THE UNIVERSITY OF MANITOBA

Brood Preferences in Brooding Mallard Hens

(*Anas platyrhynchos platyrhynchos*)

by

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Bachelor of Arts, 1982

Wake Forest University

Winston-Salem, North Carolina

A Thesis

Submitted to the Faculty of Graduate Studies

In Partial Fulfillment of the Requirements for the Degree of

Master of Arts

DEPARTMENT OF PSYCHOLOGY

WINNIPEG, MANITOBA

ISBN 0-315-33920-9

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Acknowledgements

I would like to thank Mr. Jim Wojtas and Ms. Paula Josephson, Animal Technicians, for their help during the completion of this project. Special thanks go to Dr. George Hochbaum, Canadian Wildlife Service, and to Dr. Ross Hartsough, Department of Psychology, for their time and assistance. Finally, a very special thanks goes to my thesis advisor, Dr. L. James Shapiro, Director of the Avian Behaviour Laboratory, for all his help, advice, and guidance.

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Abstract

Brood preferences in brooding mallard hens (*Anas platyrhynchos platyrhynchos*) were investigated. Three experiments were conducted in the laboratory and then again in the field. In the laboratory all hens were tested in a sound deadened, heat-controlled experimental chamber. In the field similar testing occurred without the controls present in the laboratory.

The first experiment attempted to determine whether brooding hens exhibited a brood size preference. Results from Experiment 1 revealed that hens tend to prefer larger broods over smaller broods. The second experiment attempted to determine if brooding hens preferred their own brood or unfamiliar broods of equal size. The results of Experiment 2 revealed no statistically significant preferences among the hens' own brood, two unfamiliar broods of equal size, and an empty quadrant. The third experiment attempted to determine if brooding hens show a preference for their own brood or larger, unfamiliar broods. The results of Experiment 3 indicated that hens prefer larger broods over their own brood and that the largest brood presented to a hen was preferred the most.

There were no statistically significant differences found between aviary and field station hens.

The results are discussed in terms of evaluating behavioral differences between laboratory and field station hens, in terms of incorporating mother to offspring attachments in discussions of avian attachment behavior, in terms of helping to explain the behavior pattern known as crèching (gang-brooding), and in terms of possible relevance to restocking and releasing programs involving mallard ducklings.

Introduction

Avian Attachment Behavior Versus "Imprinting"

Avian attachment behavior is not a new subject to the field of animal behavior. A common misconception, however, is to equate avian attachment behavior with the term "imprinting". The latter term was used by Konrad Lorenz (1935/1970) to refer to the formation of an attachment by a newly hatched bird to its mother or surrogate mother. At the time, Lorenz was working mainly with greylag geese (Anser anser) and mallard ducks (Anas platyrhynchos platyrhynchos). It was this work that focused the attention of the scientific community on the phenomenon labelled imprinting and began the intense investigation of it.

The term "imprinting" is primarily associated with offspring to mother attachments. The term, however, has also been used to describe attachments involving siblings (Klint, 1973), mates (Immelmann, 1972, 1975), the environment (Lamprecht, 1977), and food (Hess, 1962). Presumably these are different forms of attachments involving different mediating mechanisms. Various attachments are being named but they are not being explained. "Imprinting" has become a nominal fallacy.

For the purposes of this study, the term "avian attachment behavior" will be used in place of the term "imprinting". The use of the former term is preferred in order to avoid any possible confusion associated with the use of the term "imprinting." Specific avian attachments will be designated where appropriate, as in "mother to offspring attachments", which is the topic of the present study.

Five kinds of Attachment Behavior

Although extensive research has been conducted on what has been called "imprinting", it remains only one aspect of attachment behavior. Avian attachments may form from mother to offspring, from father to offspring, among the offspring, from offspring to the father, and from offspring to the mother (Shapiro, 1980). The last type of attachment has traditionally been referred to as "imprinting."

An unfortunate aspect of avian attachment behavior research is that only the offspring have been used as experimental subjects. Parental attachment behavior has been observed and described (Beard, 1964) but has not been subjected to controlled experimentation.

Father to Offspring and Offspring to Father Attachments

In the mallard, temporary pair bonds are formed. Following courtship and mating, males usually remain with their mates until the female has begun to incubate a clutch of eggs. Occasionally males desert their consorts before a clutch is complete, but the average length of stay is into the second week of incubation (Gilmer, Kirby, Ball, & Reichmann, 1977). This behavior is adaptive because the males, with their brightly colored breeding plumage, could easily attract predators to the nest area. Mallards are not physically competent to fend off most predators. Predator avoidance for an incubating mallard hen is most easily accomplished by an unattended, well-camouflaged female.

Mallard hens care for their ducklings after hatching, without assistance from the males. Thus, for the mallard, as well as most duck species whose males have brightly colored breeding plumage, little or no interaction occurs between the drakes and the developing ducklings (Gilmer et al., 1977). Presumably, as a consequence of this situation, there is also little or no attachment between parental males and their ducklings. Consequently, two of the five kinds of attachments that can form between parents and offspring do not occur in the mallard. The remaining attachments that could form are those from mother to offspring, among the offspring, and from offspring to the mother.

Offspring to Mother Attachments

Lorenz (1935/1970) used a special term for that form of avian attachment which was directed to the mother or maternal surrogate by the offspring. He called this form of avian attachment behavior "imprinting". Long before Lorenz labelled this phenomenon, however, it was observed by others.

Avian attachment behavior was observed to occur in precocial birds (those that are relatively independent shortly after hatching), by Aristotle as early as the fourth century B.C. (cited in Smith, 1969, p. 1). Reginald of Durham observed young eiders (Somateria sp.) following humans in 1167 (Watt, 1951). Sir Thomas More made more detailed and systematic observations in 1515, noting that farm workers would hatch out large numbers of chicken eggs artificially. Once hatched, the chicks came to follow the workers instead of their real hen mothers (Kevan, 1976). Spalding (1873/1954) also noted this behavior in chicks, and inferred the concept of a "critical period", wherein the attachment formed could only take place within a specified period of time.

Lorenz (1937) felt that the imprinting phenomenon was a conditioning process that allowed young precocial birds to recognize their own species. In addition, he stated that this process differed from normal associative learning in several respects. First, he felt the process was confined to a definite period of time. Second, it was irreversible. Third, the process may be latent, in terms of mate preferences when the organism was sexually mature. Subsequent research has revealed that there is much more flexibility in this type of attachment (offspring to mother or surrogate mother) than was initially proposed (Hinde, 1961).

The mechanisms mediating offspring to mother attachments that have been investigated include visual (Bateson, 1964; Jaynes, 1958), auditory (Gaioni, Hoffman, Klein, & DePaulo, 1977; Klopfer & Gottlieb, 1962; Miller, 1983), and social (Demarest, 1976; Hess, 1959; Sluckin & Salzen, 1961) variables. Some investigators have examined the so-called "critical period" and its apparent irreversibility (Gottlieb, 1961; Hess, 1964; Shapiro & Thurston, 1978; Sluckin & Taylor, 1964). Others have questioned the strict rigidity that has been applied to this time period (Fabricius & Boyd, 1954; Kovach, Paden, & Wilson, 1968; Salzen & Sluckin, 1959). Differences in testing procedures as well as species differences prevent any detailed explanations of the "imprinting" phenomenon. Major literature reviews of this area to which the reader is directed are Bateson (1966), Hess (1973), Shapiro (1980), and Sluckin (1965).

Offspring to Offspring Attachments

Attachments among the offspring have been investigated more in-depth in recent years. Raitasuo (1964) suggests that relationships among brood members seem to be based on an "imprinting"-type process. Ducklings become attached to their brood and develop reactions of restlessness and distress when the brood size is reduced below a certain minimum number, usually two to four ducklings depending on the size of the original brood. These "reduced-brood" ducklings often attempt to join unfamiliar, larger broods. Sherrod (1974) concluded that brood experience during the juvenile period (48-84 days) was most important in determining both social and sexual companion preferences, though early experiences (0-48 days) did have partial significance. More recently, research conducted at the Avian Behaviour Laboratory, University of Manitoba (see Shapiro, 1980), has shown that the brood is a highly attractive stimulus to individual ducklings. Presented with a choice, mallard ducklings preferred to be near larger broods of conspecifics than smaller broods. Ducklings also preferred their own brood over their natural mother. Thus, the brood may be seen as a form of cohesive unit that may direct attachment behavior to the hen, show attachments within itself, serve as the object of the hen's attachment behavior.

Mother to Offspring Attachments

The final and least investigated type of attachment that may form in the mallard is that from mother to offspring. This form of avian attachment is the topic of the present investigation. A review of the literature has revealed that while there are a number of field studies that have incorporated this facet of avian attachment behavior in their studies (Beard, 1964; Gorman & Milne, 1972; Munro & Bedard, 1977; Ringelman & Longcore, 1982), there is a substantial lack of actual laboratory and field experimentation in this area.

The present research investigated mother to offspring attachments in the mallard duck. Brood preferences of the hen were investigated. A series of three experiments was conducted using brooding mallard hens as the experimental subjects. For this research, brooding hens are defined as those that have laid a clutch of eggs and successfully hatched out a brood of ducklings. Non-brooding hens are those that have not been brought into an egg-laying state, whether by natural or artificial light and temperature conditions (L. J. Shapiro, personal communication, June, 1982).

The initial experiment attempted to determine whether brooding hens exhibit a brood size preference. Previous research conducted at the Avian Behaviour Laboratory (Shapiro & Mahoney, 1982) has shown that non-brooding hens do not prefer broods of ducklings under similar testing procedures. The second study was designed to test whether hens would recognize and subsequently prefer their own brood over two unfamiliar broods of equal size and age. The final experiment tested the hens' preferences for their own brood versus two larger, unfamiliar broods. All these experiments were conducted at the field station of the Avian Behaviour Laboratory as well as in the laboratory.

This research incorporated both biologically appropriate stimulus objects (ducklings, including those broods actually hatched out by the hens) and a natural developmental stage for the ducklings. Hens were tested for seven consecutive days beginning 24 hours after nest exodus. This time period approximates the first stage of plumage development in the mallard duck (Gollop & Marshall, 1954). In addition, previous researchers studying the "critical" or "sensitive" period in "imprinting" have tended to restrict their investigations to a 48 hour post-hatch age or less. There is ample experimental evidence suggesting that attachments do take place during this time period (Hess, 1959, 1962; Lorenz, 1935/1970; Sluckin, 1965), but there is no reason to conclude that the process ends there, or to suspect that attachments are not modified after 48 hours or that new attachments are not subsequently formed. By using a natural development stage in the present investigation it was hoped that these possibilities would be detected should they occur during the one week testing period used in this study.

The Hypotheses

This research represents a new approach to the study of avian attachment behavior. The experiments were designed to answer several questions. Do brooding mallard hens exhibit brood size preferences? Do these hens prefer their own broods over unfamiliar broods? Do these hens prefer very large broods as opposed to their own broods? For Experiment 1, it was hypothesized that hens would prefer the largest of the stimulus broods (a brood of 15). Since none of the stimulus broods would be the hens' own brood, any demonstrated preference would occur in the absence of any biasing familiarity for one particular brood. It was assumed, therefore, that the largest brood should provide an enhanced attractiveness for the hens, who, by definition, were in a broody state and, therefore, presumably, would be responsive/attracted to ducklings. For Experiments 2 and 3 it was hypothesized that hens would prefer their own brood to either unfamiliar broods of equal size or larger, unfamiliar broods. In these experiments it was assumed that each hen would have an increased familiarity with their own brood, in terms of both auditory communication before and after hatching (Caswell, 1967) and visual/tactile (and possible olfactory) stimulation post-hatching (see Shapiro, 1980). Familiarity, potentially mediated by these mechanisms, should translate into a behavioral preference for the hens' own brood.

Implications

The implications of this research are fourfold. First, this research allows field station and laboratory housed mallards to be evaluated on similar behaviors.

Second, this study allows the hen's involvement in the attachment process to be evaluated. Considering the extent to which offspring to mother attachments (previously called "imprinting") have been studied, it is surprising that the opposite has not occurred. A reciprocal theory of attachment formation between the hen and her brood has been postulated. It is felt that this research will help investigators understand mother to offspring attachments more fully as well as complement previous research concerning offspring to parent attachments.

Third, this research may have relevance to the study of a behavior pattern seen in the natural environment known as crèching, or sometimes as gang-brooding. Gorman and Milne (1972) provide a recent review of those Anatinae that display this behavior. McAloney (1973) defines a crèche as any group of ducklings containing young from more than one nest regardless of the number of females attending. Bedard and Munro (1976) define the crèche as a group containing any number of adult females and ducklings with two or more of the ducklings being parentally unrelated. This behavior has also been observed in mallards by the author as well as other members of the Avian Behaviour Laboratory at the Field Station of the Avian Behaviour Laboratory.

Bedard and Munro (1976) have designated a different behavioral status to those females which associate with a crèche. "Neutral" hens display no interest or attraction to a nearby brood or crèche (similar observations were made when non-brooding hens were tested for brood size preferences by the author (Shapiro & Mahoney, 1982)). "Visiting" hens show transitory broodiness, swimming near the crèche for short periods, but having no strong attraction to either the crèche as a whole or to individual ducklings. "Associate" hens show more broodiness and attraction to the crèche, but have no obvious attachments to individual ducklings. These hens may be vocal and defensive, especially when a predator is near, but they do so infrequently. "Brooding" hens are a prominent part of the crèche. They are highly vocal and defensive and have obvious attachments to individual ducklings. There are usually between one and three "Brooding" hens per crèche, depending on the number of ducklings and the aggressiveness of individual "Brooding" hens. Bedard and Munro (1976), whose observations were made on the common eider (Somateria mollissima), believe that "Associate" and "Brooding" hens have hatched clutches of ducklings and attribute their broodiness or brood preferences to having had actual experience with ducklings. If brooding hens have a preference for larger broods, then crèching behavior may potentially be explained, at least partially, through this preference.

As crèching research is investigated further, it may become apparent that brood preferences operate under hormonal control as the female progresses through incubation to hatching. Variations in hormonal levels have been documented (Blume, Phillips, & Burke, 1982). Research conducted at the Avian Behaviour Laboratory involving non-brooding hens seems to support this view. When non-brooding hens (those that have not been brought into a breeding or egg-laying state) were tested for brood size preferences, they preferred to a statistically significant degree an empty quadrant over all broods presented to them (Shapiro & Mahoney, 1982). The present research tested those hens that have actually hatched out clutches of ducklings. Future research conducted at the Avian Behaviour Laboratory will investigate brood preferences in hens during various stages of incubation in order to further assess any hormone-behavior relationship.

The fourth potential application of the current research is to restocking and releasing programs used as wildlife management techniques. The use of restocking programs to supplement natural populations has been studied intensively (Bailey, 1979; Burger, 1975, 1976; Sellers, 1973). Restocking is especially important for mallards, North America's most prominent sport waterfowl species (Posphala, Anderson, & Henny, 1974). Restocking programs are of increasing importance due to the mismanagement and overexploitation of natural nesting grounds, especially in the pot hole regions of the prairie provinces in Canada where an estimated 70% of the North American waterfowl population breeds (Burwell & Sugden, 1964; Leitch, 1975; Smith, Stoudt, & Gollop, 1964; Whitesell, 1979), and, to a lesser extent in the northern prairie regions of the United States (Kirsch, 1975).

Releasing programs can serve several purposes. First, they can provide stock for controlled shooting preserves, thus easing the hunting toll on natural populations. Second, they can supplement wild stock with the hope of enlarging breeding populations. Lastly, they can help extend the range of natural populations (Burger, 1976).

Releasing programs usually involve the release of adult birds or those juveniles that are just about to develop their first flight feathers (Burger, 1976). This procedure can be expensive in terms of caring for the birds (food, housing, etc.) until it is time to release them. The present research may lend itself to developing releasing programs which involve ducklings and which may be less expensive than current programs while also offering ducklings a more natural prefledging period of development. One study (Ball, Gilmer, Cowardes, & Reichmann, 1975) investigating brood mortality and success, found that approximately 70% of all brood mortality occurred during the first two weeks post-hatching and that this mortality was positively correlated with the amount of overland travel. The overall brood success was about 45%. This study included wood ducks and mallards and concluded that the hen mallards showed a stronger attraction to the brood than wood duck hens and that the hen mallards seemed more important to mallard ducklings for brood survival. The priority rests, though, in establishing whether brood preferences do exist in brooding mallard hens and under what circumstances these preferences are exhibited.

General Methods

Subjects

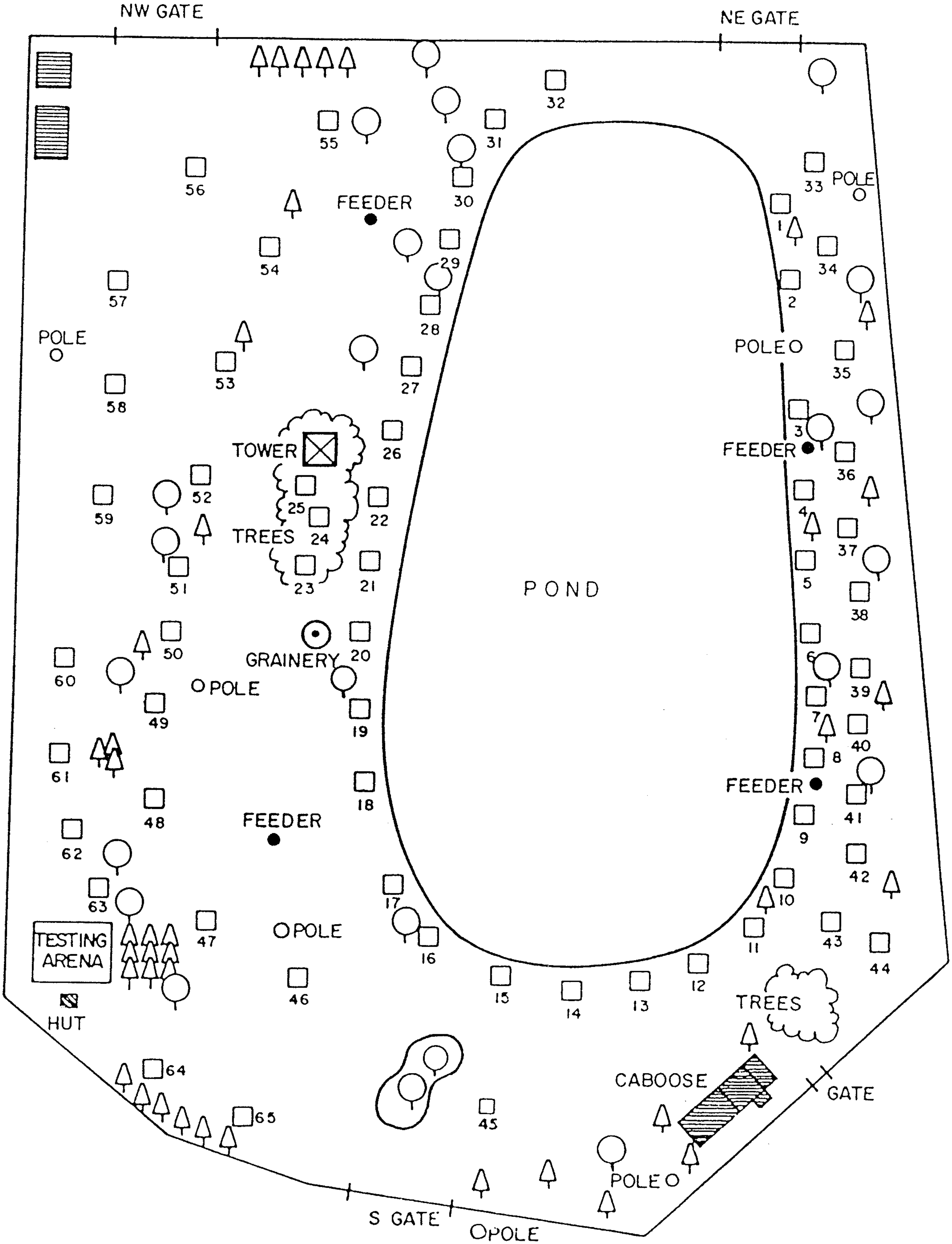
For the laboratory experiments, all subjects were obtained from a flock maintained in the Avian Behaviour Laboratory (Shapiro, 1978) on the campus of the University of Manitoba. This pinioned flock is housed in Aviary 2 of the Duff Roblin Building and was obtained from stock kept at the Field Station of the Avian Behaviour Laboratory. The aviary measures approximately 4 x 6 x 4 meters and contains a 1.5 x 2.5 x 1 meter water tank for drinking, bathing, and swimming. Water depth is approximately 0.25 meters and fresh water is continuously circulated through the tank. In addition to floor space, the aviary contains two elevated platforms which increase the available area by 8 square meters as well as providing exercise for the birds. There are 20 nest boxes in the aviary.

The male:female sex ratio within the aviary is maintained at 1:4. Birds are maintained on a diet of pelleted food that is adjusted according to their breeding condition. Oyster shell is independently available to insure adequate calcium levels.

For the field experiments, all subjects were obtained from a flock maintained at the Field Station of the Avian Behaviour Laboratory, located 12 miles south of the University of Manitoba at Glenlea, Manitoba. A diagram of the field station is illustrated in Figure 1. Approximately 100 pinioned mallards reside at the 1 hectare field station along with 100 giant Canada geese. The male:female sex ratio is approximately 1:4. The birds can feed from any one of six 800-lb. turkey range feeders which contain pelleted food during the breeding season and various grains (barley, corn, triticale) plus a 40% protein food supplement the remainder of the year. In addition, the birds can feed from a 0.33 hectare pond located at the field station and graze on available pasture (see Figure 1).

Mallards from Aviary 2 are obtained from eggs laid by the mallards at the field station (which are free to mate with free-flying mallards). Eggs are artificially incubated in one of

Figure 1. Diagram of the Field Station of the Avian Behaviour Laboratory.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two Petersime Model 1 incubators (Petersime Incubator Co., Gettysburg, Ohio, USA 45232). Both the indoor and the outdoor flocks are replaced approximately every two years with ducklings obtained from eggs laid at the field station. All adult mallards must meet confirmation specifications of the wild mallard (Bellrose, 1976; Godfrey, 1966; Johnsgard, 1979; Scott, 1968). All birds used in these experiments were governed by Canadian Wildlife Service permit WP-M41.

Stimulus Objects

Stimulus objects (ducklings) that were not hatched out by a subject hen were obtained from eggs laid by the unrestricted hens in Aviary 2. These eggs were collected daily and set weekly in a Petersime Model 1 incubator. After 24 days they were transferred to a Petersime Model H145 hatcher. After hatching, ducklings were housed communally in a Petersime Model 2SD brood unit. Water and chick starter (21% protein content) were always available. Stimulus objects for both the laboratory and field aspects of this research were obtained through this procedure. Stimulus objects used during field station testing were transported by car to and from the field station daily.

Apparatus

Subjects from Aviary 2 were tested on campus in a heat-controlled, sound-deadened experimental chamber (measuring 2.5 cubic meters). Within this chamber is a 1.5 square meter sand-covered platform which is divided into four quadrants. The platform is enclosed by 2.54 cm chicken wire-mesh to a height of

40 cm. Each quadrant contains a circular, 2.54 cm wire-mesh pen 40 cm. in diameter and 45 cm. in height. Stimulus objects were randomly placed in three of the four quadrants with one quadrant remaining empty.

Subjects obtained from the field station were run at the field station in a specially constructed testing arena which is an enlarged, outdoor replica of the testing platform on campus. The testing arena measures 3 square meters and is enclosed by chicken wire-mesh, approximately 1.5 meters high. The same circular, wire-mesh pens used on campus were placed in each of the four quadrants of the testing arena. An observation hut is centered on the south side of the arena. Two sheets of black nylon mesh cover the front of the hut, which allows the experimenter to observe a subject while minimizing possible detection by both the subject and the stimulus objects.

Pre-testing Procedure

A light regime was instituted to bring the birds in Aviary 2 into breeding condition. This regime represents an abbreviated version of natural seasonal cycles and allows two laying seasons per year with this flock. The amount of light per day within the aviary was gradually reduced from 16 to 8 hours over a period of six to eight weeks and subsequently returned to 16 hours over another six to eight week period. All mallards in Aviary 2 were hatched on 23 June 1982 and hens were on their 6th laying cycle at the time of testing.

Brooding hens were obtained in two ways. First, five individual pens, each measuring approximately 1 x 2 x 1 meters are located in Aviary 2. All birds in Aviary 2 have access to these pens. Hens were permitted to mate and, subsequently, construct nests in these pens. Those hens that did so were potential subjects in this study. Eggs laid by hens trying to establish a nest outside the five pens were collected daily and removed from the aviary. Those nests that were constructed within a pen were monitored and the eggs marked with the date laid and the pen in which it was laid. A maximum of 12 eggs per nest was desired since the average brood size for the mallard is between 8 and 12 (Bent, 1962; Coulter & Miller, 1968; Kortright, 1967). Hens lay eggs approximately once each day. To facilitate this objective one egg was added to a nest on each day that the hen did not lay an egg. If the hen continued to lay eggs and 12 eggs were exceeded, the additional egg(s) were removed.

Once it was determined that a hen was incubating a clutch strongly, the pen she occupied was closed off from the rest of the flock. Hens were visually and physically isolated from the flock once they were confined to a pen. Food and drinking water was provided through the use of sliding trays in the door of the pen. Such a procedure reduced experimenter contact with the incubating hen and helped prevent nest desertion due to experimenter interference. All pens were individually lit and were kept on the same light cycle and at the same illumination level as the main aviary. Hens began nesting in three of the five pens within Aviary 2. Two of these hens abandoned their nests within 24 hours of being closed off from the rest of the flock. It was felt that this procedure stressed the hens to a point where they abandoned their nests, despite their investments over the proceeding three to four weeks. The remaining hen completed incubation and hatched out eight ducklings.

The second method of obtaining brooding hens involved four randomly selected pairs of mallards from Aviary 2. They were placed in four separate rooms in the Duff Roblin Building. These rooms ranged in size from 3 x 3 meters to 3 x 4 meters. Wilson (1974) states that an area of approximately 2 x 3 meters is the minimum required for successful breeding in most dabbling ducks, of which the mallard is a member. Rooms contained food, drinking water, bedding, and a nest box. Pairs were permitted to mate and the females were allowed to construct nests. A male was returned to the main flock once his mate had been incubating for 2 weeks. The same procedure regarding clutch size was employed. All rooms were kept on the identical light cycle and illumination level as Aviary 2. Of the four pairs of mallards placed in separate rooms, three of them were successful in hatching a clutch. These hatches resulted in broods of 6, 10, and 10 ducklings. One hen died six weeks after being placed in the room, without having laid any eggs. A post-mortem examination conducted by Dr. Bernard Boycott (Poultry Specialist, Veterinary Services Branch, Department of Agriculture, Province of Manitoba) revealed stress related heart failure as the cause of death.

At a time when the maximum number of females were incubating strongly, their clutches were replaced by an identical number of mechanically incubated fertile eggs. All hens received eggs at the same developmental stage and incubated them for approximately the same period of time. This procedure increased the probability of equal clutch sizes across hens as well as obtaining simultaneous nest exodus.

The birds maintained at the field station are under natural seasonal cycles, breeding once per year. All pinioned mallards at the field station were hatched in the Spring of 1983 and were on their 2nd laying cycle at the time of testing. Hens were allowed to freely mate and construct nests at sites of their choice. Covered plywood and wire-mesh pens, measuring approximately 2 x 2 x 2 meters, were subsequently placed around the hens that were incubating strongly. These pens allowed easy access by the experimenter as well as providing protection to the hen and her brood from possible predators. Pens were provided with fresh food and drinking water daily. Nine females began nesting, and were potential subjects, at the field station. Predators, namely great-horned owls (Bubo virginianus), crows (Corvus brachyrhynchos), magpies (Pica pica), racoons (Procyon lotor), and skunks (Mephitis mephitis) caused several nest desertions and actually took an incubating hen off her nest in three cases. Predator interference occurred before these hens were penned, despite the fact that nests were well camouflaged, avian predators were deterred from the field station when possible, live traps were placed both inside and outside the field station to deter mammalian predators, and a provincial trapper was eventually recruited in an attempt to prevent any further predation. Two hens successfully hatched broods of 5 and 6 ducklings and were subsequently tested.

When a hen at the field station was incubating strongly, its clutch was replaced with mechanically incubated fertile eggs obtained from Aviary 2 on campus. The hen received a number of eggs equal to the number removed. Replacement eggs were at the same developmental stage as the removed eggs. All hens were treated in the same manner.

Testing Procedure

The actual testing procedures began 24 hours after nest exodus, the time when the hens had completed hatching and had taken their ducklings off the nest. This procedure was followed so that any attachments that were forming just prior to, during, or just after hatching were not disturbed or interrupted. Hens from Aviary 2 and their broods were taken from their pens to the experimental chamber in a vented transport box measuring approximately 50 x 30 x 30 cm. Each hen was tested in all three experiments before she and her brood were returned to their pen.

Stimulus objects were randomly placed in three of the four quadrants on the testing platform before testing began. There was a one minute habituation period (in the dark) for all stimulus objects prior to the start of each trial. A hen was then placed in the center of the testing platform, in the dark, facing the empty quadrant. Lights inside the testing chamber were turned on as a trial began. The amount of time the subject spent in each quadrant was automatically recorded by a four-quadrant timer and latency clock located outside the experimental chamber in front of a one-way window. Behavioral observations were also recorded during each trial. Lights inside the chamber were automatically turned off at the end of each 15 minute testing period. Hens were returned to the transport box between trials while the sand covering the testing platform was smoothed and the stimulus objects were arranged for the next trial.

Hens and their broods from the field station were tested in a similar manner. The hens were taken from their pens to the testing arena in the same transport boxes used by the experimenter on campus. The hens were randomly tested in all three experiments. Stimulus objects were placed in the testing arena and habituated for one minute before testing began. Hens were released from their transport boxes into the testing arena from a point midway between adjacent quadrants. This procedure was randomly determined both within and across testing days. A thirty second grace period was allowed before the trial officially began to allow the experimenter to position and prepare himself inside the observation hut.

At the field station the amount of time the subject spent in each quadrant was manually recorded on stopwatches by the experimenter. The 15 minute testing period was also timed on a stopwatch. Behavioral observations were recorded during each trial. Between trials, hens were placed in a transport box and kept inside the observation hut while the stimulus objects were arranged for the next trial.

Prior to testing in the three experiments, each hen was placed in the experimental chamber (for on-campus testing) or the testing arena (for field station testing) for 15 minutes without any stimulus objects present. After the first day's testing on campus this time period was reduced to five minutes due to the restlessness shown by the hens in response to this procedure. Hens began to pace the perimeter of the platform rapidly. Some hens attempted to escape from the testing platform by jumping/climbing over the retaining fence. During this time the location and the behavior of the hen was recorded. This procedure provided some habituation to the testing chamber for the hen and acted as a control condition providing baseline data for each hen in the absence of any ducklings.

The position and composition of the stimulus broods was randomly determined and was changed after each trial. Each hen's own brood was kept together at all times. The order of experimental presentation was also randomly determined for each hen both within and across days. Hens were tested once per day for seven consecutive days beginning 24 hours after nest exodus. The total experimental time per day per hen was approximately one hour and 5 minutes (5-minute control trial, 3 15-minute experiment trials, plus habituation and transportation time). Hens and their broods were kept together at all times when the hen was not being tested. Stimulus ducklings were returned to a common holding container between each series of experiments within a given day to allow feeding and drinking. All subject hens were identified by numbered leg bands. All conditions of animal care stipulated by the Canadian Council on Animal Care were adhered to. Following the completion of testing on campus, all hens were returned to Aviary 2. Following the completion of testing at the field station, hens were returned to the outdoor flock. Ducklings from both sets of experiments were released at the field station as part of an annual restocking program.

Statistical Analysis

Each experiment was analyzed using a three way analysis of variance with repeated measures on two factors. The three factors were location (Aviary 2 vs. field station), days (days 1 through 7), and stimulus objects (broods of ducklings). The repeated measures factors were days and stimulus objects. The following interactions were analyzed: Location X Day, Location X Stimulus Objects, Day X Stimulus Objects, and Location X Day X Stimulus Objects. To evaluate the presence of a position preference in the hens, their quadrant preferences were analyzed and, when this was done, this factor replaced the stimulus objects factor in a separate three way analysis of variance.

Behavioral Observations

Behavioral observations were recorded during each trial for all hens. Observations were also noted for each hen during between-trial periods as well as during transport times. Behavioral observations were also noted for stimulus objects during all of the above mentioned periods.

Experiment 1

The purpose of this study was to determine whether brood size preferences exist in mallard hens.

Method

Subjects and Apparatus. The subjects and apparatus were as described in the General Methods section.

Procedure. Brooding mallard hens were tested for brood size preferences using the procedures described in the General Methods section. Hens were able to choose among, 0, 3, 9, and 15 ducklings of the same age as the subject's own brood. None of the hens' own broods acted as stimulus objects during this experiment. They were kept in a transport box in a separate room out of audible range from the hen. During campus testing, broods were held in a separate room from the experimental chamber. During field station testing, broods were kept inside a converted caboose which serves as housing, office, and observation post for field station research. Since the average brood size for the mallard duck is between 8 and 12, the stimulus brood of 3 represented a small brood, the brood of 9 represented an average brood, and the brood of 15 a large brood. One quadrant remained empty on every trial. Quadrant positions and brood composition were randomly determined for all hens both within and across days.

Results

This experiment tested the brood size preferences of brooding hens for broods of 0, 3, 9, or 15 ducklings, with none of the stimulus objects being the hens' own brood.

Statistical results. The results of this experiment indicated that the hens preferred larger broods more than smaller broods. The analysis of variance revealed a significant main effect for the stimulus object factor $F(3, 12) = 11.53$, $p < .05$. There were no other significant main effects nor were there any statistically significant interactions. The order of means, in terms of minutes spent with each set of stimulus objects, was; brood of 15 ($\overline{X} = 5.52$ min.), brood of 9 ($\overline{X} = 4.36$ min.), brood of 3 ($\overline{X} = 3.17$ min.), and the empty quadrant ($\overline{X} = 1.95$ min.). Tukey's studentized range statistic revealed that the hen preferred the brood of 15 significantly more than the brood of 3 ($p < .05$) and the empty quadrant ($p < .05$). The brood of 9 was preferred significantly more ($p < .05$)) than the empty quadrant. There were no other statistically significant differences. These results are illustrated in Figure 2.

Quadrant preferences were also analyzed in a separate analysis of variance. No significant ($p > .05$) main effects or interaction effects were obtained. These results are presented in Figure 3.

Behavioral observations. Hens showed no obvious attraction to any particular set of stimulus objects, in terms of physical closeness to a pen or vocalizations near a particular pen. Hens tended to remain in those quadrants containing stimulus objects. There were no attempts to escape from the testing arena and the hens remained near the center of the testing arena when in the empty quadrant and oriented themselves toward the ducklings.

Figure 2. Mean time spent by brooding hens from Aviary 2 and the field station with broods of 0, 3, 9 or 15 ducklings during the seven day testing period in Experiment 1.

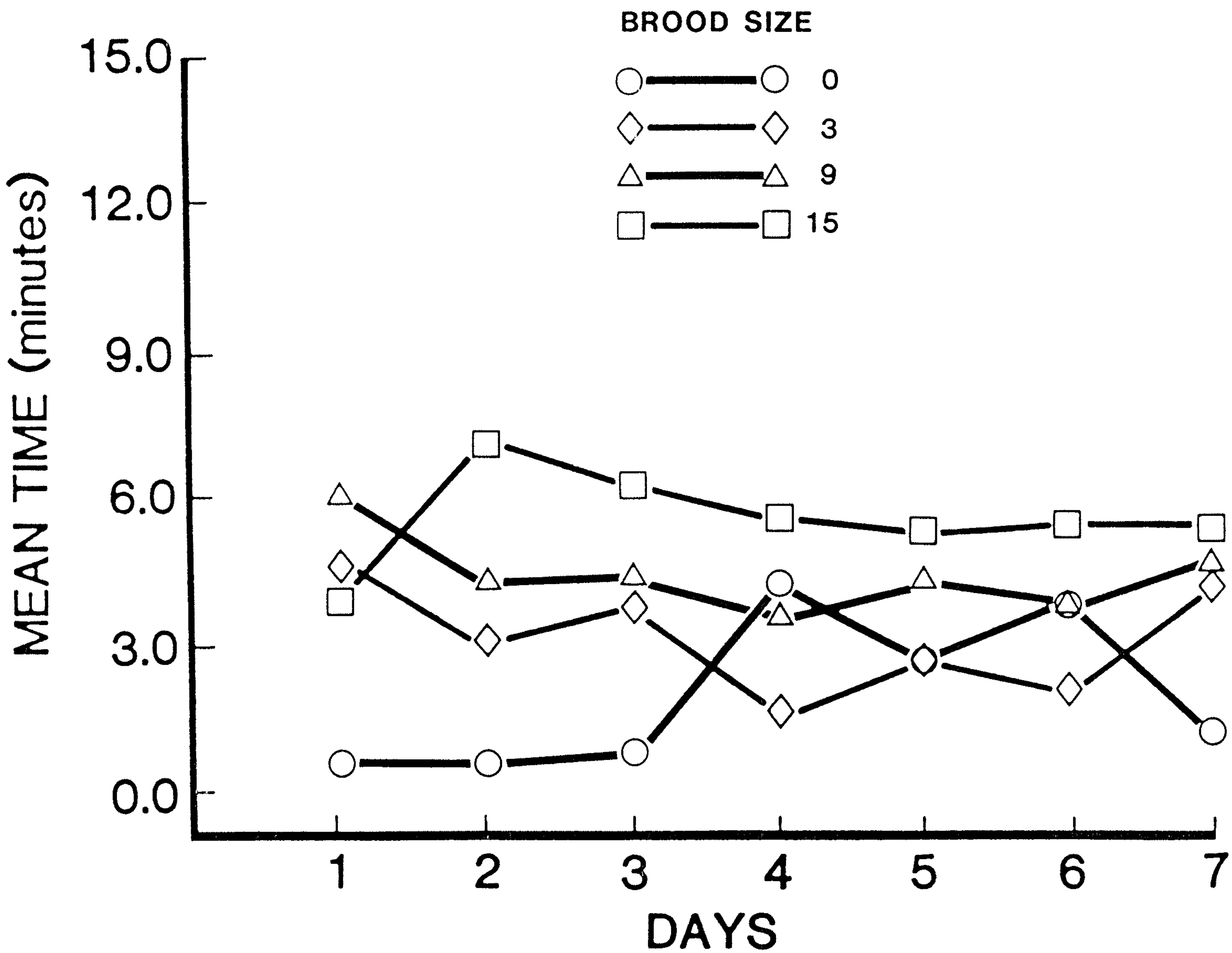
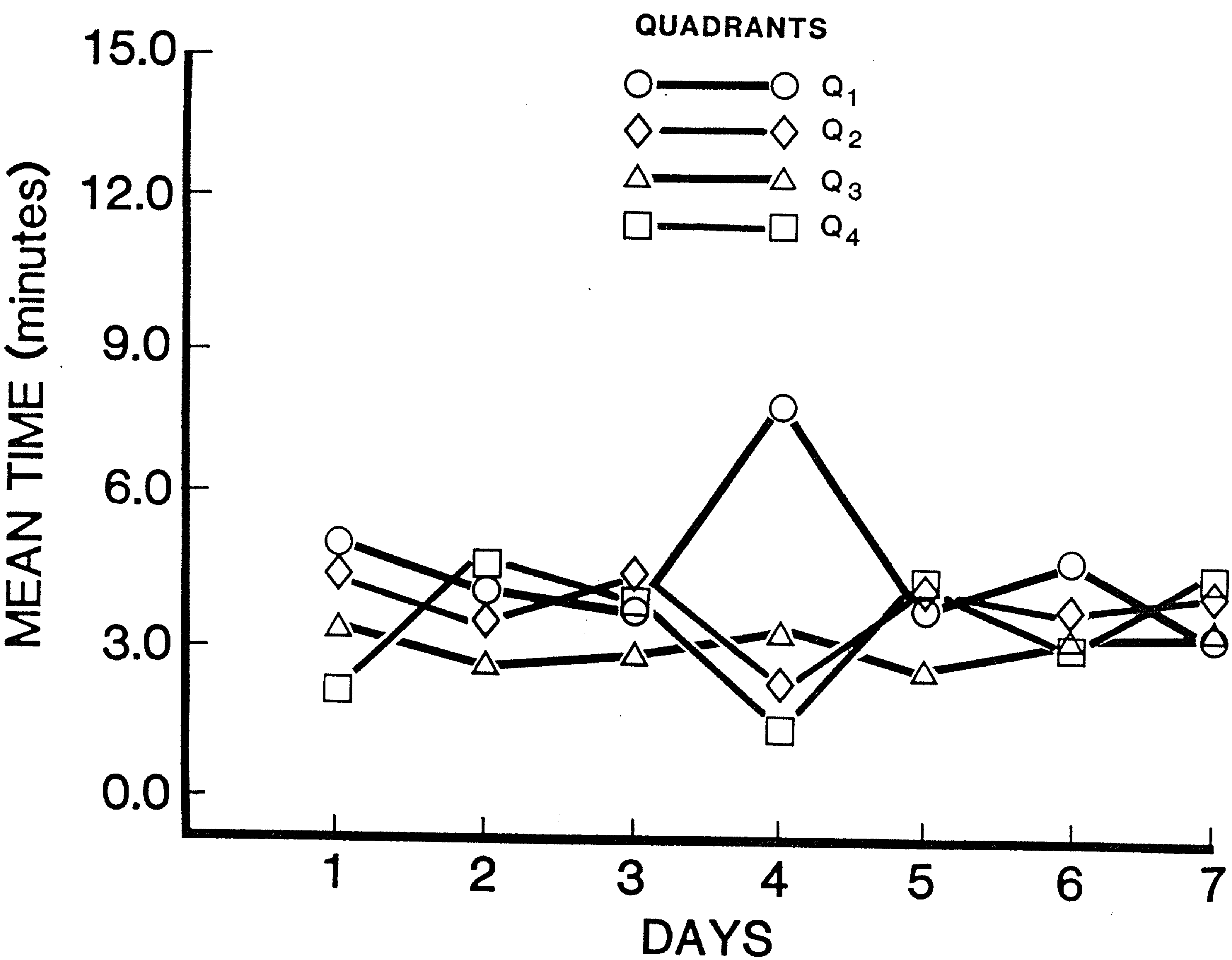

BROOD SIZE
0
3
9
15
15.0
12.0
9.0
6.0
3.0
0.0
MEAN TIME (minutes)
1
2
3
4
5
6
7
DAYS

Figure 3. Mean time spent in each quadrant of the testing platform/arena by brooding hens from Aviary 2 and the field station during the seven day testing period in Experiment 1.


QUADRANTS
Q1
Q2
Q3
Q4
15.0
12.0
9.0
6.0
3.0
0.0
MEAN TIME (minutes)
1
2
3
4
5
6
7
DAYS

Stimulus objects remained calm and quiet for all trials. The brood of three showed greater restlessness than either of the two larger broods. This restlessness was not constant and amounted to a greater time spent walking around the pen and shuffling positions while huddling.

Discussion

It was hypothesized for Experiment 1 than hens would prefer the largest of the stimulus broods, the brood of 15, in terms of time spent in that brood's quadrant. None of the stimulus broods were the subjects' own brood but since all hens were in a broody state at the time of testing, it was presumed that this broodiness would translate into a behavioral preference for ducklings, even though none of the hens' own ducklings acted as stimulus objects. It was assumed that the brood of 15 would be chosen as the likely object of this preference since that brood should have provided an enhanced attractiveness, in terms of sheer numbers and the probability of greater movement, vocalizations, and possibly greater heat generation.

The results of Experiment 1 showed that, indeed, the brood of 15 was preferred over all other stimulus broods (0, 3, and 9 ducklings) in terms of mean time spent in the quadrant of each brood. Statistical significance, however, was achieved only in comparison with the brood of 3 and the empty quadrant. The brood of 9 was significantly preferred over the empty quadrant. These results seem to indicate that brooding hens tend to prefer ducklings in general, as well as larger broods over smaller broods. Behavioral results also support this hypothesis. Observations revealed that hens actively avoided spending time, except in passing, by the pen in the empty quadrant. When inside the empty quadrant for any length of time, hens would remain close to the center of the arena, in closer proximity to all stimulus broods. It is not likely that the hens' preferred the brood of 15 because they generated more heat than the other broods. The testing chamber on campus is heat controlled, while testing at the field station was conducted during hot summer weather. Therefore, it is assumed that a potentially greater amount of heat generated by the brood of 15 would not affect the hen's preference.

Hens did not spend lengthy periods of time by any of the stimulus broods, nor was there any indication of vocal exchange between the hen and any brood. Preference for the brood of 15 may be due to greater movement within their pen, to sheer numbers alone, or to some combination of these factors. The brood of 3, however, showed more movement and restlessness than the other stimulus broods, yet it was not preferred. There was no obvious difference between the brood of 9 and the brood of 15 with respect to amount of movement. Perhaps brooding hens, who appear to be attracted to ducklings in general, prefer groups of ducklings that resemble their own brood size, or larger. The brood of 3 may be too small to elicit a preference under these experimental conditions.

Experiment 2

The purpose of this study was to determine whether brooding hens prefer their own brood when simultaneously exposed to their own brood and to two unfamiliar broods of equal size and of the same age as their own brood.

Method

Subjects and apparatus. The subjects and apparatus were as described in the General Methods section.

Procedure. The same brooding hens used in Experiment 1 were tested in this experiment using the procedures described in the General Methods section. The subject's own brood occupied one quadrant while two randomly selected broods of equal size and of the same age as the subject's brood occupied two of the remaining three quadrants. One quadrant remained empty on every trial. Quadrant positions and the composition of the stimulus broods (not the subject's own brood) were randomly determined within and across days.

Results

This experiment tested a hen's preferences for her own brood versus two unfamiliar broods of equal size.

Statistical results. No statistically significant ($p > .05$) main effects or interaction effects were obtained in this experiment. In decreasing order, the mean time spent per set of stimulus objects was as follows; own brood ($\bar{X} = 4.64$ min.), first brood counter-clockwise from own brood ($\bar{X} = 3.77$ min.), first brood clockwise from own brood ($\bar{X} = 3.53$ min.), and the empty quadrant ($\bar{X} = 3.06$ min.). These results are presented in Figure 4.

Quadrant preferences were also analyzed in a separate analyses of variance. No significant ($p > .05$) main effects or interaction effects were obtained. These results are illustrated in Figure 5.

Figure 4. Mean time spent by brooding hens from Aviary 2 and the field station with their own brood, with two unfamiliar broods of the same size and of the same age as their own brood, or in an empty quadrant during the seven day testing period in Experiment 2.

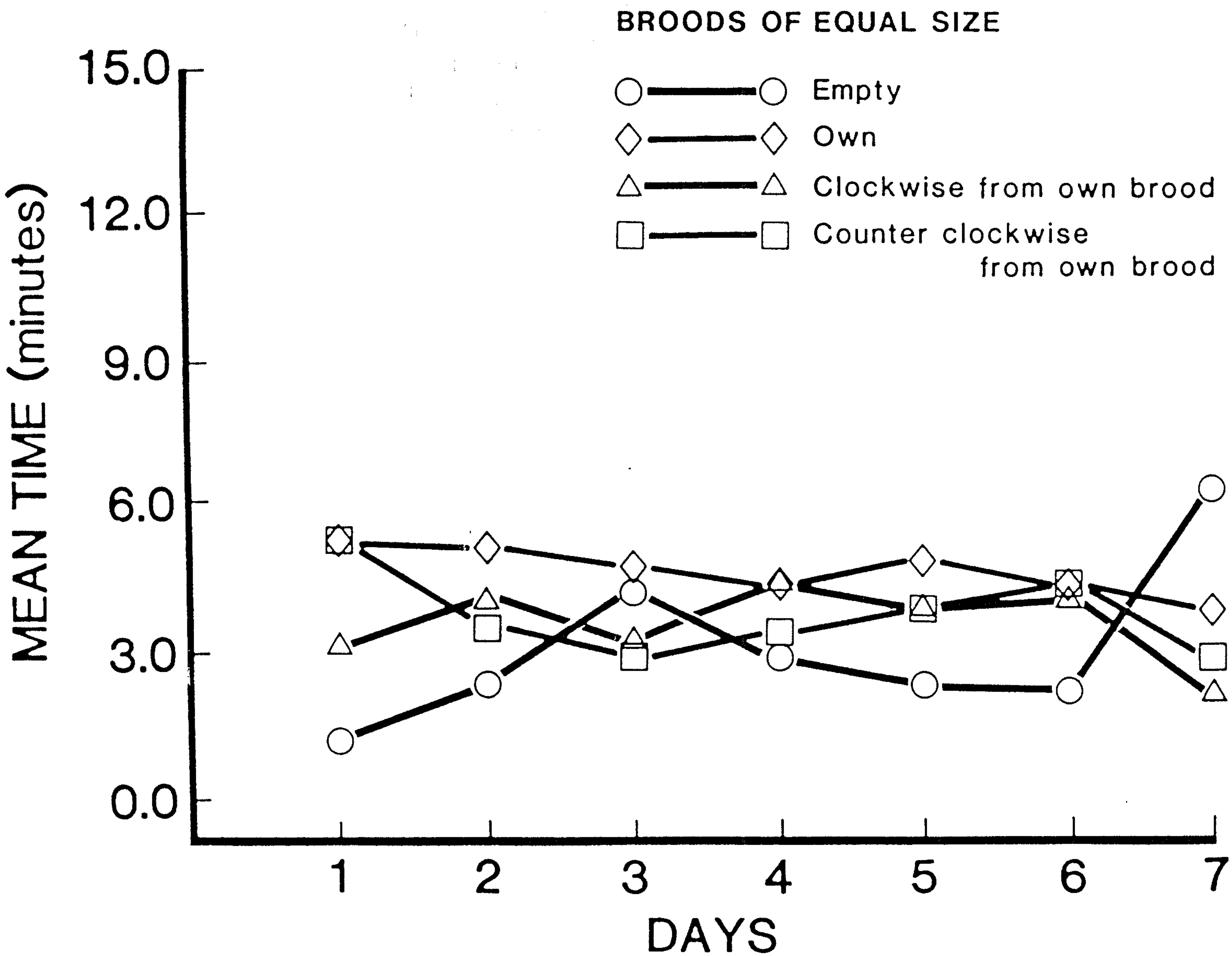
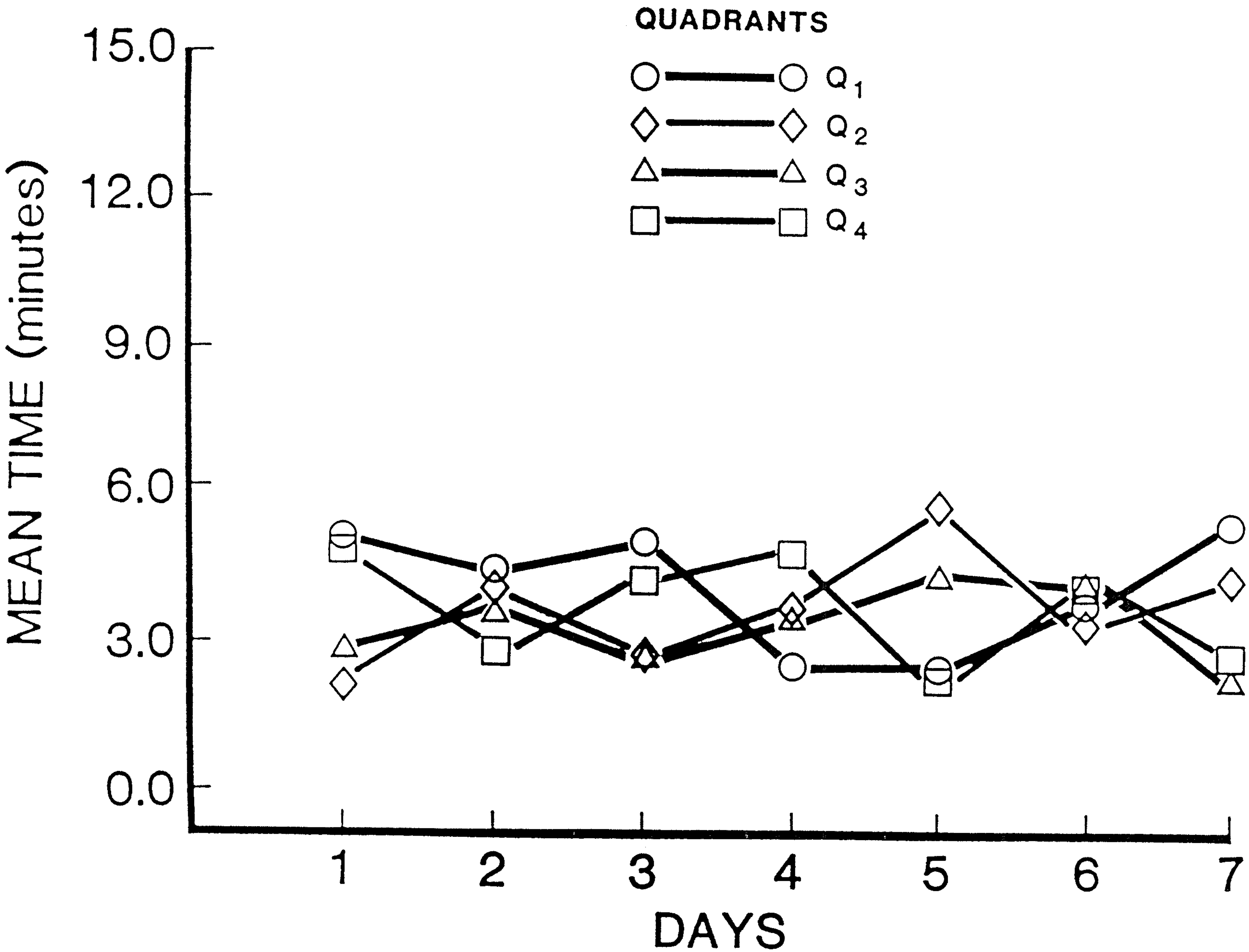

BROODS OF EQUAL SIZE
Empty
Own
Clockwise from own brood
Counter clockwise from own brood
MEAN TIME (minutes)
15.0
12.0
9.0
6.0
3.0
0.0
1
2
3
4
5
6
7
DAYS

Figure 5. Mean time spent in each quadrant of the testing platform/arena by brooding hens from Aviary 2 and the field station during the seven day testing period in Experiment 2.


QUADRANTS
Q 1
Q 2
Q 3
Q 4
15.0
12.0
9.0
6.0
3.0
0.0
MEAN TIME (minutes)
1
2
3
4
5
6
7
DAYS

Behavioral observations. Hens' behavior during testing on this experiment was consistent with that during Experiment 1 with one exception. On the whole, hens' spent more time in a stationary position, either standing or sitting. When doing so, hens' positioned themselves near the center of the testing arena, facing the ducklings. A good deal of this time was spent in the empty quadrant, which accounted for the lack of statistical significance between the stimulus broods and the empty quadrant. There were no attempts to escape.

There were no obvious differences among the stimulus broods in terms of either restlessness or vocalizations. All broods oriented and positioned themselves toward the center of the testing arena.

Discussion

For Experiment 2 it was hypothesized that hens would prefer their own brood over two unfamiliar broods of equal size and of the same age as the subjects' own brood. Previous research (Shapiro & Donovan, 1984; Shapiro & Mahoney, 1982) indicated that there should be no behavioral differences between these broods. Hens would have had an increased familiarity with their own brood, in terms of pre- and post-hatching auditory communication and visual/tactile (and possibly olfactory) stimulation post-hatching. It was presumed that this increased familiarity would be expressed as a behavioral preference for the subjects' own brood.

The results of Experiment 2 showed no statistical preference for any of the stimulus broods or the empty quadrant. The results were in the predicted direction, however, with the hens' own brood being preferred most, followed by the brood counterclockwise from the subject's own brood (CC brood), the brood clockwise from the subjects' brood (CL brood), and the empty quadrant. Behavioral observations revealed that the hens spent more time in the empty quadrant during this experiment than in Experiment 1, but they remained near the center of the arena when doing so. The statistical results of Experiment 2 may be misleading, since the hens did not try to avoid the stimulus broods by remaining as far away from them as possible but, instead, positioned themselves nearly equidistant from all three broods and oriented themselves toward them indicating some interest in them.

The behavioral observations of Experiment 2 revealed no apparent differences between any of the stimulus broods. The hens' slight preference for their own brood may be due to their increased familiarity with that brood. There was no reason to assume a difference between the CC brood and the CL brood. Their overall means were extremely close. In addition, the observations revealed no directional preference by the hens while walking around the testing arena.

Experiment 3

The purpose of this study was to determine whether brooding hens prefer their own brood or larger broods.

Method

Subjects and Apparatus. The subjects and apparatus were as described in the General Methods section.

Procedure. The same brooding hens used in Experiments 1 and 2 were tested in this experiment using the procedures described in the General Methods section. The subject's own brood occupied one quadrant while two randomly selected larger broods, of the same age as the subject's own brood, occupied two of the remaining three quadrants. One quadrant remained empty on every trial. The two larger broods consisted of a number of ducklings in increments of six greater than the hen's actual brood size. For example, a hen with a brood of eight would require larger broods of 14 and 20 ducklings. Six had been chosen so that the broods were, presumably, discriminably larger to the hen. Again, quadrant positions and stimulus brood composition were randomly determined within and across days.

Results

This experiment tested a hen's preference for her own brood versus larger, unfamiliar broods.

Statistical results. The analysis revealed significant differences with regard to the stimulus object factor $F(3, 12) = 18.80$, $p < .05$. There were no other significant differences or interactions. Tukey's post-hoc analysis revealed that the largest brood, consisting of a number of ducklings 12 greater than the subject hens' own brood, was preferred ($p < .05$) over the large brood (own brood size plus 6 ducklings), over the hen's own brood, and over the empty quadrant. The large brood was preferred significantly more ($p < .05$) than the empty quadrant. There were no other significant differences. The order of the means, in terms of minutes spent with each set of stimulus objects, was; largest brood (own brood size plus 12 ducklings) ($\overline{X}$ = 6.12 min.), large brood (own brood size plus 6 ducklings) ($\overline{X}$ = 4.06 min.), own brood ($\overline{X}$ = 2.98 min.), and the empty quadrant ($\overline{X}$ = 1.79 min.). These results are illustrated in Figure 6.

Quadrant preferences were also analyzed in a separate analysis of variance. No significant ($p > .05$) main effects or interaction effects were obtained. These results are presented in Figure 7.

Behavioral observations. The behavior of the hens was consistent across the seven testing days of this experiment. Hens obviously spent more time in those quadrants that contained the largest brood. In doing so, hens stood or sat near the center of the arena in the quadrant containing the largest brood, orienting toward all broods. There was no obvious preferred orientation nor vocal communication between the hen and any particular brood.

Stimulus object behavior remained consistent with the other two experiments. There were minimal vocalizations and most of their time during testing was spent huddling and dozing. Space inside the quadrant holding pens was ample, even for the largest stimulus brood of 22 ducklings at seven days post nest-exodus.

Discussion

It was hypothesized in Experiment 3 that hens would prefer their own brood over two larger, unfamiliar broods due to each subject's increased familiarity with their own brood. This familiarity was presumed to override the enhanced physical attractiveness of the larger broods. The results of Experiment 3

Figure 6. Mean time spent by brooding hens from Aviary 2 and the field station with their own brood, with larger broods (own brood size + 6 or + 12 ducklings), or in an empty quadrant during the seven day testing period in Experiment 3.

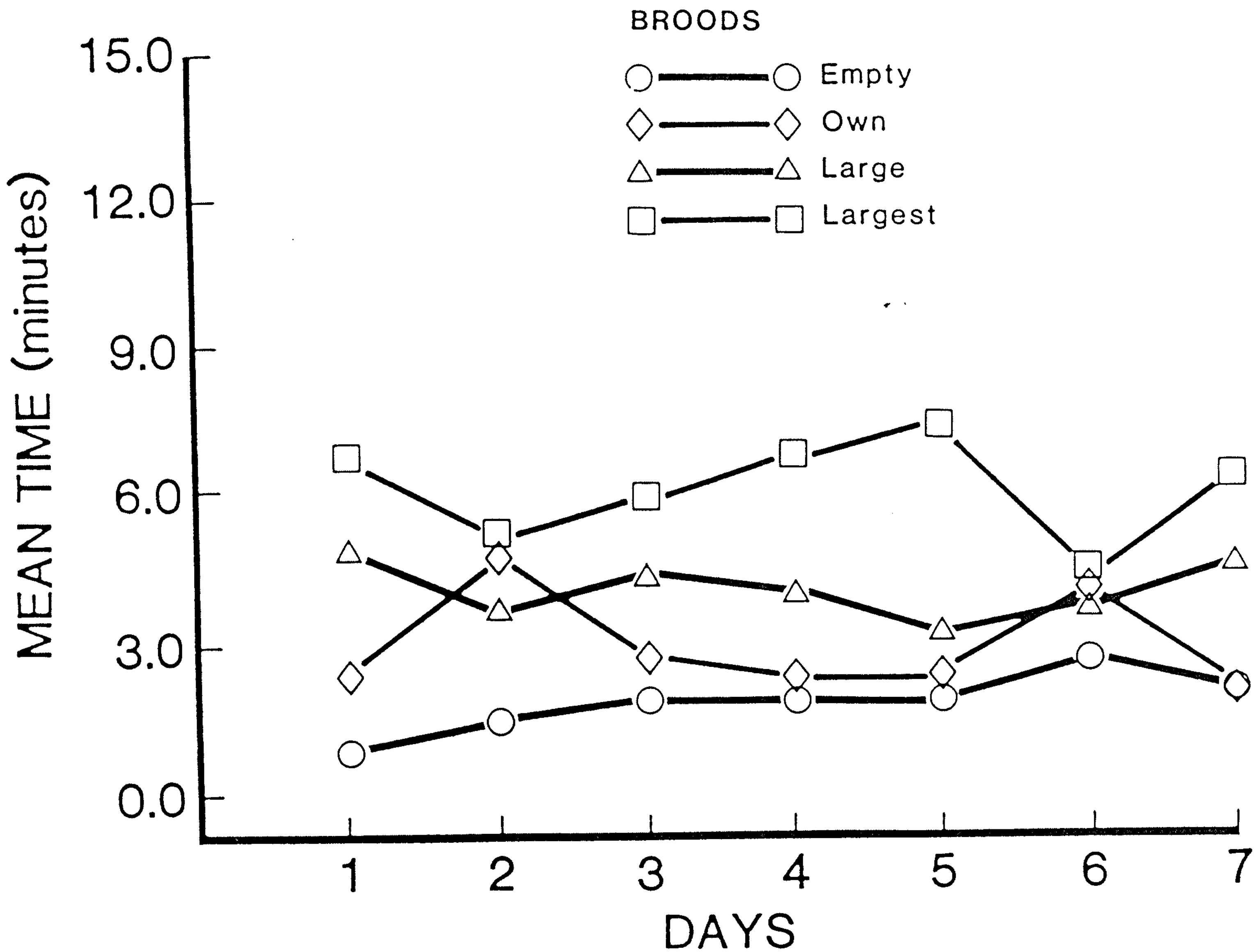
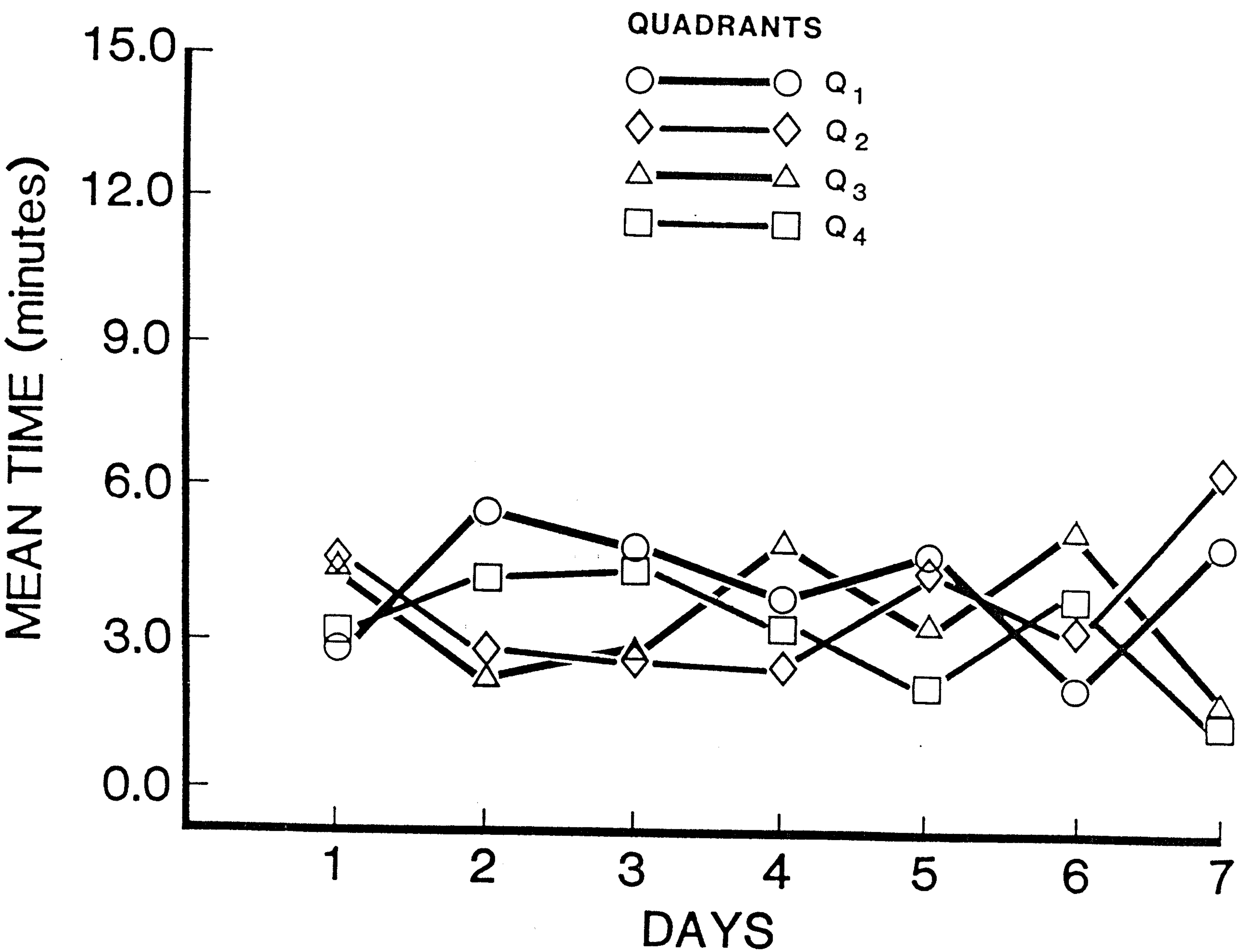

BROODS
Empty
Own
Large
Largest
15.0
12.0
9.0
6.0
3.0
0.0
MEAN TIME (minutes)
1
2
3
4
5
6
7
DAYS

Figure 7. Mean time spent in each quadrant of the testing platform/arena by brooding hens from Aviary 2 and the field station during the seven day testing period in Experiment 3.


QUADRANTS
Q 1
Q 2
Q 3
Q 4
15.0
12.0
9.0
6.0
3.0
0.0
MEAN TIME (minutes)
1
2
3
4
5
6
7
DAYS

contradicted this hypothesis entirely. The order of means, from highest to lowest, in terms of time spent in each quadrant was; largest brood (subjects own brood size plus 12 ducklings), large brood (own brood size plus 6 ducklings), own brood, and the empty quadrant. The largest brood was statistically preferred over all other stimulus broods, including the empty quadrant, and the large brood was preferred over the empty quadrant. These results support those of Experiment 1. They indicate that brooding hens prefer larger broods.

Behaviorally, hens exhibited no vocal communication with any brood nor a preference to remain in close physical proximity to any brood. No behavioral differences between the stimulus broods was evident during testing. The hens' preference for the largest brood may potentially be mediated by the same factors as in Experiment 1. These factors are the total number of ducklings in the brood, possibly combined with overall movement. Again, vocalizations were minimal and heat generation may be discounted.

General Discussion

The primary objective of these experiments was to evaluate the involvement of the mallard hen in the attachment process that occurs between the hen and her brood. Experiments 1 and 3 indicated, in part, that hens prefer larger broods over smaller broods while Experiment 2 indicated that hens do not prefer their own brood significantly more than two unfamiliar broods of the same species and of the same size and age as their own brood.

The results of Experiment 3 seem unequivocal. Broods larger than the hen's own brood by 12 ducklings are preferred to a significantly greater extent that broods larger than the hen's own brood by 6 ducklings. The latter, in turn, is preferred significantly more than the hen's own brood and an empty quadrant. These results partially support the findings of Experiment 2. In that experiment it was found that the hen does not prefer her own brood significantly more than strange broods of the same size and age as her own brood. It would seem that for a hen to prefer an unfamiliar brood significantly more than her own brood, the unfamiliar brood must be larger than her own brood.

Experiment 1, however, provides some puzzling data. This experiment was designed to evaluate the hen's preferences for larger and smaller broods of the same age as her own brood. In general, larger broods were preferred significantly more than smaller broods. The broods of 15 and 9, however, were not found to differ to a statistically significant degree, although their mean times were in the predicted direction ($\overline{X}_{15}$ = 5.52 min. as opposed to $\overline{X}_9$ = 4.36 min.). Similarly, a brood of nine was not found to differ significantly from a brood of three, yet nine was preferred significantly more than the empty quadrant (a brood of 0). Why should broods of 15 and 9 and broods of 9 and 3 be equivalent? The answer is not apparent from these results. The small sample size used in these studies may be masking any true difference in that potentially exists in the hen's preference for larger broods. The results of Experiment 3 support this possibility and indicate that Experiment 1 should be repeated with a larger sample size.

Low sample size reduces the power of a statistical test. This low sample size may account for the equivocal results of some of these studies. The behavior of Aviary 2 and field station hens was extremely similar both within and across experiments, however. This behavioral similarity moderates the view that these results are equivocal. Where equivocal results have been obtained, only a replication with a larger sample size will resolve the question concerning the validity of these results.

Classical imprinting theory assumes that a duckling forms an attachment to its mother. No mention is made of the mother's role in the attachment process. The present results indicate that although the hen does not seem to prefer her own brood over strange broods of the same size and age as her own brood, she does seem to exhibit a preference for larger broods. Consequently, the hen's preferences should be taken into consideration in future discussions of avian attachment behavior.

Statistical Considerations

All three experiments were analyzed in the same manner. In all experiments there were no statistically significant ($p > .05$) main effects attributable to the location factor (Aviary 2 vs. field station). There were no statistically significant ($p > .05$) interactions nor were there any statistically significant ($p > .05$) quadrant preferences when the data were analyzed for that factor. There were also no statistically significant ($p > .05$) quadrant preferences manifested by the hens during the pre-testing period when the hens were placed in the testing arenas without stimulus objects present.

Behavioral Observations

Hen behavior was very consistent between Aviary 2 and field station hens. When the experimenter entered individual pens or rooms, hens and their broods were always together. They were never dispersed throughout the room or pen, and tended to be either near the nest box, feeder, or waterer. The experimenter only entered a room or pen to clean, add food or water, or to collect subjects and stimulus objects for daily testing. Upon entering, ducklings would huddle into a tight group. Distress vocalizations were sometimes heard but were not prominent. Hens immediately began threat displays. These included a low, neck-outstretched posture, fluffing of their feathers, hisses or low, squeaky quacks, and partial lunges toward the experimenter. Hens were collected first on testing days. No aggression toward the experimenter was observed other than threat displays.

Threat displays by all hens were also prominent during between-trial periods. During this time the experimenter entered the testing arena to place a subject hen in a transport box while stimulus objects were rearranged for the next trial. The presence of the experimenter was sufficient to evoke threat displays. This occurred no matter which brood the hen or the experimenter happened to be nearest to. Ducklings did not vocalize during these periods.

Hen behavior during testing was remarkably similar. In trials when hens were placed in the testing arenas without the presence of stimulus objects, all hens behaved in an agitated manner. Hens would pace the perimeter of the arena in no particular pattern. They would poke with their bills at the stimulus object pens as well as at the wire mesh surrounding the arena. Hens would also push with their breasts against the wire-mesh surrounding the testing arena. The velocity of the hens' pacing generally increased as the control trial went on. On two occasions, on the first days of testing, hens attempted to push against and climb over the wire-mesh fencing. It was for this reason that the total trial time was reduced from 15 to 5 minutes for the particular trials.

When stimulus objects were presented to the hens their behavior changed. In all experiments, the hens tended to avoid the empty quadrant and remain primarily in those quadrants containing ducklings. Hens would poke at and pace around pens, but showed no obvious behavioral preference for any particular brood, including their own. Vocalizations by hens were minimal and short-lived and only occurred toward the beginning of a trial (i.e. in the first 3 minutes). For the most part, hens would walk around during testing trials. Their pace was much slower than when stimulus objects were not present during the pre-testing trials, and the hens did not remain at the perimeter of the testing arena, but stayed more toward the middle of the arena. When hens did stand or sit for a period of time, they did so at a point near equidistant from all broods. Hens sometimes did so inside the empty quadrant (near the center of the testing arena) but always faced the stimulus objects.

Stimulus object behavior was also very similar for all broods in all experiments. All broods tended to orient and position themselves toward the center of the testing arena, although at times they were dispersed throughout a pen. As with the hens, vocalizations were minimal and occurred early during a trial. All ducklings spent over half of every trial huddling quietly together, dozing off and on. When not dozing, they would peck around the floor of the pen and at the pen itself. Ducklings would sometimes poke their heads through the fencing of the pen, but there were no strong attempts to get out. On several occasions when a hen walked or stood closely by a pen, some ducklings would stand and try to peck at the hen in a non-aggressive manner. This behavior did not last more than a few seconds. There were no attempts by any duckling, including a hen's own brood, to follow a hen as she passed by. Overall, larger broods tended to be slightly less active than smaller broods. Between trials, ducklings would huddle together and orient themselves away from the experimenter.

Implications

One of the questions of practical importance to similar experiments that may be done in the future in the Avian Behaviour Laboratory is whether there are behavioral differences between Aviary 2 mallards and the field station mallards. Aviary 2 mallards are obtained from eggs laid by field station mallards who are permitted to mate with free-flying mallards. Both flocks are replaced approximately every two years. There were no statistically significant differences obtained on the dependent variable measures used in these studies between these two groups. In addition, there were no observed behavioral differences between these two flocks. These findings allow a greater degree of confidence in future generalizations that may be made between these two flocks.

Another question of practical importance to similar studies that may be done in the future involves a potential difference in exhibited behavior attributed to the size of the testing arena on campus and the size of the testing arena at the field station. The testing arena at the field station is an enlarged replica of the one on campus. The behavior exhibited by the hens tested at the field station was almost identical to that of the hens tested on campus. These observations lead to the conclusion that the size of the testing arena can vary without biasing the outcome of these results but that the size should probably not be smaller than the testing platform on campus (1.5 m^2) nor should it be much larger than the testing arena at the field station (3 m^2).

Behavioral observations revealed that hens, at times, tended to position themselves near the center of the testing platform, at a point nearly equidistant from all stimulus broods. Testing platforms smaller than 1.5 m^2 would have the stimulus broods closer to each other and make it more difficult for a hen to show a clear behavioral preference for any particular brood because she would be that much closer to all broods. The testing arena at the field station (an enlarged replica of the testing platform) was constructed to accommodate the possibility that the testing platform was too small for a clear preference to be exhibited. If a hen preferred to remain near a particular brood, she would have had to walk approximately 2 meters from the center of the arena to be next to the pen it occupied as opposed to approximately 0.75 meters on the testing platform on campus.

The present research has some bearing on the behavior pattern known as crèching. A crèche can be defined as a group containing any number of adult females and ducklings with two or more of the ducklings being parentally unrelated (Bedard & Munro, 1976). This behavior has been observed to occur in natural waterfowl populations as well as captive populations, such as that maintained at the Field Station of the Avian Behaviour Laboratory. In their study of crèching behavior, Bedard and Munro (1976) designated different behavioral categories to those hens which associate with a crèche. As mentioned previously, these categories include "Neutral" hens, which display no interest or attraction to a brood. These observations of Bedard and Munro are consistent with those seen when non-brooding hens were tested for brood size preference at the Avian Behaviour Laboratory (Shapiro & Mahoney, 1982).

"Visiting" hens show transitory broodiness, but no strong attraction to the crèche as a whole or to individual ducklings. "Associate" hens show a stronger attraction to the crèche, and may be vocal and defensive, but do so infrequently. They show no attraction to individual ducklings. "Brooding" hens are highly vocal and defensive and have obvious attachments to individual ducklings. Results from the present study show that those hens acting as subjects fall in between the "Associate" and "Brooding" hen categories. Hens were consistently defensive throughout testing for all ducklings, like "Brooding" hens. However, they showed no obvious attachment to individual ducklings (i.e. their own brood), resembling "Associate" hen behavior. Crèching in brooding hens may have as its biological basis a natural preference for larger broods.

Should broodiness, a state of being attracted to and defending a brood, be strongly related to hormonal levels (Blume, Phillips, & Burke, 1982), then testing hens during different stages from pre-laying to post-hatching should reveal changing behavioral preferences and tendencies as hormonal levels vary. Avian Behaviour Laboratory research has looked at either end of this continuum, non-brooding hens who were not in an egg-laying state and brooding hens who have hatched out a brood. The in-between stages need to be studied.

The present results may also have some relevance to wildlife management techniques associated with restocking and releasing programs. The numbers of migrating mallards have been decreasing over recent years, with the decline from 1984 to 1985 being quite significant ("Duck Populations", 1985) according to U.S. and Canadian Wildlife Services. The mallard is North America's most prominent sport waterfowl species; annual migration estimates are 62 million birds in 1985. This figure, however, represents a drop of 22 percent in just one year's time. Mallards are not being considered endangered, or even threatened, but to prevent this from being the case, sound management practices should be implemented.

Perhaps the largest problem facing waterfowl populations in the prairie pot hole regions of the northern U.S. and western Canada is the mismanagement and overexploitation of natural nesting grounds. Here is where an estimated 70% of the total North American waterfowl population breeds. Local and federal governments need to become fully involved in this situation before drastic management procedures need to be put into effect.

Governments have several options that they can implement. First, they can begin to use these natural nesting grounds more wisely, even setting aside certain areas as breeding preserves or creating man-made breeding areas where natural ones have disappeared. Second, governments can reduce the hunting toll on existing populations (Jessen, 1970). This idea involves reducing daily and overall bag limits and even suggests designating refuge areas during hunting seasons. The effects of hunting mortality on populations has been a cloudy area and is currently being looked at more closely (Hochbaum & Walters, 1984).

Finally, restocking and releasing programs could be implemented. These programs can provide stock for controlled shooting preserves, which eases the hunting toll on natural populations. They can also help to enlarge a breeding population as well as help to extend its range. These types of programs have usually involved the release of adult or near-adult birds. Lee and Kruse (1973) give an example of high survival and homing rate for a group of hand-reared wild-strain mallards. This program utilized the "gentle release" technique. This involved allowing the birds to fly away on their own. Birds are enclosed by a fence to discourage predators, yet they are not covered. As their flight feathers develop they are able to leave the compound, usually and eventually joining passing migrating groups. Although success has been achieved with such programs, they can be expensive to operate, in terms of caring for the birds until this adult or near-adult age.

The present research may lend itself to programs involving ducklings. If brooding hens prefer larger broods then it should be possible for wildlife management personnel to supplement broods with additional ducklings at an early age. This procedure may prove to be a sound management practice because fewer hens would be required to raise more ducklings. This procedure would also offer ducklings a more natural prefledging environment in which to develop (being raised with a hen as opposed to group rearing in pens without a hen). A natural preference for larger broods would contribute to the success of such a procedure.

References

Bailey, R. O. (1979). Wild mallard stocking in a large marsh habitat. Canadian Field Naturalist, 93, 55-62.

Ball, I. J., Gilmer, D. S., Cowardin, L. M., & Reichmann, J. H. (1975). Survival of wood duck and mallard broods in north-central Minnesota. Journal of Wildlife Management, 39, 776-780.

Bateson, P. P. G. (1964). Changes in chicks' responses to novel moving objects over the sensitive period for imprinting. Animal Behaviour, 12, 479-489.

Bateson, P. P. G. (1966). The characteristics and context of imprinting. Biological Review, 41, 177-220.

Beard, E. B. (1964). Duck brood behavior at the Seney National Wildlife Refuge. Journal of Wildlife Management, 28, 497-521.

Bedard, J., & Munro, J. (1976). Brood and crèche stability in the common eider of the St. Lawrence Estuary. Behaviour, 50, 221-236.

Bellrose, F.C. (1976). Ducks, geese,and swans of North America. Harrisburg, PA: Stackpole Books.

Bent, A. C. (1962). Life histories of North American wildfowl. New York: Dover.

Bluhm, C., Phillips, R. E., & Burke, W. H. (1982). Serum levels of leutenizing hormone, prolactin, estradiol, and progesterone in laying and nonlaying mallards (Anas platyrhynchos). Biology of Reproduction, 28, 295-305.

Burger, G. (1975). Artificial propagation in waterfowl management. First International Waterfowl Symposium, 1, 104-109.

Burger, G. (1976). Propagation and release of mallards. Second International Waterfowl Symposium, 2, 30-34.

Burwell, R. W., & Sugden, L. G. (1964). Potholes-going, going... In J. P. Linduska (Ed.), Waterfowl Tomorrow. Washington, DC: U.S. Government Printing Office.

Caswell, F. D. (1967). The development of acoustical communication in the mallard (Anas platyrhynchos). Unpublished Master's Thesis, University of North Dakota, Grand Forks.

Coulter, M. W., & Miller, W. R. (1968). Nesting biology of black ducks and mallards in northern New England. Vermont Fish & Game Department Bulletin, 68, 57-64.

Demarest, J. (1976). Some studies analyzing aspects of social organization in clutches of young waterfowl (Anas platyrhynchos). Unpublished doctoral dissertation, State University of New York.

Duck populations feared lowest on record. (1985, August). Winnipeg Free Press, p. 58.

Fabricius, E., & Boyd, H. (1954). Experiments on the following reaction of ducklings. Wildfowl Trust Annual Report, 6, 84-89.

Gaioni, S., Hoffman, H. S., Klein, S. H., & DePaulo, P. (1977). Distress calling as a function of group size in newly hatched ducklings. Journal of Experimental Psychology: Animal Behavior Processes, 4, 335-342.

Gollop, J. B., & Marshall, W. H. (1954). A guide to aging duck broods in the field. Mississippi Flyway Council Technical Section Report (mimeo).

Gilmer, D. S., Kirby, R. E., Ball, I. J., & Reichmann, J. H. (1977). Post-breeding activities of mallards and wood ducks in north-central Minnesota. Journal of Wildlife Management, 41, 345-359.

Godfrey, W. E. (1966). The birds of Canada. Ottawa: National Museum of Canada.

Gorman, M. L., & Milne, H. (1972). Crèche behaviour in the common eider (Someteria mollissima). Ornis Scandinavica, 3, 21-25.

Gottlieb, G. (1961). Developmental age as a baseline for determination of the critical period in imprinting. Journal of Comparative and Physiological Psychology, 54, 422-427.

Hess, E. H. (1959). Imprinting. Science, 130, 133-141.

Hess, E. H. (1962). Imprinting and the critical period concept. In E. L. Bliss (Ed.), Roots of behavior. New York: Hoeber.

Hess, E. H. (1964). Imprinting in birds. Science, 146, 1128-1139.

Hess, E. H. (1973). Imprinting - early experience and the developmental psychobiology of attachment. New York: Van Nostrand.

Hinde, R. A. (1961). The establishment of the parent-offspring relation in birds, with some mammalian analogies. In W. H. Thorpe and O. L. Zangwell, Current problems in animal behaviour. Cambridge: Cambridge University Press.

Hochbaum, G. S., & Walters, C. J. (1984). Components of hunting mortality in ducks: A management analysis. (Occasional Paper No. 52). Winnipeg, Manitoba, Canada: Canadian Wildlife Service.

Immelmann, K. (1972). Sexual and other long-term aspects of imprinting in birds and other species. Advances in the Study of Behavior, 4, 147-174.

Immelmann, K. (1975). Ecological significance of imprinting and early learning. Annual Review of Ecology and Systematics, 6, 15-37.

Jaynes, J. (1958). Imprinting: The interaction of learned and innate behavior: III. Practice effects on performance, retention, and fear. Journal of Comparative and Physiological Psychology, 51, 234-237.

Jessen, R. L. (1970). Mallard population trends and hunting losses in Minnesota. Journal of Wildlife Management, 34, 93-105.

Johnsguard, P. A. (1979). A guide to North American waterfowl. Bloomington, IN: Indiana University Press.

Kevan, P. G. (1976). Sir Thomas More on imprinting: Observations from the sixteenth century. Animal Behaviour, 24, 16-17.

Kirsch, L. (1975). Predation and prairie duck production. First International Waterfowl Symposium, 1, 101-103.

Klint, T. (1973). Praktdräkten som "sexuell utlösare" hos gräsand. Zoologisk Revy, 35, 11-21.

Klopfer, P. H., & Gottlieb, G. (1962). Imprinting and behavioral polymorphism: Auditory and visual imprinting in domestic ducks and the involvement of the critical period. Journal of Comparative and Physiological Psychology, 55, 126-130.

Kortright, F. H. (1967). The ducks, geese, and swans of North America. Harrisburg, PA: Stackpole Books.

Kovach, J. K., Paden, P., & Wilson, J. (1968). Stimulus variables in the elicitation and short-range reversibility of early approach and following responses. Journal of Comparative and Physiological Psychology, 66, 175-178.

Lamprecht, J. (1977). Environment-dependent attachment behavior of goslings (Anser indicus) due to environment-specific separation experience. Zeitschrift für Tierpsychologie, 43, 407-414.

Lee, F. B., & Kruse, A. D. (1973). High survival and homing rate of hand-reared wild-strain mallards. Journal of Wildlife Management, 37, 154-159.

Leitch, W. G. (1975). Waterfowl habitat and management in western Canada. 1st International Waterfowl Symposium, 1, 52-57.

Lorenz, K. Z. (1970). Studies in human and animal behaviour (Vol. 1). Cambridge, MA: Harvard University Press. (Original work published 1935).

Lorenz, K. Z. (1937). The companion in the bird's world. Auk, 54, 245-273.

McAloney, R. K. (1973). Brood ecology of the common eider (Somateria mollissima dresseri) in the Lescombe area of Nova Scotia. Unpublished master's thesis, Acadia University, Wolfville, Nova Scotia, Canada.

Miller, D. B. (1983). Alarm call responsivity of mallard ducklings: II. Perceptual specificity along an acoustical dimension affecting behavioral inhibition. Developmental Psychobiology, 16, 195-205.

Munro, J., & Bedard, J. (1977). Crèche formation in the common eider. The Auk, 94, 759-771.

Posphala, R. S., Anderson, D. R., & Henny, C. J. (1974). Population ecology of the mallard. II. Breeding habitat conditions, size of the breeding populations, and production indices. Washington, DC: U.S. Government Printing Office.

Raitasuo, K. (1964). Social behaviour of the mallard (Anas platyrhynchos) in the course of the annual cycle. Papers on Game Research, 24, Helsinki.

Ringelman, J. K., & Longcore, J. R. (1982). Survival of juvenile black ducks during brood rearing. Journal of Wildlife Management, 46, 622-628.

Salzen, E. A., & Sluckin, W. (1959). The incidence of the following response in domestic fowl. Animal Behaviour, 7, 172-179.

Scott, P. (1968). A coloured key to the wildfowl of the world. London: W. R. Royle & Son, Ltd.

Sellers, R. A. (1973). Mallard releases in understocked prairie pothole habitat. Journal of Wildlife Management, 37, 10-22.

Shapiro, L. J. (1978). The Avian Behaviour Laboratory: A laboratory for waterfowl research. *The Journal of Biological Psychology*, *20*, 2-10.

Shapiro, L. J. (1980). Species identification in birds: A review and synthesis. In A. Roy (Ed.), *Species identity and attachment*. New York: Garland STPM Press.

Shapiro, L. J., & Donovan, R. J. (1984). The relative attractiveness of a brood, a brooding hen, and a non-brooding hen to mallard ducklings. Unpublished manuscript, University of Manitoba, Winnipeg, Canada.

Shapiro, L. J., & Mahoney, M. J. (1982). *Brood size preferences in non-brooding mallard hens*. Unpublished manuscript, Department of Psychology, University of Manitoba.

Shapiro, L. J., & Thurston, K. G. (1978). The effect of enforced exposure to live models on the reversibility of attachments in white peking ducklings. *The Psychological Record*, *28*, 479-485.

Sherrod, L. (1974). The role of sibling associations in the formation of social and sexual companion preferences in ducks (*Anas platyrhynchos*): An investigation of the primacy versus recency question? *Zeitschrift für Tierpsychologie*, *34*, 247-264.

Sluckin, W. (1965). *Imprinting and early learning*. London: Methuen.

Sluckin, W., & Salzen, E. A. (1961). Imprinting and perceptual learning. *Quarterly Journal of Experimental Psychology*, *13*, 65-77.

Sluckin, W., & Taylor, K. F. (1964). Imprinting and short-term retention. British Journal of Psychology, 55, 181-187.

Smith, A. G., Stoudt, J. H., & Gollop, J. B. (1964). Prairie potholes and marshes. In J. P. Linduska (Ed.), Waterfowl Tomorrow. Washington, DC: U.S. Government Printing Office.

Smith, F. V. (1969). Attachments of the young - Imprinting and other developments. Edinburgh: Oliver & Boyd.

Spalding, D. A. (1954). Instinct, with original observations on young animals. British Journal of Animal Behaviour, 2, 3-11. (Reprinted from Macmillan's Magazine, 1873, 27).

Watt, G. (1951). The Farne Islands: Their history and wildlife. London: Country Life.

Whitesell, D. E. (1979). Why Canada? Ducks Unlimited Magazine, 43, 39-40.

Wilson, C. (1974). Construction of pens and fences. In D. O. Hyde (Ed.), Raising wild ducks in captivity (pp. 47-51). New York: E. P. Dutton and Co.