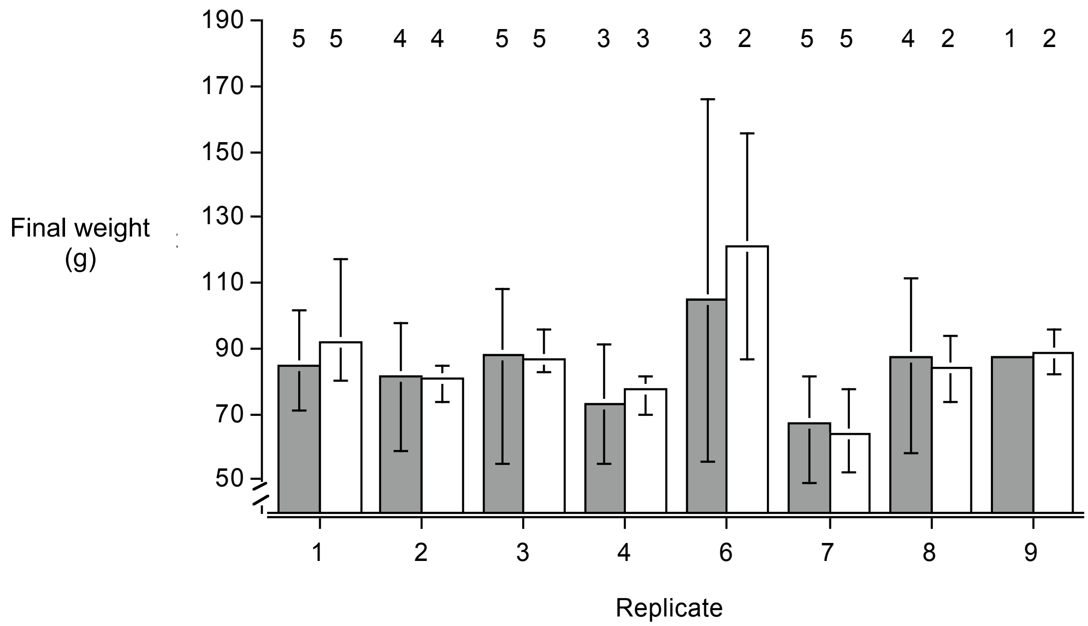

Figure 3.2. Final weights (mean ± range) for each replicate in the study. Grey bars represent control groups; empty bars represent treatment groups. Sample sizes are shown at the top. The control group in replicate 9 consisted of one individual and therefore has no range.

weight: t = 0.66, *df*=7, P=0.52, *two-tailed*). However, the within-group % CV in final weight was 11.1% larger in the control groups than in the mentor groups (paired-t= 4.48, *df*=6, P=0.004, *two-tailed*) (Figure 3.2). This reflected a tendency toward greater within-group variation in growth rates in the control groups relative to the mentor groups (paired-t= 3.22, df=6, P=0.018, *two-tailed)* (Figure 3.3). Within-group variation in initial weight did not differ significantly between treatments (signed-rank= 4.00, *df*=6, P=0.578, *two-tailed*).

Within each group, the bird with the least growth relative to its cage-mates had a tendency to grow faster in the mentor groups than in the control groups (t=3.27, *df*=6, P=0.017, *two-tailed*). At the end of the first week in care, these poorest-gaining birds weighed, on average, 16.2 g more in the mentor groups than they did in the control groups (t= 4.80, *df*=6, P= 0.003, *two-tailed*) (Figure 3.4). Initial weights of these birds did not differ between treatments (t=0.30, *df*=6, P=0.774, *two-tailed*).

Conversely, the birds with the greatest growth in each group did not differ between treatments in growth rate (t=-1.45, *df*=6, P=0.197, *two-tailed*) or in body weight at end of the first week (signed-rank= -8.00, *df*=6, P=0.203, *two-tailed*) (Figure 3.4). The initial weights of these birds did not differ between treatments (signed-rank= -2.00, *df*=6, p=0.812, *two-tailed*).

Mentor and control groups did not differ in mean body condition by the end of the treatment (t = -1.29, *df*=6, P=0.878, *one-tailed*).

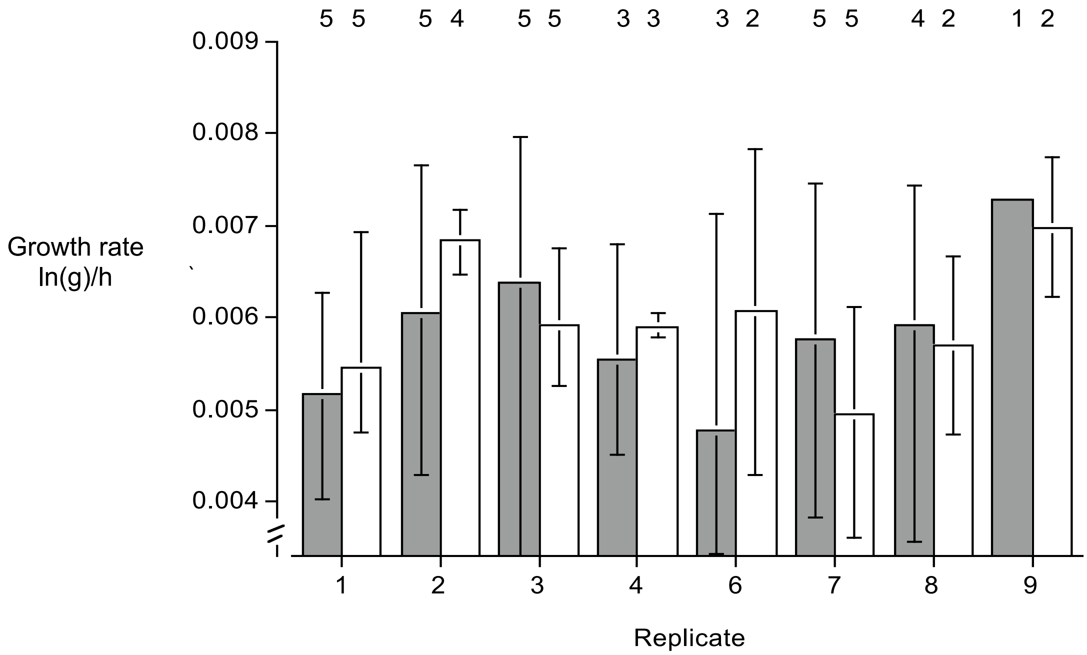

Figure 3.3. Mean growth rates (± range) for each replicate, grey bars indicate control groups, empty bars represent treatment groups. Growth was measured for each bird as the best-fitted slope of the natural log-transformed weights plotted against time (h). Sample sizes are shown at the top. The control group in replicate 9 consisted of one individual and therefore has no range.

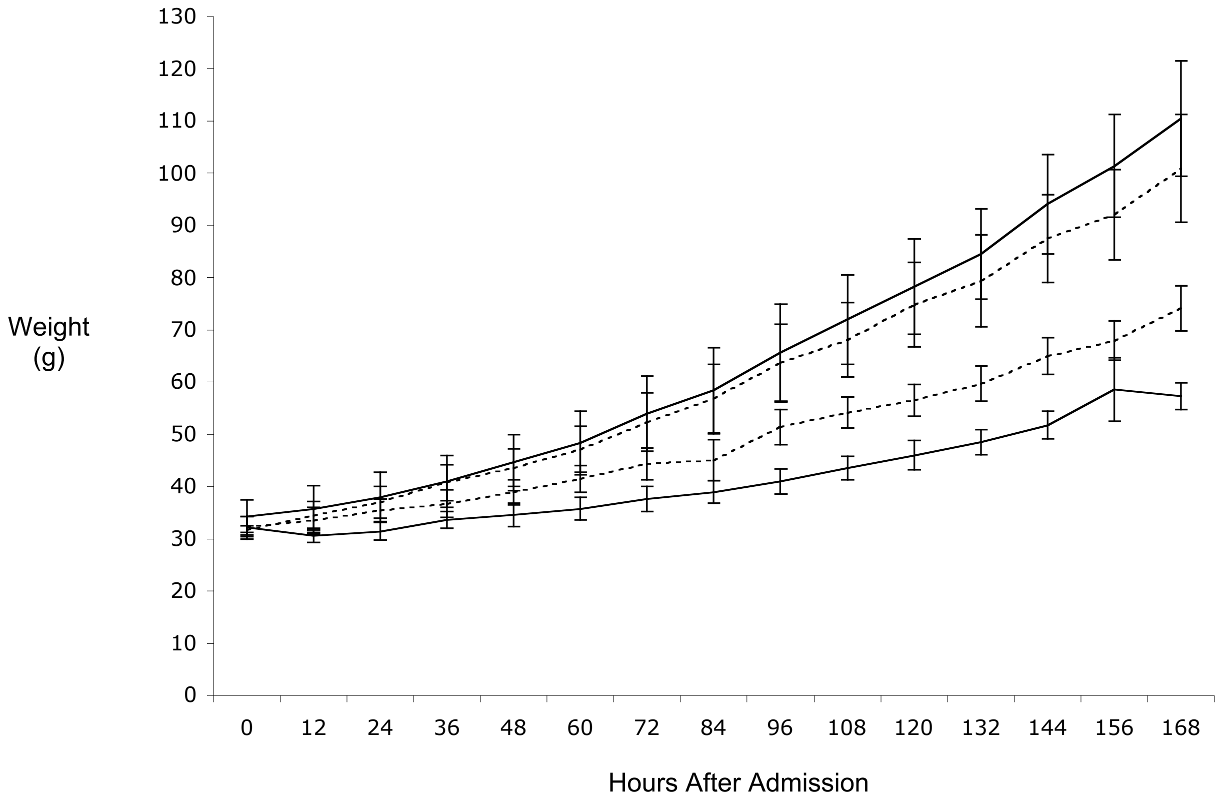

Figure 3.4. Mean body weight (± SE) of ducklings over the first week in care for the slowest and fastest growing birds in mentor groups (dashed lines) and control groups (solid lines) (n=7). * The increase in the mean weight of the slowest growing control birds at 156 h was driven by a single bird and may be the result of a measuring error.

DISCUSSION

The mentor and control groups showed no difference in survival in that all birds survived to the end of the experiment (at one week) in both groups. This is an interesting result in itself, given that this facility (WRA) typically loses 42% of mallards before release and that 86% of these deaths typically occur in the first week. It is likely that differences in housing and husbandry prevented duckling deaths during the experimental period. The poultry brooders used in this experiment differed from the standard brooders used by WRA in their heating system (using a resistor coil rather than heat lamp) and this, together with a separate heated section and rubber matting on the floor, may have maintained higher and more stable temperatures within the brooder. Also, the large water troughs in the poultry brooders ensured that no birds were without water during the day. Smaller inverted jar drinkers used in the facility brooders require constant refilling and this may mean that water is not always available.

Groups with mentors did not have more rapid mean weight gains nor greater mean body condition by the end of the first week in care. These groups did, however, show a tendency toward a reduced spread in growth rates which translated into a reduced range in final body weights. This reduction in the variation within groups appears to be because the slowest-growing birds in the mentor groups gained significantly more weight (16.2 g) than their counterparts in the control groups. This difference resulted in the slowest growing bird in mentor groups ending the experiment an average of 29% heavier than counterparts in control groups.

The mentor may alter the social environment experienced by novice broods. Adult dabbling ducks are known to form dominance hierarchies in the winter when they group in flocks and compete over preferred feeding sites (Hepp and Hair 1984). Most aggressive interactions in wintering flocks are associated with feeding (Baldassarre and Bolen 2006). Anderson and Alisauskas (2002) suggest that hierarchies also exist in duckling broods and affect individual growth. The mentor's large body size may allow it to rapidly and permanently establish itself as the dominant individual within the group. This in turn, may reduce intra-group aggression and challenging, behaviours that are known to affect food access and displaced aggression in other species (for example, male Olive baboons (*Papio anubis)* have been seen to "displace" aggression onto subordinate third parties when they have lost a confrontation with another male (Virgin and Sapolsky 1997)).

Mixed weight groups may be less aggressive than groups where all birds are of a similar size. Young pigs, for example, are more likely exhibit aggressive retaliations in groups where individuals start out with equal body weights than in those where individuals have quite different weights (Tindsley and Lean 1984). Additionally low-ranking pigs within even-weight groups are more aggressive and are attacked more often than in mixed-weight groups. Although even-weight groups show higher weight gains overall, individual weight variation increases over time relative to mixed-weight groupings (Tindsley and Lean 1984). Tindsley and Lean (1984) postulate that subordinate pigs are more deprived and stressed in even-weight groups than in mixed-weight ones. Similarly, in this study, intra-brood challenging may have been more frequent in the control groups due to the individuals' similar size and this may have resulted in increased stress and deprivation for subordinate birds.

One form of deprivation may be limited access to food. Active dominance hierarchies often result in differential feed access (e.g. Baker *et al* 1981). If the presence of the mentor mallard resulted in duckling broods showing less pronounced dominance, this would explain the reduced spread in weight gains seen the treatment groups.

Finally, in primates, individuals who have lost challenges frequently displace aggression onto third parties (e.g. Olive baboons (*Papio anubis*) (Virgin and Sapolsky 1997)). This type of harassment, anecdotally observed in juvenile mallards (*personal observation*), might also affect the weight gain of subordinate birds. Behavioural studies would have to be done in order to support any of these explanations. Anecdotally, when merging one replicate together at the end of the experimental period, the heaviest bird in the control group was the only individual that actively challenged the mentor bird (through charging and grabbing at its neck and chest down) during the first day they were housed together despite a substantial difference in body size.

In addition to any impact on dominance structure, the mentor may influence duckling behaviour in other ways. Older mallards spend more time than younger birds in "comfort" and resting activities (Ringelman and Flake 1980, Pietz and Buhl 1999). The mentor's larger body size and calmer nature may have induced more resting periods in the treatment groups and provided increased body heat during these rest periods for the least-thriving birds. Small ducklings expend more energy per unit of body mass to maintain homeothermy than larger birds (Rhymer 1988). Additionally temperature tolerance is lower for light ducklings: temperatures below 15°C are lethal for light-weight, newly hatched mallards whereas heavy newly hatched birds can cope with temperatures as low as 5°C (Rhymer 1988). If novice ducklings imitated mentor behaviour and spent more time resting, non-thriving birds would have reduced their total energy expenditure on both movement and active maintenance of homeothermy by reducing the time spent outside the heated section of the brooder. Again, behavioural studies would be necessary to support any of these explanations.

Rehabilitators often avoid mixing broods, particularly with birds of different ages, because the ensuing aggression can result in deaths. In this study, only one of nine older birds did not integrate well with the younger brood. This may be because they were singletons and were motivated to join a group. In ducklings, as in many species, much aggression occurs when individuals in established groups challenge new individual/s. However, this type aggression was not seen directed toward the mentor, perhaps because of the substantial body size difference. Even so, monitoring novice broods and mentors for the first day of care is important to ensure that aggression is not a problem.

Diet is one final concern associated with the mentoring system. Ducklings require high-protein food during early development but are at risk of developing wing deformities (angel/slipped-wing) should they be kept on this diet after 2-3 weeks of age (Bourne WildPRO). Mentors therefore should be as young as possible, and should be removed from broods on high protein diets after they are 2-3 weeks of age or weighing more than 260-280 g (Lokemoen *et al* 1990))

CONCLUSION

Although mentor birds did not induce greater growth or improve body condition overall, they offer some benefit the least-thriving individuals in the treatment groups. Although no deaths occurred over the course of this experiment, because risk of death is greater for birds with slow weight gains (Cox *et al.* 1998) this advantage might help prevent deaths under conditions that are less favorable than occurred in this study.

In all, the effect of mentor birds on novice broods appears to be small relative to the apparent effect of the housing modifications on brood survival. However, as providing a mentor is a simple, low-cost procedure that does not appear to be detrimental in any way, it may be a worthwhile practice where housing is suboptimal.

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CHAPTER 4: GENERAL DISSCUSSION

The research described in this thesis indicates that pre-admission and post-admission treatment affect young mallard ducklings. As described in Chapter 2, the likelihood of ducklings surviving in the rehabilitator's care increased with higher body weight at admission, larger brood size, and a shorter time spent with the finder. Even though the provision of food and water by the finder is often considered harmful by the rehabilitator, whether ducklings were fed and/or watered had no apparent effect on survival. Additionally, if it was possible to separate the provision of water from the provision of a pool, it is possible that the offering of food and water by the finder may be beneficial to ducklings. These results indicate that the risk of death for ducklings received by rehabilitators varies and, to a certain extent, is dependant on each bird's condition and history.

The conditions in which ducklings are subsequently reared may compensate for some of the disadvantages certain birds have at admission. The experiment discussed in Chapter 3 showed that the social environment in which mallards are housed does have a modest effect on these birds. Specifically, providing a single older bird to novice broods reduces the within-brood spread in weights, and significantly increases the 7-day weight of the least-thriving individual in such broods. As low growth rates are associated with greater risk of death (Cox *et al* 1998), this modification to the social environment of ducklings in captivity may reduce deaths in care.

Although it was not something that this research set out to test, the housing used in the mentor experiment appears to have had a substantial impact on duckling survival. Thirty-four percent of ducklings generally die in the first week of care at the facility where this research was conducted; over the same period none of the 66 birds used in this experiment died. It is probable that the commercial brooders used in the experiment and the rubber matting provided to birds resulted in higher, more stable temperatures and prevented energy expenditure on the maintenance of homeothermy. As discussed below, factors contributing to in-care deaths point to energy starvation in newly admitted birds.

General data suggest that the majority of mallards received at the WRA were found shortly after hatching. Probably these young birds were orphaned after leaving the nest but before they reached a suitable water source. Mallards are usually upland nesters and hens remain at the nesting site for 13-16 hours after their ducklings hatch (Drilling *et al* 2002). Newly hatched birds spend the majority of their time being brooded by the hen (Drilling *et al* 2002) and are not fully homeothermic until they older than 24 hours (Caldwell 1973). This would suggest that birds orphaned during the trip from nest to water are susceptible to hypothermia.

Upon leaving the nesting site the hen will lead her ducklings to an appropriate water body where they can feed on invertebrates for the first 25 days (Drilling *et al* 2002). One study indicates that the distance the hen travels ranges from 45 m to 3 kilometers (Rotella and Ratti 1992) during which time the ducklings may become lost, and are susceptible to predation, exposure, road hazards, and entrapment in man-made structures. Despite reports that intentional human interference is a major cause of duckling loss in urban environments (e.g. Heusmann and Burrell 1974), the majority of mallards brought into WRA were reported to be orphaned by accidental causes rather than by malicious actions. Only 2% of broods could be described as orphaned due to direct human intervention. Even so, 56% of broods were orphaned by human structures. Roads were the largest known source of brood harm, followed closely by man-made barriers and unnatural water bodies. Rehabilitation facilities do not, however, receive a random sampling of orphaned ducklings from the wild. Birds are more likely to be noticed and captured in populated and developed areas, skewing admission data toward anthropogenic causes for admission.

A large proportion of duckling broods (40.7%) were brought into the WRA shortly after being found and were not described as being fed, watered or handled by their finder. This matches the advice generally given to the public by rehabilitation facilities. Finders are also encouraged to provide their charges with a warm environment. An inability to thermoregulate may explain the positive relationship between survival and duckling body weight and brood size, both of which reduce heat loss for the individual. Whether birds were kept warm before admission may in fact be one of the most important predictors of future mortality and this information should be requested by the rehabilitator. That birds admitted in small broods are more likely to die than those in larger broods also suggests that the post-admission practice of housing small broods together deserves review. It is possible that this kind of brood mixing exposes birds to inter-brood aggression and results in deaths. Singletons and light-weight birds are likely at the greatest disadvantage when broods are mixed. Singletons have no siblings with whom to seek refuge from attacks, while light-weight birds may assume the subordinate position in a dominance hierarchy and may have limited access to food as a result.

Ultimately, rehabilitators may have to accept higher mortality rates than duck producers because many factors contributing to duckling deaths are out of their control. Beyond pre-admission events, wild ducklings have not been isolated from, or vaccinated against, common waterfowl diseases; moreover, new, potentially disease-carrying birds are constantly added to the rehabilitator's seasonal "flock" making control difficult. Identifying disease through post-mortems and sterilizing housing may be the only way to control viruses and bacteria that may contaminate housing.

For birds that are identified as being at-risk or those known to have experienced food, heat and water deprivation but are otherwise healthy, husbandry changes may reduce deaths. As these factors point to energy starvation, providing such birds with high calorie, palatable food and warm housing (32 ^{o}C) upon admission may minimize further energy loss. This process of identifying at-risk birds and taking steps to prevent further energy loss may prove to be the single most effective way to reduce the number of duckling dying in the rehabilitator's care.

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