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TECHNIQUES FOR USING THE GROWTH AND BEHAVIOR OF IMPRINTED DUCKLINGS TO EVALUATE HABITAT QUALITY

ABSTRACT

We developed a technique for evaluating duckling habitat quality that is based on two assumptions. In good habitat young birds: 1) grow rapidly and thus are better able to survive stresses such as inclement weather, and 2) spend relatively less time moving about in search of food and more time resting and thus are less conspicuous to predators. We imprinted artificially-incubated and hatched ducklings by being present at the time of hatching; i.e. the ducklings thought we were their mother. Ducklings were split into broods and placed on ponds where their growth was measured and their behavior monitored for several days. Comparisons of growth rates and behavioral time budgets allowed us to determine which ponds were better habitat. This paper describes techniques for imprinting, duckling husbandry, and measurement of growth and behavior.

TECHNIQUES FOR USING THE GROWTH AND BEHAVIOR OF IMPRINTED DUCKLINGS TO EVALUATE HABITAT QUALITY

INTRODUCTION

Imprinting, the process by which a young animal rapidly learns a social preference for a restricted class of objects, is a well-studied phenomenon (26, 18, 2, 14, 6). Wildlife biologists have imprinted recently-hatched birds to people in order to facilitate observations of wary, precocial species such as turkey (Meleagris gallopavo) (10, 9, 20, 19, 1, 12), bobwhite quail (Colinus virginianus) (4), and ruffed grouse (Bonasa umbellus) (17, 16). This work has been primarily oriented toward evaluating the quality of brood-rearing habitat.

We have developed a new methodology for using imprinted animals to assess habitat quality working with 17 duckling broods (Anas rubripes, A. platyrhynchos, and Aix sponsa) over the last 6 years. This method makes two assumptions about what constitutes good habitat for young precocial birds. In good habitat young birds: 1.) grow rapidly and thus are better able to survive stresses such as inclement weather, and 2.) spend relatively less time moving about in search of food and more time resting and thus are less conspicuous to predators. The method involves keeping ducklings on the study areas from dawn to dusk for several days, starting the day after hatching, and monitoring their growth and behavior. Using these methods we have documented the effects of pesticides (15) and acidity (Hunter et al. in prep) on duckling habitat. In this paper we describe the husbandry of imprinted ducklings and our methods of assessing habitat quality.

HATCHING AND IMPRINTING

Eggs were incubated in either a home-made still air incubator or a G. Q. F Co. 0800 Sportsman circulated air incubator at 37°C. Clutches comprised either a natural clutch or eggs from several nests. Simultaneous hatching was achieved by taking eggs from nests before the hen began incubating and initiating incubation simultaneously. During the last days of incubation we began the imprinting process by calling to the eggs during our daily checks (7). We used a soft, rapid "quack" call with the syllables slurred together to make a "wackwackwackwack" sound. When hatching began we examined the eggs frequently and called whenever the incubator was open. Often ducklings had difficulty hatching and we assisted them using the techniques described by Greenwall (8).

After a duckling hatched, it was allowed to dry either in our shirts or in the incubator, and then weighed and marked with an individually numbered web tag. After a duckling was strong enough to walk, ca. 30-90 minutes post-hatching, intensive imprinting began. Initially ducklings were called to while we crawled backwards with our heads close to the floor and our fingers waving to maximize acoustical and visual stimulation. After an hour or so we began walking long distances, 15-25 m, while calling, and we led them over small barriers (egg cartons) because imprinting is apparently strengthened when following the "mother" is difficult (13). When ducklings became tired we brooded them in our shirts, calling occasionally, until they awoke. This process continued for 24-36 hours until dawn of the first day of observations. We do not know when the "critical period" (sensu 18, 3) or "sensitive period" occurred, but it was probably during the first 24 hours and thus we believed it essential to maximize contact during this time. Before taking the ducklings to the study area we assigned them to broods with a balance of hatching weights, sexes, and hatching times. Ducklings were individually color-marked with 3 x 5 cm elliptical patches of plastic flagging sewn to the back of their necks with surgical thread.

DAILY CARE

Each brood stayed on its pond from dawn (ca 0530-0600 hours) to dusk (1900-2000 hours) followed by an observer in a rowboat. The observer called occasionally throughout the day but made no attempt to lead the ducklings except at the end of the day when, calling insistently, the ducklings were coaxed ashore, put under the observer's shirt, and taken to the field camp. At night broods were kept separate in a partitioned box. They were given water, but no food, and kept warm with an apparatus constructed of 20 gauge copper Constantan wire stapled to a board, with a blanket covering. This operated on a 12 volt battery; if AC current were available commercial heating pads could be used. At dawn the ducklings were transported back to the pond in the observer's shirt. In our early experiments the ducklings were transported to and from the ponds in a box and a 15-30 minute drive was involved. In 1983 and 1984 we camped beside the ponds and transported ducklings in our shirts and believe the socialization with people remained much stronger as a result.

Because socialization is weakened by rough handling it was essential to coax the ducklings from the pond each night and not remove them forcibly. We carried a net in the boats but used it only in emergencies such as a predator attack. Mink (Mustela vison), snapping turtles (Chelydra serpentina), bullfrogs (Rana catesbeiana), and unidentified fishes and hawks have attacked our birds. Predator threats were often the main reason an observer had to stay with the ducklings all day. Some predators were deterred and some ducklings were rescued, e.g., one duckling was pulled from the mouth of a bullfrog from which only its legs still projected.

Besides removing the ducklings at night our only major manipulation of the brood's behavior was to brood them under our shirts on cold days. This was done only when the ducklings were young (generally < 5 days) and after they had already begun resting. Some ducklings would actually climb into the boat to be brooded on cold days. After preening they would fall asleep and brooding continued until they awoke.

EXPERIMENTAL DESIGN

In our pesticide research we used a four-cell Latin-square design with before and after treatment (i.e. pesticide application) on experimental and control ponds; in our acidification work we used experimental and control ponds.

GROWTH ANALYSIS

Birds were weighed with Pesola scales every morning (ca 0500 hour) before being taken to the ponds and every evening (ca 2030 hour) soon after they were dry. The evening data were taken primarily to corroborate accuracy, i.e. to make sure a duckling did not "gain" weight overnight because of an incorrect weighing. For our analyses we used weight gain from one morning to the next, instead of from morning to evening, because we wanted to measure change over a 24 hour cycle. Thus overnight weight loss, which was not a constant proportion of daily gain, was taken into account. Tarsi lengths were also measured each evening during 1983 and 1984 using a micrometer.

Growth differences among broods were analyzed by comparing best fit linear regressions from individual duckling weights or tarsi lengths (Figs. 1 and 2). Analyzing a long growth sequence using linear regression is inadvisable because the slope of the line is likely to change; e.g., in the American black duck growth rate decreases sharply at ca 40 days (25). If a duckling died during the experiment all growth data for it were deleted because the regression models assume sample size is constant and cannot account for the differences in variance if it is not. The regressions shown in Fig. 1 became significantly different at the $p < 0.05$ level on the 7th day, but we have generally continued observations for at least 10 days. We also prefer to use ca. natural brood sizes because of the possible importance of duckling interactions.

BEHAVIORAL OBSERVATIONS

Observers used prepared data sheets, Appendix 1, on which they recorded data regarding four aspects of the ducklings' activities; time-budgets, habitat selection, movement, and miscellaneous activities. We shall discuss each of these aspects separately.

Time Budgets

Individual ducklings were watched for 5 -10 minutes each in an ordered sequence which remained consistent throughout the day and from one day to the next. Observers used an electronic metronome (27) that clicked every 15 seconds and recorded the duckling's activity every 30 seconds. The first click signalled the observer to start watching carefully; the observer then recorded the activity being performed at the instant of the second click. If a duckling were not visible when the metronome clicked nothing was recorded. Observations on a given duckling continued until 10 activities were recorded; thus observations lasted between 5 minutes (for a duckling that was always visible) and about 10 minutes (for a duckling that was often out of sight). Each duckling was observed from 5 -20 times per day depending on brood size.

We recorded 34 different activities as outlined in Table 1. Two broad types of feeding activity were observed: pecking -a quick thrust of the head directed at an invertebrate or substrate and straining -the bill was opened and closed in rapid succession to filter invertebrates from the water or off vegetation. Pecking and straining were both subdivided into 12 classes; 1) by whether they occurred above the surface (bill was completely out of the water), below the surface (bill was completely submerged), or at the surface (bill touching or partly submerged) and 2) by whether the pecking or straining was directed generally at air or water, or directed at vegetation, mud, or a miscellaneous substrate (e.g., rock or log).

The remaining activities were defined as follows:

Swallowing masticating, manipulating, and ingesting food. Usually observed when a duckling picked up a large item and/or after straining. The transition from Straining to Swallowing took place when the duckling moved its head back from the substrate.

Diving - completely submerging. This could have been comfort, escape, or feeding behavior.

Moving - locomoting with the head not turning from side to side, but rather facing the direction of movement. If the head were turning the activity was recorded as Search.

Resting sleeping and brooding, and the absence of other activities during the interval between actions. This last could be thought of "catching-your-breath" momentarily but if the bird looked around during this interval it became Search.

Brooding in shirt - ducklings rested or preened while being brooded but we recorded this as a separate activity.

Comfort movements preening, stretching, scratching, head shake, bathing.

Drinking - head was tilted back and bill moving to ingest water.

Searching bird moved head from side to side looking for food, predators, or its siblings. These movements could be very slight.

Social interactions pecking a sibling was observed infrequently.

Miscellaneous - <1% of activities could not be assigned to one of the above classes.

For many purposes this classification of activities was too detailed; during analysis we often combined the data into 4 classes; Feeding (pecking and straining), Search/Move, Rest/Comfort, and Miscellaneous.

From the activity data we constructed time budgets of the amount of time allocated to various activities by different individuals in the broods. To analyze these data we transformed them by taking arcsine square roots and set up a series of 2 x 2 contingency tables (25). These took the form of (activity Z all other activities) by (Brood A - Brood B). From these tables t values could be derived to determine if Brood A allocated more time to activity Z than Brood B, etc. We used the same analysis to compare time budgets between different periods, e.g. before and after pesticide application (Table 2).

Habitat

The duckling's habitat was also described every 30 seconds by encoding all moves into new microhabitats. Suitable microhabitat classifications will be different for various studies and should be developed before the onset of the field season. Allocation of time to different microhabitats could be analyzed similarly to the time budget analysis.

Movement

We recorded two kinds of measurements of duckling movements on the assumption that if the density of food was very high the ducklings would move through the habitat relatively slowly due to area-restricted foraging. At the end of each 5 minute series of observations the duckling was watched for an additional 15 seconds and an estimate was made of the distance it moved during that interval; this is referred to as "short-scale" movement. The bird's dominant activity during this 15-second period was recorded as Feeding, Searching, Moving, or Rest/Comfort.

"Long-scale" movements of the brood were recorded by reference to a series of numbered stations, at 50 m intervals, located around the perimeter of the ponds. At the beginning of each observation period the duckling's location was estimated (to the nearest 10 m) and it was noted whether or not it was with the rest of the brood. Distances between successive observations of the brood and time elapsed could be determined and the speed of movement around the pond calculated. (Ducklings rarely ventured more than 5 m from shore.)

The long and short scale movement data were converted to velocity (m/minute) and analyzed with nested Analysis of Variance (ANOVA) with individual ducklings, broods, and time periods nested in that order (Table 3). To remove the effect of time allocated to resting and comfort we only used data from periods when the ducklings were active.

Miscellaneous

The data sheet had a Notes section where additional information was recorded such as 1) further explanations on diving, social interactions, and miscellaneous observations; 2) vocalizations (ducklings occasionally called while searching or moving), and 3) food items that could be identified. This information was not quantifiable but it was useful in the refinement of our methodology because it made observers sensitive to the whole scope of duckling behavior.

DIETS

It was usually not possible to see what the ducklings were eating. We unsuccessfully attempted to sample esophageal contents of live ducklings using neck ligatures (22) and evacuation (21). Thus we had to kill birds with a .22 revolver loaded with dust shot after watching them feed for a few minutes to ensure that the esophagus was not empty. We then removed the esophagus immediately and emptied its contents into vials of ethanol.

OBSERVERS

Selection of observers was critical because not everyone can be a careful observer and responsible "parent" while sitting alone in a row boat for up to 15 hours, especially when weather and biting insects are bad. We trained observers for three days using practice broods, initially in a group session and then in two or three solo sessions with the crew chief present for guidance. Observer bias was not a problem in recording the major classes of behavior that are critical to habitat evaluation (feeding, search/move, and rest/comfort). However, interpretation of finely classified behavior, notably feeding activities, was subject to observer bias.

This bias problem can be mitigated with appropriate scheduling. We used the following system: each brood had three observers (a morning person, an afternoon person, and an all-day person) who worked on a 3-day rotation. On days 1 and 2 the morning and afternoon persons worked from dawn to noon and noon to dusk respectively; the all-day person had the days off. On day 3 the all day person worked and the others had off. Individuals kept the same shifts and worked with the same brood throughout the study.

This system maximized the amount of data suitable for diel (all-day observer) and ontogenetical (morning and afternoon observers) analysis. Although observers remained with the same brood, interbrood comparisons could be made for a coarse classification (feeding, search/move, rest/comfort, miscellaneous) because observer bias was negligible for these. Some investigators may wish to sacrifice temporal resolution to make interbrood comparisons more reliable.

Fatigue was not a serious problem even for the all-day observers. The rate of data gathering was not excessively intense and observers were encouraged to take 5-10 minute breaks between brood cycles, (ca every 45-90 minutes).

DISCUSSION

Many researchers have used imprinted birds to evaluate the quality of brood-rearing habitat but most studies have focused on just one parameter, feeding rates (pecks/minute) (4, 9, 20, 16). We could not use this measure because: 1) ducklings often do not feed with discrete pecks, and 2) many smaller food items cannot even be seen, let alone identified. Furthermore, even for upland birds there could be considerable variation in food quality or quantity between bites; consider a chick rapidly pecking at grass seeds versus one occasionally eating a grasshopper. We feel that time budgets and movement rates are much better behavioral correlates of habitat quality than pecking rates, and growth rates are probably even better. The major disadvantage of our method is that it requires more time, at least 100-150 hours per habitat tested.

One could cut down observer time considerably if predation risks were minimal and the birds could be easily found at intervals through the day. Ducklings were quite easy to locate but upland birds might require a radio transmitter. If just daily weight gain, instead of total growth, were analyzed one could move the same brood back and forth between different habitats on successive days. However, we would not recommend this procedure because the following factors vary daily and can affect growth: 1) weather, 2) age (particularly important with young birds), and 3) invertebrate availability (particularly important in aquatic systems where invertebrate populations often metamorphose synchronously, i.e., "hatch"). It might be possible to cut costs by keeping ducklings on artificial diets most days and using them as necessary, but problems with switching diets should be carefully explored first. Pehrsson (23) imprinted mallard ducklings to a domestic duck to observe their behavior closely thus obviating the need for imprinting. However he found it preferable to restrain the surrogate mother in a harness or small, floating cage and thus she was unable to influence the ducklings' foraging behavior.

Previous researchers (10, 11) believed the behavior of imprinted birds was a reasonable approximation of wild bird behavior and we concur. Immediately after being placed on a pond for the first time the ducklings would begin moving down the shoreline foraging as they went. A mother duck was not necessary to direct activity although she would undoubtedly influence foraging location and brooding time. We allowed the ducklings to determine their brooding time and foraging location; in the small ponds where we worked ducklings explored the entire shoreline and presumably concentrated their foraging where food was most abundant.

We believe the important points are: 1) broods were treated in the same manner in each habitat and 2) growth and behavior of the broods were a better index of habitat quality than any scheme for sampling vegetation and invertebrates could have provided. This last point must be emphasized. Our duckling research (15, Hunter et al. in prep. a) was undertaken simultaneously with detailed invertebrate (5, Gibbs et al. in prep) and vegetation (Hunter et al. in prep. b.) work, and it is clear that the ducklings were quite selective in their "sampling" of the habitat, far more so than a net or other sampling tool would be.

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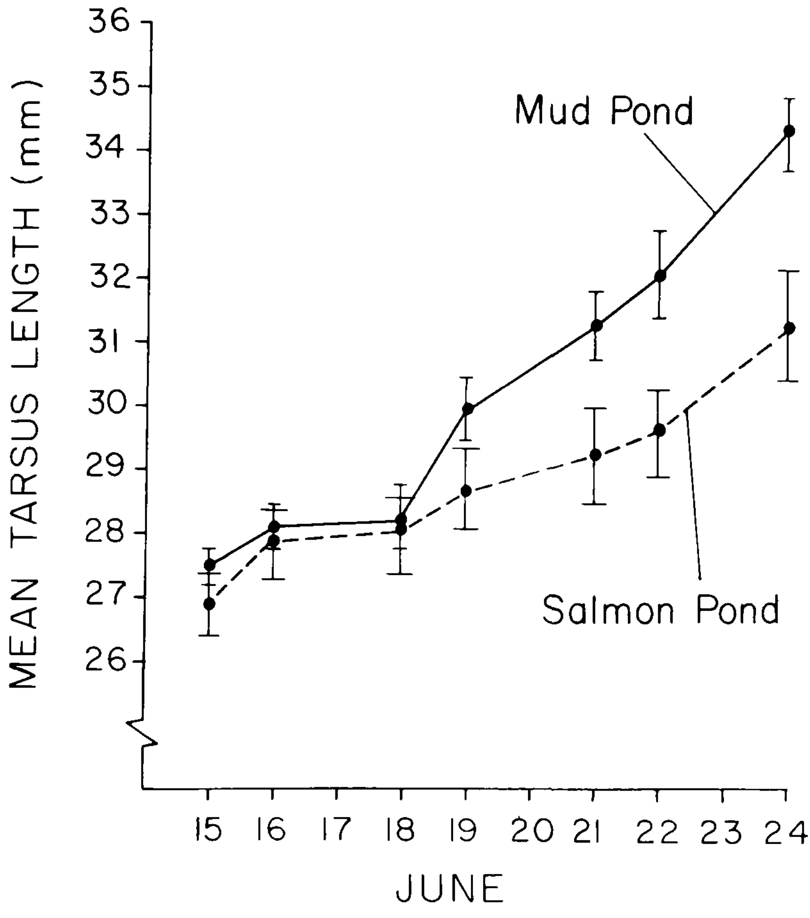

Fig. 1. Differences in mean weights of ducklings ($P<0.05$) placed on ponds where water chemistry was different.

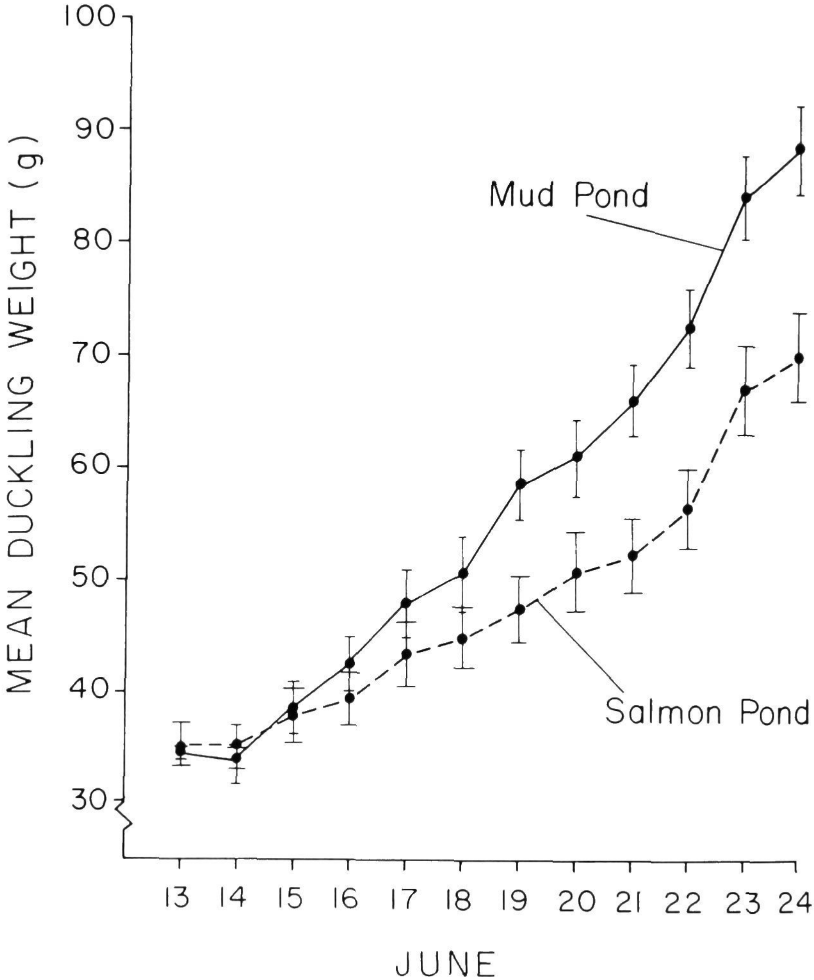

Fig. 2. Differences in mean tarsi lengths of ducklings (P<0.05) placed on ponds where water chemistry was different.

Table 1. Matrix of 34 activity classes used for recording duckling behavior and the codes employed.

	Above water	At surface	Below water
Peck (general)	11	21	31
Strain (general)	12	22	32
Peck at vegetation	13	23	32
Strain vegetation	14	24	34
Peck at mud	15	25	35
Strain mud	16	26	36
Peck at miscellaneous substrate	17	27	37
Strain miscellaneous substrate	18	28	38

Dive	19
Swallowing	41
Movement	51
Resting	61
Brooding in shirt	62
Comfort movements	71
Drinking	81
Searching	91
Social interactions	98
Miscellaneous	99

Table 2. Percent of time ducklings were engaged in different activities before and after spraying. (From Hunter et al. 1984)

Behavior[a]	Pond	Pre-spray		Post-spray
Feeding	Experiment	27.3	NS[b]	28.4
		***		NS
	Control	22.4	***	28.3
Search/move	Experiment	36.8	***	46.0
		***		***
	Control	43.1	***	33.6
Rest/comfort	Experiment	33.0	***	23.2
		*		***
	Control	29.0		37.1
N	Experiment	5,153		8,057
	Control	5,506		9,633

[a] Miscellaneous behavior, which comprised less than 3%, was not included in the analysis.

[b] NS, not significant; *, $P < 0.05$; **, $P < 0.01$, $P < 0.001$.

Table 3. Mean rates of movement (long and short scale) around the ponds by ducklings before and after spraying.

		Time Period						ANOVA[a]		
		Pre-spray			Post-spray			F Values		
		X	SE	(N)	X	SE	(N)	Among Ducks	Between Ponds	Between Periods
Long Scale	Expt.	5.12a±[b]	0.04	(484)	9.11b±	0.41	(714)	0.67	27.65	29.75
Rate								p=0.8636	p<0.0001	p<0.0001
m/min	Cont.	5.70a±	0.27	(542)	5.70a±	0.26	(936)	NS		
Short Scale	Expt.	7.77c±	0.58	(320)	8.73d±	0.26	(528)	1.01	12.36	2.06
Rate								p=0.4524	p<0.0004	p=0.1274
m/min	Cont	7.34c±	0.24	(387)	7.22±	0.23	(597)	NS		NS

[a]A nested analysis of variance was used to estimate differences with the independent variables nested in the following order: duckling; ponds (experimental/control); and periods (pre-spray/post-spray).

[b]Means were compared with a Duncan's multiple range test; values followed by the same letter are not significantly different at the F - 0.05 level.

APPENDIX 1

Name ____________________________

Date ____________________________

Pond ____________________________

Prox[1]	Loc[2]	Duck[3]	Time Beg[4]	Time End[5]	Behaviors	Tot Dist[6]	Displ[7]	Dom Act[8]	Notes

1. Proximity of observed duckling to the brood
2. Location of observed duckling
3. Ducklings tag color
4 Time at onset of observation
5. Time at end of observation
6. Total distance
7. Displacement
8. Dominant activity