

**EXAMINING THE COMPONENTS OF ATTACHMENT IN MALLARD**

**DUCKLINGS (*Anas platyrhynchos platyrhynchos*)**

**By**

**Laura A. Beaudoin**

**A Thesis**

**Submitted to the Faculty of Graduate Studies  
in Partial Fulfilment of the Requirements for the Degree of**

**MASTER OF ARTS**

**Department of Psychology  
University of Manitoba  
Winnipeg, Manitoba**

**© July 2006**

**THE UNIVERSITY OF MANITOBA  
FACULTY OF GRADUATE STUDIES  
\*\*\*\*\*  
COPYRIGHT PERMISSION**

**EXAMINING THE COMPONENTS OF ATTACHMENT IN MALLARD  
DUCKLINGS (*Anas platyrhynchos platyrhynchos*)**

**BY**

**Laura A. Beaudoin**

**A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of  
Manitoba in partial fulfillment of the requirement of the degree**

**OF**

**MASTER OF ARTS**

**Laura A. Beaudoin © 2006**

**Permission has been granted to the Library of the University of Manitoba to lend or sell copies of this thesis/practicum, to the National Library of Canada to microfilm this thesis and to lend or sell copies of the film, and to University Microfilms Inc. to publish an abstract of this thesis/practicum.**

**This reproduction or copy of this thesis has been made available by authority of the copyright owner solely for the purpose of private study and research, and may only be reproduced and copied as permitted by copyright laws or with express written authorization from the copyright owner.**

## Acknowledgements

Many people have helped me in the course of completing my master's degree. To begin with, I gladly acknowledge my debt to my academic advisor, Dr. L. J. Shapiro, for taking me under his supervision and teaching me everything I know about avian attachment behaviour. Without his advice and assistance I could not have made it this far.

My committee members, Dr Linda Wilson and Dr Scott Forbes, provided me with valuable feedback and constructive criticism through the course of my studies. My graphic artist, Allen Patterson, who created the computer graphs for my result figures.

I would also like to thank my good friend, travel companion, lab-mate, and fellow graduate student, Tyler Wereha, who made my career as a master's student enjoyable and helped me get through the darkest hours of my research.

Finally, I would like to thank my family for their continued support, both financially and emotionally. Without your love, encouragement, guidance, and healthy sense of humor, this thesis would have never been completed.

## TABLE OF CONTENTS

LIST OF FIGURES.....	v
ABSTRACT.....	vii
INTRODUCTION.....	1
HISTORY OF IMPRINTING.....	1
USE OF THE TERM "IMPRINTING".....	4
CRITICISM OF "IMPRINTING".....	5
DEVELOPMENTAL CONDITION AT HATCH.....	9
NATURAL HISTORY OF THE MALLARD DUCK.....	12
IMPRINTING RESEARCH.....	14
WAYS OF EVALUATING AN ATTACHMENT.....	15
VISUAL CUES.....	18
AUDITORY CUES.....	21
COMBINED STIMULUS CUES.....	24
FILIAL IMPRINTING.....	25
PEER IMPRINTING.....	26
BROOD SURVIVAL.....	29
THE PURPOSE OF THESE EXPERIMENTS.....	30
GENERAL METHOD.....	31
Subjects.....	31
Egg source.....	31
Egg collection.....	32
Incubation.....	32

Hatching.....	33
Leg banding.....	33
Brooding.....	34
Randomization of subjects.....	35
Experimental subjects.....	35
Stimulus objects.....	35
Apparatus.....	35
Procedure.....	37
Stimulus object placement.....	39
Experimental subject placement.....	40
Statistical analysis.....	40
<b>EXPERIMENT 1: PREFERENCES FOR A BROOD OF MALLARD</b>	
<b>DUCKLINGS OR A MALLARD MATERNAL CALL.....</b>	
Method .....	41
Subjects.....	41
Experimental subjects.....	41
Stimulus objects.....	41
Apparatus.....	41
Procedure.....	41
Results and Discussion.....	42
Time spent in each quadrant.....	42
Latency.....	42
Time spent with models.....	43

Discussion.....	43
<b>EXPERIMENT 2: PREFERENCES OF MALLARD DUCKLINGS FOR A BROOD OF MALLARD DUCKLINGS OR A MALLARD MATERNAL CALL PAIRED WITH A MALLARD HEN.....</b>	<b>48</b>
Method.....	48
Subjects.....	48
Experimental subjects.....	48
Stimulus objects.....	48
Apparatus.....	49
Procedure.....	49
Results and Discussion .....	50
Time spent in each quadrant.....	50
Latency.....	50
Time spent with models.....	50
Discussion.....	55
<b>EXPERIMENT 3: PREFERENCES OF MALLARD DUCKLINGS FOR A BROOD OF MALLARD DUCKLINGS OR A MALLARD MATERNAL CALL PAIRED WITH A MALLARD HEN AND A BROOD OF MALLARD DUCKLINGS.....</b>	<b>55</b>
Method.....	56
Subjects.....	56
Experimental subjects.....	56
Stimulus objects.....	56

Apparatus.....	57
Restraining Pens.....	57
Procedure.....	57
Results and Discussion.....	58
Time spent in each quadrant.....	58
Latency.....	58
Time spent with models.....	59
Discussion.....	59
GENERAL DISCUSSION.....	67
REFERENCES.....	71
APPENDIX A.....	87

### LIST OF FIGURES

FIGURE 1. Factors affecting the formation of attachment in the natural post-hatch environment.....	11
FIGURE 2. Experimental platform as seen from above.....	38
FIGURE 3. Experiment 1: Latency.....	45
FIGURE 4. Experiment 1: Preferences for a brood of mallard ducklings or a mallard maternal call.....	47
FIGURE 5. Experiment 2: Latency.....	52
FIGURE 6. Experiment 2: Preferences of mallard ducklings for a brood of mallard ducklings or a mallard maternal call paired with a mallard hen.....	54
FIGURE 7. Experiment 3: Latency.....	61

FIGURE 8. Experiment 3: Preferences of mallard ducklings for a brood of mallard ducklings or a mallard maternal call paired with a mallard hen and a brood.....63

FIGURE 9. Comparison of Maternal Stimulus Preferences across experiments.....66

### Abstract

The process by which young precocial birds form social relationships has been extensively investigated (for example, see Gottlieb, 1971; Hess, 1973; Hess & Petrovich, 1977; Lorenz, 1935/1957; Skutch, 1976; Sluckin, 1972). Two of the most frequently employed mediating mechanisms used in attachment behaviour research are auditory and visual stimuli. There have been conflicting data, however, over which stimulus is most effective at producing an attachment response in young ducklings. Both the mallard maternal call, an auditory stimulus, and a live brood, a combination auditory and visual stimulus, elicit an attachment response in the form of approach and stay near behaviour in mallard ducklings. A series of experiments was conducted to evaluate the effectiveness of visual and auditory stimuli found in the natural environment in evoking the development of attachment in mallard ducklings. The preferences of mallard ducklings for a brood of conspecifics or a mallard maternal call were examined in the first week of development. It was found that a brood of ducklings is extremely attractive to other young ducklings. Also, it appears that as one adds attractive stimuli to the mallard maternal call, it becomes more attractive to subject ducklings.

## INTRODUCTION

The process by which young precocial birds form social relationships has been extensively investigated (for example, see Gottlieb, 1971; Hess, 1973; Hess & Petrovich, 1973; Lorenz, 1935/1957; Skutch, 1976, Sluckin, 1972). The approaches developed, however, may have overlooked some of the essential stimuli that govern the evolution of avian attachment behaviour, namely those found in the natural environment of an organism. Specifically, the role that siblings or peers play in the formation of attachment has not been thoroughly investigated, nor have the effects of combining prominent stimuli been investigated in the development of attachment in young precocial avian species.

Typically, investigators of avian attachment behaviour have focused on the role that parents play in eliciting attachment behaviour (Bateson, 1971; Bowlby, 1969; Dyer & Gottlieb, 1989, 1990; Gibson & Shapiro, 1972; Gottlieb, 1971; Hess, 1964; Johnston & Gottlieb, 1981; Lickliter & Gottlieb, 1986a, b; Shapiro, 1970, 1971; Storey & Shapiro, 1972). In the case of precocial birds (such as goslings, domestic chicks and ducklings), hatchlings have a tendency to approach and follow their parent(s) very soon after hatching (Beard, 1964; Spalding, 1873/1954; Sluckin, 1972). The young of many different species stay with their parents for a time after "birth" (Sluckin, 1972). This proximity of parents and their offspring may be a result of the care required by offspring for their survival and the ability of the parents to provide that care.

## HISTORY OF IMPRINTING

Documentation of young precocial hatchlings following their parent(s) soon after hatching dates back to the writings of Sir Reginald of Durham in 1167 (as cited in Watt,

1951). Konrad Lorenz (1935/1957) however, was the first individual to go further than mere observation of this behaviour (which he denoted as “imprinting”) by attempting to define it and specifying the characteristics of the process (Darczewska, 1999). He derived his insights into attachment behavior from studying birds, most particularly the greylag goose (*Anser anser*).

Although “there is little that can be said by way of defining imprinting that cannot be challenged or queried, it would, however, be generally agreed that the term, in its empirical sense, refers to the formation by young precocial birds of relatively specific attachments” (Sluckin, 1972). Lorenz (1935/1957) postulated that “imprinting” was the swift learning of the auditory and visual characteristics of a parent and the tendency to follow and be near the parent upon which one has become “imprinted”. Lorenz (1935/1957) postulated specific characteristics of “imprinting”. It was said to occur during a very limited maturational period (critical period) in a young organism and this process was also thought to be both rapid and irreversible.

The critical period for “imprinting” was thought to occur within 13 and 74 hours after hatching (Hess, 1973; Jaynes, 1957; Lorenz, 1935/1957; Spalding, 1873/1954). It was designated a critical period because it was thought that “imprinting” attachments could not be formed at any other times. If “imprinting” did not occur during the critical period, it would never occur (Colombo, 1982).

Investigators studying the phenomenon of “imprinting” often asked how an attachment to the imprinting object could be formed so quickly. There are a variety of factors that can influence the speed of attachment including the type of stimulation

utilized, the subject's initial age, the activity of the subject during training and the rearing conditions of the subject.

Lorenz (1935/1957) referred to the developmental process of attachment as also being "irreversible" (p119) because once imprinted upon, a hatchling will not imprint on another stimulus. Lorenz (1935/1957) wrote that, "...once the physiologically critical period is over, the animal knows the imprinted object of its innate reactions to a fellow member of the species exactly as though this knowledge were innate. It cannot be forgotten!"(p.105).

Lorenz's (1935/1957) postulation that this process was both swift and irreversible was based on "facts gleaned for the most part from random observations" (Lorenz, 1935/1957, p.92) and not on empirical research. Although observation is the preferred method when initially investigating a behaviour, "...observation has one great drawback: it is hard to convey to others. Experimental conditions can be reproduced, pure observation unfortunately cannot. Therefore it does not have the same objective character."(Lorenz, 1935/1957, p. 92). Scott (1973) believed that the "analytical study of processes... depends on systematic and thorough descriptive studies of behavioural development."

Lorenz's assumptions and theories have brought about a great deal of empirical research on the topic of imprinting in birds (Bateson, 1966; Gottlieb, 1971; Hess, 1958; Hoffman & Solomon, 1974; Sluckin, 1972). Furthermore, theories postulated by Lorenz regarding the formation of attachments in young waterfowl have been generalized to other species, most notably the bonds formed between human mothers and infants (see Bowlby, 1969)

### USE OF THE TERM "IMPRINTING"

When a person asks "why do ducklings follow their mother hen?" a reply of "because they have been imprinted" does not adequately explain what mechanisms and stimuli produce such a response. Lorenz (1935/1957) defined "imprinting" as "the name we have given the process by which the releaser of an innate reaction to a fellow member of the species is acquired" (p.119). Lorenz's postulation of "imprinting" is a hypothetical construct used to infer mechanisms for observed behaviour in young precocial birds.

The term "imprinting" does not specify any particular stimuli that activate this mechanism nor does it imply which types of expressed behaviours should be seen when the process has occurred. By using the term imprinting, Lorenz is committing a nominal fallacy. He uses the term to label the concept but does not explain it. Thus, the behaviour expressed is labelled "imprinting" when observed but the mechanisms mediating the behaviour are never defined. "Attachment behaviour", on the other hand, describes the expressed preferences of subjects for certain stimuli without inferring a mechanism, and allows one to more fully describe and postulate possible processes mediating the behaviour.

Because of the negative attributes associated with the term "imprinting", the use of the term will be restricted in this paper. If progress is to be made, we must do more than label certain behaviour as "imprinting". "Rather we must study the development of behaviour both before and after birth or hatching" (Scott, 1973) in order to understand both the mechanisms mediating the development of the behaviour and the evolutionary benefits of the behaviour. In this paper then, the term attachment behaviour will be used to describe the preferences demonstrated by young precocial fowl. Attachment behaviour

simply “implies there is some sort of bond between one individual and another” (Scott, 1973).

### CRITICISM OF “IMPRINTING”

Studies which support Lorenz’s initial postulations are soiled by poor experimental design and inadequate evaluation of behaviour in the natural environment. “The most commonly committed scientific sin is the lack of proper experimental control” (Dethier, 1962, p. 19). In the case of imprinting research, many researchers erroneously conclude that imprinting has occurred because their subjects successfully approached and followed the stimulus object (specifically, an inanimate, biologically inappropriate object) presented to them (for example see Jaynes 1957, 1958b; Moltz & Rosenblum, 1958; Salzen & Sluckin, 1959a). It is possible, however, that approach and following responses were obtained only because the subject duckling had no other more appropriate options available to it. Therefore, “successful imprinting” experiments may not be due to the stimuli presented, but, rather, a consequence of what is not presented to the subject.

A lack of the proper evaluation of natural behaviours may also have led some researchers to conclude in favour of Lorenz’s postulations. For instance, Lickliter and Gottlieb (1986a) conducted a study in which some duckling subjects were exposed to siblings between imprinting sessions. It was found that ducklings who had contact with other ducklings failed to imprint properly on the maternal stimulus. However, instead of postulating why a brood may be an important and beneficial stimulus to an individual duckling, and investigating the role of the brood as a social stimulus in the natural environment, the researchers simply concluded that brood mates “interfere with maternal

imprinting” and that “continued social interaction with the mother is necessary to maintain” a bond.

The results of much avian attachment research contradicts Lorenz’s assumptions (Rajecki, 1973). Shapiro (1972) stated that the body of literature dealing with imprinting is a compendium of contradictory evidence. Many investigations (for example see Fabricius & Boyd, 1954; Scott, 1973; Shapiro, 1968) have shown that imprinting is neither rapid nor irreversible and is also not restricted to a critical period. Also, it seems that a young organism can “imprint” to more than one stimulus (for example see Salzen & Meyer, 1968).

Although Lorenz (1935/1957) and Sluckin (1972) thought that the critical period for imprinting was confined to the first few hours after hatching, Fabricius and Boyd (1954) found that imprinting-like behaviour could be elicited in some mallard ducklings at 10 days of age. Additionally, Shapiro (1968) found that there may, in fact, be more than one critical time frame in which attachment behaviour can be elicited when testing domestic chicks. It appears that “there is a considerable flexibility with respect to the timing and ordering of developmental processes within a species” (Scott, 1973).

With respect to the irreversibility of imprinting, Salzen and Meyer (1968) trained domestic chicks for three days with one object and then established that imprinting had occurred. These researchers then trained the subjects with a different object for several more days and found that a preference for the new object had developed. Schutz (as cited in Scott, 1973) also found that attachment behaviours of mallard ducklings could be re-directed to another stimulus a few weeks after the initial establishment of attachment and this attachment could again be shifted a year later prior to the formation of mating bonds.

Results such as these, which contradict Lorenz's initial speculations regarding attachment behaviour, may be due to his writing style. In his paper, *Companionship in Bird Life* (1935/1957, 1970), Lorenz described his theories and observations in a somewhat confusing and convoluted manner, even contradicting himself at times. For instance, although Lorenz wrote that the process of imprinting is irreversible (p. 105), one paragraph earlier in his paper he stated "it is too early to claim definitely that the imprinting process is irreversible" (p. 105). Lorenz then went further to say that "if a bird has first responded to an inadequate object, it can still be transposed to a fellow member of the species at a time when the reverse process is no longer possible" (p. 107) indicating to readers that, in fact, the formation of attachment is reversible.

Although Lorenz postulated that the formation of an attachment between young and their parents "is not innately determined" (p. 102) and that young hatchlings "do not seem to recognize their parents instinctively as members of their own species" (p. 104), he also wrote that "...the young bird has an innate 'schema' of the parent. The nestling's innate image of the parent bird consists of enough characters so that its parent specific motor patterns will be sure to respond only to the adult bird of its own species." (p. 103). If this is actually the case, then how is Lorenz able to elicit "imprinting" in young goslings, ducklings and partridge chicks using only himself as a stimulus?

Additionally, it is not until the end of his paper that Lorenz stated an operational definition of the term imprinting. "Imprinting is the name we have given the process by which the releaser of an innate reaction to a fellow member of the species is acquired" (p.119). Unfortunately, this somewhat brief definition does not reflect his musings regarding the process of attachment earlier in the paper. And although Lorenz criticized

the scientific community for the use of terms that have been used to describe the inner life of humans without adequately explaining their meanings, Lorenz himself was reifying the term "imprinting". Lorenz created the term to describe attachment formation in hatchlings but he never adequately explained its meaning or the process by which it occurs. This lack of specificity may be one reason why the results of many researchers have conflicted with Lorenz's postulations, since many of the "characteristics originally associated with the term have been questioned by experimenters who have failed to support them empirically" (Shapiro, 1972).

The poor readability of *Companionship in Bird Life* (1935/1957, 1970) may be due to several issues. Foremost is that Lorenz's original work was published in German and English reproductions vary in both length and content (for example see Lorenz, 1970). When translating documents in a foreign language, the original language is open to misinterpretation by those translating it to another language. Thus, some facets of Lorenz's theory may have been lost in translation.

Page restraints restrict the length of a translation. Although Lorenz's original publication was nearly 300 pages long, English translations of it may be as short as 48 pages (for example, see Schiller's (1957, pp. 83-128) translation of Lorenz's 1935 work (Lorenz, 1935)). When publishers cut large sections of Lorenz's article in an effort to save paper and convey only the most crucial points of the article, they may have unintentionally been confusing readers and predisposing them to misinterpret Lorenz's writings.

Additionally, Lorenz's paper was written prior to APA guidelines, which were first published in 1953. Thus, the format of Lorenz's paper is unconventional with poorly cited references or no references at all in some cases. This situation makes it difficult to assess Lorenz's claims.

It is possible, then, that some of Lorenz's assumptions were misleading to researchers and taken out of context. Misinterpretations of Lorenz's observations may be the root of some of the perplexing results obtained when subsequent testing has occurred. If this is indeed the case, much of what we know about the process of forming attachments is based upon poor experimental design and false impressions.

In order to assess the accuracy of Lorenz's assumptions and the reliability of results obtained by experimenters investigating avian attachment behaviour, we must objectively define the process of attachment and determine its ecological value for the young involved.

### **DEVELOPMENTAL CONDITION AT HATCH**

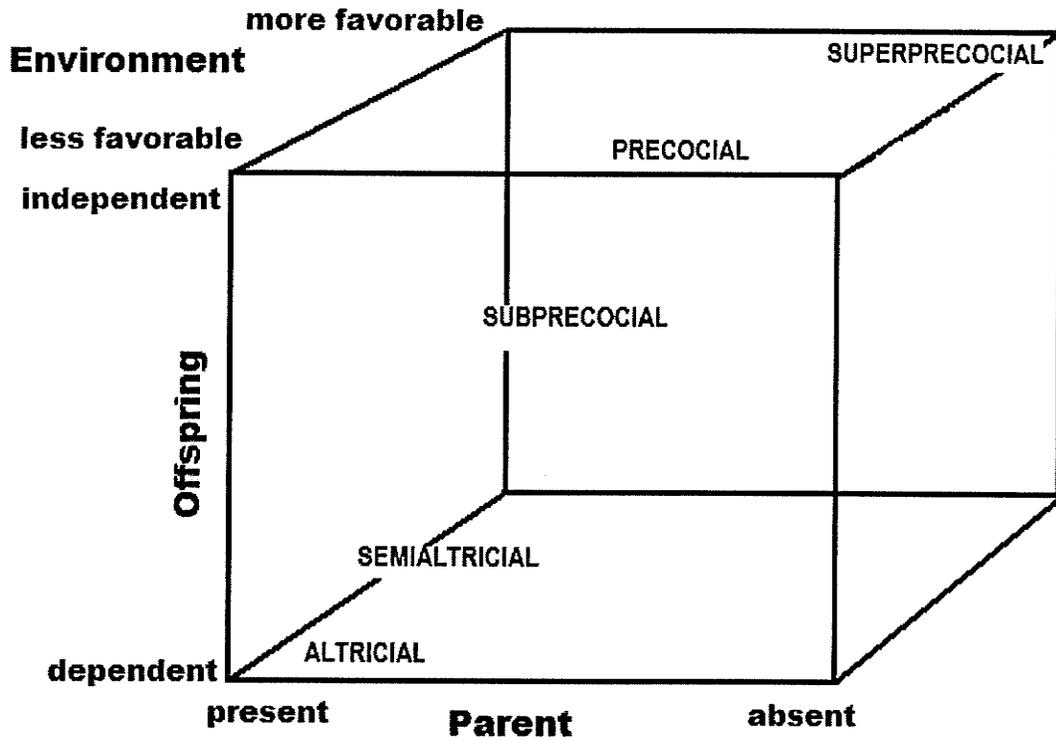
Not all species form attachments in the same manner (Shapiro, 1980a). As well, the developmental condition of the young at hatch plays a prominent role in the process of forming an attachment.

Some young are considered altricial, meaning that as neonates they are largely helpless and require a great deal of care. Avian examples of this include some species of birds such as robins and parakeets. It can be observed that due to the amount of care required to raise altricial young, both parents are usually present. In these species, attachments formed between parent and young are largely due to the behaviour of the adults (Sluckin, 1972).

Precocial species, on the other hand, are somewhat more developed upon hatching. They are able to locomote, thermoregulate, and feed themselves and, thus, require less care from their parents. In these species, both parents are not required for care of the young and, consequently, in many precocial species only one parent raises the offspring. In the case of precocial birds (such as goslings, domestic chicks and ducklings), hatchlings have a tendency to approach and follow their parent(s) very soon after hatching (Spalding, 1873/ 1954; Sluckin, 1972). It is thought that this behaviour is a response to stimulation of some kind. Parent-young attachments in these species are more difficult to determine since the young are developmentally advanced and a need for parental bonds may not seem obvious at first glance.

The environment in which hatching and rearing occurs also plays a part in the development of attachments (Shapiro, 1980a). As environments become more favorable (i.e., the climate is more tolerable and food resources are plentiful), hatchlings do not require as much parental care and tend to hatch at a more developed state.

“Whether or not a hatchling forms attachments depends upon three factors: whether the parent is present, its dependence upon a caregiver, and the quality of the environment in which it is raised” (Wereha & Shapiro, 2004). Shapiro (1980b) plotted the differences in developmental condition at hatch in altricial and precocial species, the environmental conditions at hatch, and the amount of parental care required by avian young (see Figure 1). Shapiro (1980b) described this figure as follows: “It may be seen from this figure that with a parent/ adult bird present the offspring can be more dependent in a less favorable environment. With the parent absent, however, the offspring must be more independent and hatch in a more favorable environment” (p. 82).



**Figure 1.** Factors affecting the formation of attachment in the natural post-hatch environment. From: "Species Identification in Birds: A Review and Synthesis", by L.J. Shapiro, in M. A. Roy (Ed.), 1980, *Species Identification and Attachment*, p. 82. New York: Garland Press.

Figure 1 shows that an altricial species (located on the lower left hand side of the cube) has a parent present to care for hatchlings. As mentioned previously, these species are born at a relatively undeveloped state requiring much care and attention. On the y (Offspring) axis of the cube, one sees that these species are labeled as dependent, which means they require care from a parent. These species are also born in a relatively harsh environment, labeled less favorable on the z (Environment) axis of the cube. This environmental state also requires care be given to offspring for their survival. A precocial species, on the other hand, is plotted toward the top right side of the cube, indicating that young hatch well developed, are largely independent of their parents, and are raised in a more favorable environment.

By examining the environment in which a hatchling is raised, its developmental state at birth, and the role that parents play in the development of their young, researchers can begin to understand the mechanisms mediating attachments and start to pull the process apart in order to fully comprehend the concept of avian attachment behaviour in a variety of species.

### **NATURAL HISTORY OF THE MALLARD DUCK**

The mallard duck populates much of the world and is one of the most recognizable species of waterfowl (Drilling Titman, & McKinney, 2002; Todd, 1996). In North America, the mallard is the most plentiful duck species (Drilling et. al, 2002). Due to its highly adaptive nature, mallards occupy a variety of habitats, avoiding only the high arctic and desert areas.

The mallards breeding area ranges from Alaska, south to California and across the prairies to the Atlantic coast (Drilling et. al, 2002), with a focus on Prairie Pothole and Parkland regions. Wintering areas extend as far north as weather allows if open water and a food source is available and mallards may migrate as far south as Mexico (Drilling et. al, 2002).

When temperatures begin to rise, and food and water supplies become available, mallards begin to migrate north to their breeding grounds. When in breeding condition (which typically occurs from late April until mid July), females pair with males and find a home range and appropriate nesting location. Although mallard hens typically nest in upland cover, hens will nest in wetland areas near or on water (Drilling et. al, 2002).

Once the nest is made, a hen will lay a clutch of eggs. A female mallard will lay one egg a day until her clutch is complete. Clutch size varies from 1- 13 eggs (Drilling et. al, 2002). The female begins incubating after the last egg has been laid. Only the female incubates the eggs. Incubation ranges from 23- 30 days, averaging 28 days (Palmer, 1976).

Upon hatching, young stay in the nest until they have completely dried (approximately 12 hr). Upon leaving the nest, ducklings are cared for by the hen. Typically, the hen will stay with her brood until they can fly and are independent (52- 70 days after hatching) (Drilling et. al, 2002). When weather begins to worsen and food and water supplies decrease, mallards will congregate in local areas and begin their fall migration to southern wintering grounds.

## IMPRINTING RESEARCH

As mentioned earlier, the term “imprinting” has problems associated with it. The behaviours observed in early “imprinting” experiments were a result of expressed preferences by the subjects used. From the behaviours observed (mainly in the form of approach and stay near responses) researchers in the area inferred the mechanisms of these behaviours.

Most research conducted in the area of attachment behaviour has been done in a laboratory setting and used precocial birds as subjects (Beaudoin & Shapiro, 2003; Bruce & Shapiro, 1977a, b; Buss & Shapiro, 1987; Collias, 1952; Darczewska, 1999; Deng & Rogers, 2002; de Vos & van Kampen, 1993; Fischer, 1966; Feltenstien, Ford, Freeman, & Suka, 2002; Gottlieb, 1971; Gvaryahu, Snapir, & Robinzon, 1988; Hess, 1959; Jones, Facchin, & McCorquodale, 2002; Levy & Shapiro, 2003; Lickliter & Gottlieb, 1986a, b; Lickliter & Virkar, 1989; Marx, Leppelt, & Ellendorf, 2001; Ramsay, 1951; Salzen & Sluckin, 1959a; Shapiro, 1980a; van Kampen, de Haan, & de Vos, 1994; Waunters & Richard-Yris, 2002; Wereha & Shapiro, 2003).

According to Sluckin (1972), the first of such studies was conducted by Fabricius (as cited in Sluckin, 1972). He used shoveller, tufted duck and eider hatchlings. Later, Fabricius (1951) observed that wild ducklings could be “imprinted” onto a variety of moving objects, but certain stimuli were more effective at evoking a response than others.

Although “imprinting” was initially developed from observing wild fowl, domestic fowl have also been used to study the phenomenon (Collias, 1952; Deng & Rogers, 2002; de Vos & van Kampen, 1993; Feltenstien, Ford, Freeman, & Suka, 2002;

Gvoryahu, Snapir, & Robinzon, 1988; Hess, 1959; Jones, Facchin, & McCorquodale, 2002; Marx, Leppelt, & Ellendorf, 2001; Ramsay, 1951; Salzen & Sluckin, 1959a; Shapiro, 1980a; van Kampen, de Haan, & de Vos, 1994; Waunters & Richard-Yris, 2002; Wereha & Shapiro, 2003). Ramsay (1951), for example, used domestic chicks and turkey poults in studying the phenomenon.

Domestic breeds of fowl have been used because they are easily accessible to researchers, are relatively inexpensive, and require little care or special treatment (Beaudoin & Shapiro, 2002). Generalizing results using domestic species to their wild counterparts may be erroneous since it is likely that behaviours seen in wild forms have 'dropped out' through the domestication process (Lockhart, 1968, Lorenz, 1935/1957, Shapiro, 1980b). Because young chicks and ducklings are raised by their mothers in the natural environment, many studies investigating the phenomenon called "imprinting" have examined the role of the hen in eliciting an attachment response (Bateson, 1971; Dyer & Gottlieb, 1989, 1990; Gibson & Shapiro, 1972; Gottlieb, 1971; Hess, 1964; Johnston & Gottlieb, 1981; Lickliter & Gottlieb, 1986a, b; Shapiro, 1970, 1971; Storey & Shapiro, 1972).

### **WAYS OF EVALUATING AN ATTACHMENT**

Traditionally, recognition tests and discrimination tests have been used to determine if an attachment occurred in the young being studied (Sluckin, 1972). In recognition tests a number of subjects (usually chicks or ducklings) are 'trained' individually with some object. Later, the responses of these subjects to the object are compared with the responses of control subjects who have received no training with the object. If the trained subjects approach and follow the object significantly more than the

untrained subjects, a social attachment is said to have occurred. (see Harlow, 1958; Jaynes 1957, 1958b; Moltz & Rosenblum, 1958; Salzen & Sluckin, 1959a, b)

Discrimination tests have also been used extensively when investigating attachments in young precocial birds (e.g. Fabricius, 1951; Guiton, 1959a; Hess, 1958; Jaynes, 1956, 1958 b; Johnston & Gottlieb, 1985; Ramsay & Hess, 1954; Sluckin & Salzen, 1961; Sluckin & Taylor, 1964; Taylor & Sluckin, 1964). In these studies, some subjects are individually trained with an object, while other subjects are trained with a different object. Later, all subjects are tested in a situation where both training objects are present. An attachment is said to have formed if the subjects show a statistically significant preference (in the form of approaching and following) for the object with which they had been trained.

It is possible for a subject to form a strong attachment to some object as judged by a recognition test, but not as judged by a discrimination test. That is, a subject could approach and follow a training object for some time after initial experience with it, but may not prefer it to other objects to which it is presented later on. In cases such as this, "imprinting" has not been demonstrated to occur.

Both a recognition test and a discrimination test require that a session of learning is necessary to elicit an attachment response. This requirement is not consistent with the theories postulated by Lorenz (1935/1957), who stated that the process of attachment "has nothing to do with learning" (p. 118).

If a learning period is required, then it would be expected that when given the choice between an inappropriate training object and a biologically appropriate new object, young fowl should choose the object with which they were trained. This outcome

is not the case in many “imprinting” studies (for example see Johnston & Gottlieb, 1985; Lickliter & Gottlieb, 1986a, b).

Although some researchers may describe these instances of non-preference as stimulus generalization (Gottlieb, 1971, Parkhill & Collins, 2000), it is possible that the lack of preference may be due to the subjects’ desire to seek biologically appropriate objects for survival. This point is illustrated when one examines the types of stimuli that have produced contradictory results. Many studies investigating the process by which young precocial birds form attachments have used inanimate, biologically inappropriate testing stimuli such as cubes, stuffed models and flashing lights (for example, see Hess, 1957, 1958, 1959a,b; Hess, Polt, & Godwin, 1959; James, 1959, 1960a, b; Jaynes, 1956, 1957, 1958a, b; Ramsay, 1951; Ramsay & Hess, 1954; Smith, 1960; Smith & Hoyes, 1961; Weidmann, 1956). When inanimate, biologically inappropriate objects have been used as stimuli, inconclusive results concerning attachment behaviour have been found (see Cofoid & Honig, 1961; Jaynes, 1956; Moltz, 1960).

Mixed results have also occurred when similar biologically appropriate models having equal attractiveness and, possibly, having the same ecological benefits to the individual being tested have been used (e.g., Beaudoin & Shapiro, 2003; Bruce & Shapiro, 1977a; Storey, 1976). For example, Beaudoin and Shapiro (2003) found that chicks reared in a brood showed no preference for their own familiar brood over another, unfamiliar brood, of the same size and age.

To correct for the apparent shortcomings of recognition and discrimination tests, some researchers utilize simultaneous choice tests (e.g. Columbus & Lickliter, 1998; Gottlieb, 1971). In this test, subjects are not trained with any model. Instead, a subject is

exposed to one or more separate stimuli simultaneously and can choose to remain near any stimulus or none at all. "The approach response can be a highly discriminative measure when it is employed in a simultaneous choice situation" (Gottlieb, 1971).

Simultaneous choice tests allow researchers to examine the preferences of an individual to different stimuli and comment on their attachment behaviours to each object.

Both visual and auditory stimuli have been used by researchers when investigating attachment formation (Beaudoin & Shapiro, 2002; Columbus & Lickliter, 1998; Heaton, Miller, & Goodwin, 1978; James, 1959, 1960a, b; Levy & Shapiro, 2003; Lickliter & Virkar, 1989; Shapiro, 1970; Smith, 1960; Smith & Hoyes, 1961)

### **VISUAL CUES**

According to Lorenz (1935/ 1957), a moving visual object seemed necessary to elicit an approach response from a duckling. It has been shown that motion is more effective in eliciting approach and following behaviour than just a continuous presentation of an object (Sluckin, 1972). Several researchers investigated this with the use of visual flickers (James, 1959, 1960a, b; Smith, 1960; Smith & Hoyes, 1961). James (1959) found that a flickering light presented to hatchlings was as effective in producing an approach response as a neutral moving object.

The approach response to moving objects may be due to the physiology of a bird's eye. Avian eyes are relatively flat and have a cone-like structure projecting from their retina towards the pupil called the pecten. It is thought that this structure may aid a bird to detect movement (Fischer, 1966). Also, the gross morphology of a bird's brain reflects the importance vision plays in surviving (Portmann & Stingelin, 1961).

Although the results of the above mentioned studies support the idea that a moving object elicits an attachment response, other researchers have found that a stimulus object need not be in motion in order for it to elicit an approach response (for example see Beaudoin & Shapiro, 2002; Levy & Shapiro, 2003; Shapiro, 1970).

Many studies have investigated the role vision plays in the formation of an attachment (Bateson & Reese, 1969; Bolhuis & Honey, 1994; Bolhuis & van Kampen, 1992; Heim & Bjerke, 1983; Hoffman, Ratner, & Eiserer, 1972; Petro, Capretta, & Cooper, 1978; Porter & Stettner, 1968; Smith & Bird, 1963; van Kampen & Bolhuis, 1991; van Kampen, de Haan, & deVos, 1994; White & del Rio-Pesado, 1983). For example, Bohuis and Honey (1994) exposed newly hatched domestic chicks to either a novel purple circle or a red triangle visual stimulus training object and tested subjects for a preference for the red training stimulus or the novel purple visual stimulus to which they were not trained. They found that subjects preferred the visual stimulus that they were trained with over the novel stimulus.

Since it is the hen that raises the hatchlings in most duck species, the hen has been viewed as the primary visual stimulus to a young duckling (Bateson, 1971; Hess, 1964; Lorenz, 1935/1957). Gottlieb (1971) has shown that when presented with a stuffed mallard hen decoy, subject ducklings readily follow the decoy. Additionally, naïve ducklings prefer the company of mallard hens to chicken hens or no visual stimulus object (Gottlieb, 1965; Shapiro, 1970). Mallard ducklings can also identify and prefer to remain near their maternal hens when given the choice of their own hen or other brooding females (Bruce & Shapiro, 1977b), suggesting that ducklings may use visual cues to discriminate stimuli to form attachments. Furthermore, Banker and Lickliter (1993) found

that bobwhite quail chicks that were visually restricted (by means of eye patches) were unable to display a preference for visual species-specific maternal characteristics.

Inanimate objects have been used extensively in visual “imprinting” research. (Hess, 1957, 1958, 1959a, b; Hess, Polt, & Godwin, 1959; Jaynes, 1956, 1957, 1958a, b; Ramsay, 1951; Ramsay & Hess, 1954; Smith, 1960). Many studies investigating the role that vision plays in the formation of an attachment have exposed subjects to a variety of visual stimuli such as duck decoys (Hess, 1959), boxes (Fabricius & Boyd, 1954), stuffed animal models (Dyer & Gottlieb, 1990, Gottlieb 1971), and plush toys (Parkhill & Collins, 2000). The results of these studies have prompted many researchers to conclude that attachment formation in a precocial species is visual and can be accomplished using a variety of stimuli that are completely species atypical (Fabricius & Boyd, 1954; Hess, 1957, 1958, 1959a; Hess, Polt & Godwin, 1959; Jaynes, 1956, 1957, 1958a, b; Nice, 1953; Ramsay, 1951; Salzen & Sluckin, 1959a, b; Smith, 1960; Weidmann, 1956).

Other researchers have shown that live, biologically appropriate models are always preferred by subjects over inanimate stimulus objects (Levy & Shapiro, 2003; Storey & Shapiro, 1972). Under natural circumstances, an individual duckling would not encounter many of the inanimate objects used in the above mentioned studies. “It is obvious that young birds do not have to distinguish among differently coloured flashing lights, red cylinders and green cubes, or any of the other objects that are typically employed in laboratory studies of imprinting” (Johnston & Gottlieb, 1981). Therefore, any attraction shown to inappropriate stimulus objects may be a result of the artificial laboratory setting and the lack of biologically appropriate stimulus objects. It is also possible that when an individual duckling is presented with stimuli that do not contain the

cues for attachment found in biologically appropriate objects, an attachment-like behaviour may still develop if the object offers some minimal survival value. Any observations made under these circumstances are open to misinterpretation and cannot readily be generalized to any behaviour made by the subjects in their natural environment.

### AUDITORY CUES

An auditory stimulus may also be a key component for an attachment response to be elicited. Specifically, it has been postulated that the hen's maternal call is a primary auditory stimulus for ducklings (Dyer & Gottlieb, 1990; Fischer, 1975; Gottlieb, 1971). It is thought that young birds use maternal auditory vocalizations to focus on their mothers (Columbus & Lickliter, 1998; Heaton, Miller & Goodwin, 1978; Lickliter & Virkar, 1989).

Research has indicated that the offspring of many species show the ability to learn the maternal calls of their species (Allen, 1977; Espmark, 1971; Evans, 1982; Gottlieb, 1981, 1988; Heaton, Miller, & Goodwin, 1978; Heinz, 1973; Shillito, Walser, Walters, & Hague, 1982). Specifically, it has been shown that mallard ducklings will attach to a recording of a mallard hen's maternal call and will attempt to approach and follow the object from which the sound is being emitted (Dyer & Gottlieb, 1990). Hatchlings also seem to have the ability to learn and recognize features of a maternal call when presented at different repetition rates (Gottlieb, 1988). It has been shown that White Peking ducklings (*Anas platyrhynchos*), the domesticated version of the mallard duck, routinely preferred a recording of a wild mallard maternal call over a silent live mallard hen model (Storey & Shapiro, 1979). Furthermore, there is some evidence that ducklings form

attachments to a hen based solely on her maternal call, irrespective of visual characteristics (Gottlieb, 1971).

The ability of ducklings to recognize the maternal call of a hen of their species may be due to their different sound characteristics. A mallard maternal call is approximately 1125 Hz with an average of four notes per second (Gottlieb, 1971). In contrast, a chicken's call is approximately 775Hz with a rate of 2.5 notes per second (Gottlieb, 1971). Thus, ducklings may be able to recognize their hen calls by discriminating them from other noises in the environment. This possibility is supported by an observation made by Lorenz (1935/1957) when he attempted to raise mallard ducklings with hens of different species. For example, mallard ducklings hatched by musk ducks (*Biziura lobata*) did not attach to her but, instead, "they simply ran away" (Lorenz, 1935/1957, p. 115). The ducklings only adopted domesticated mallards as their mothers. Lorenz concluded that the ducklings preferred these hens because their vocalizations were almost identical to those of wild mallards.

Fischer (1966) concluded that some vocalizations are so powerful that they can override "imprinted" sounds. In her study, domestic chicks were trained with a vocal model and were tested with the same sound or a different sound or no sound at all. Her findings indicated that a parental call elicited more following than a different, but familiar sound.

Some researchers have found that auditory stimuli are preferred to visual ones (Fischer, 1966; Gottlieb & Simner, 1969). For example, Boyd and Fabricius (1965) found that sound alone was more likely to evoke responses in mallard ducklings than moving

models without calls and a calling model was found to be the most attractive. Fischer (1966) found that stimulus objects lacking sound were followed least by chicks.

Gottlieb and Klopfer (1962) found that the optimal time for "imprinting" ducklings visually occurred a little later than the best time for auditory "imprinting". This finding may have something to do with the more rapid development of a hatchling's auditory system compared to its visual system. A duckling is able to hear (and respond to) maternal calls on day 22 of incubation, but is unable to vocalize until day 24 of incubation (Gottlieb, 1971). This two-day difference in development of sensory systems may influence later attachment development.

Preferences for auditory stimuli can occur prior to hatching. Gottlieb (1971) has shown that prenatal experience to mallard maternal calls accelerated heart beat and produced physiological changes in the embryo being tested. Gottlieb (1971) has also shown that embryos exposed to audio stimulation prefer that stimulus when tested after hatching. Grier, Counter and Shearer (1967) exposed chick eggs to a pattern of sounds six days prior to hatching. When tested, hatched subjects showed a preference for the sound heard during incubation.

"In nature the mallard hen begins to vocalize as the first embryos hatch" (Gottlieb, 1971). An auditory attachment to a maternal hen's call would be advantageous in the natural environment. It has been suggested by Graves (1973) that when a social bond has been disrupted (i.e., when a duckling is unable to locate its mother) auditory cues (such as the maternal call with which it has presumably become familiar) would stimulate a hatchling to search and locate its mother. This may likely be the case, especially when a duckling is unable to see its mother but can hear it.

### COMBINED STIMULUS CUES

Generally, the formation of an attachment can be viewed as a combination of visual and auditory stimuli. Over the years, researchers have pulled these two components apart and studied each extensively. Unfortunately, most studies investigating these two components have done so in an inappropriate manner. Clearly, "the natural ecological and social context in which social preferences are formed by young hatchlings is far more complex than the design of conventional imprinting experiments" (Lickliter & Gottlieb, 1986a)

In the natural environment, a hatchling would most likely come into contact with both audio and visual stimulation. For instance, during nest departure, hatchlings are exposed to both visual and auditory characteristics of their parent (Gottlieb, 1971). Thus, some researchers have studied the effects of audio-visual stimulation on approach and following responses

Smith and Bird (1963) showed that visual and auditory stimuli combined were much more effective in producing approach responses in domestic chicks than either stimulus alone. Also, Porter and Stettner (1968) showed that Bobwhite quail chicks were more responsive to a combined visual and auditory stimulus than to a visual stimulus presented alone. Gottlieb (1971) has also shown that in both chicks and ducklings, an audiovisual stimulus combination maintained following better than either stimulus presented alone.

The preferences of ducklings for audiovisual combinations of stimuli is especially apparent when biologically appropriate stimuli are utilized. For example, Storey and Shapiro (1979) showed that white Peking ducklings preferred a live model combined

with a recording of the maternal call significantly more than either stimulus alone.

However, they also found that when given the opportunity to approach a brood of same aged ducklings or a live hen with a recording of a maternal call emanating from the same spot, subjects showed an alternating pattern of preference over days. Although some of the results in this study support the idea that audiovisual stimuli are important to young organisms, it also appears that the brood may play an important role in the process of forming an attachment.

Beaudoin and Shapiro (2004) used a simultaneous choice test to present a mallard maternal call and a brood of mallard ducklings to mallard ducklings on days 1 – 7 of their lives. The ducklings preferred the brood of ducklings significantly more than the maternal call on all days. It was observed in a few instances, however, over the first few days of testing, that a small number of subject ducklings were attracted to the maternal call but seemed confused about the direction from which the sound was coming. They continued to approach and remain near the brood of ducklings. It is possible then, that because the recording was not paired with a visual stimulus, ducklings chose to remain near the stimulus that seemed the most complete.

### **FILIAL IMPRINTING**

Lorenz (1935/1957) believed that it was a nestling's contact with its parent that initiated the process of "imprinting" and that the bond formed between young and parent was essential to the survival of the young. This type of attachment has been termed filial imprinting.

There is evidence that naive mallard ducklings will attempt to approach and follow an object from which a recording of a mallard hen's maternal call is emanating (Dyer & Gottlieb, 1990; Storey & Shapiro, 1979). They also routinely prefer the presence of maternal mallard hens over hens of other species (Lorenz, 1935/1957; Shapiro, 1970). Lorenz (1935/ 1957) postulated that the "mother call was the critical cue" for ducklings in order for following and subsequent attachment formation to occur.

There are definite ecological advantages to being able to recognize and attach oneself to a brooding hen. A hen can provide heat and assist the ducklings in finding food (Lorenz, 1970). Survival is also assisted by being with a hen since she can create a distraction (in the form of feigning) in order to assist her brood to disperse safely. Additionally, the possibility exists that a hen may provide more protection to her young due to previous experience in the natural environment. In other words, a hen may prevent her brood from engaging in or approaching a situation that she has learned to be harmful.

### **PEER IMPRINTING**

Although it has not received as much attention in the literature, broods and siblings may also be an important component in forming an attachment. It is possible that there are different kinds of attachments that an individual can form with various stimuli, each having its own mode of being formed. Scott (1973) wrote "one of the aspects of social attachment that is often neglected is that it is a reciprocal process: that parents become attached to young and that siblings become attached to each other" (p. 28). For a young mallard duckling, attachments may be formed to its mother or to its siblings, or to both. Conversely, a mallard hen may also form attachments to her brood. The concept of

“imprinting” largely ignores the possibility of sibling attachments and an attachment to the brood by the mother.

The presence of other ducklings (or brood mates) has been investigated as a possible cue for attachment to commence. Collias (1952) observed that “chicks follow each other as they move along” (p. 146). Lorenz (1970) noted that in Greylag geese (*Anser anser*) “the parent bird does not form the nucleus of the flock- the offspring primarily congregate with one another and exhibit only secondary attachment to the parents”(p. 235). Lorenz (1970) also noted that “sibling companions in young Anatids... exhibit the most intimate mutual relationships known for young birds” (p. 237). If this is indeed the case, then the brood itself may be the source of the general cohesion of the family unit.

Experiments conducted to investigate other variables regarding attachment behaviour have revealed that a brood can have strong attractant properties on subject ducklings and chicks. For example, Sluckin and Salzen (1961) reported that young birds that were trained and raised in groups would often completely ignore and avoid the “imprinting” object in favour of staying together in a brood. Guiton (1959b) found similar results when testing domestic chicks. He wrote, “communally reared chicks behave as if they were imprinted on one another” (Guiton, 1959b, p. 32). Additionally, it has been found that both chicks (Sigman, Lovern, & Schulman, 1978) and ducklings (Darczewska & Shapiro, 1997) attempt to remain in close physical contact with brood mates during testing sessions. Mallard ducklings also prefer broods of ducklings to an empty quadrant (Bruce & Shapiro, 1977a) and ducklings routinely approach the largest

brood available to them (Bruce & Shapiro, 1977b; Buss & Shapiro, 1987; Poersch & Shapiro, 1987).

Additionally, there is compelling evidence that an attachment to the brood may be a more important attachment than an attachment to the hen herself. Beard (1964) has observed in the wild that a few days after hatching, ducklings no longer follow their mother but, instead, it is the hen that tends to follow the brood. This situation may also reveal the attachment that a hen forms with her own brood.

The influence of peers on attachment behaviour has been noted in other species. Specifically, attachment to peers plays a significant role in the social development of human children (Bronson, 2000). It has been noted that peers become increasingly more important to toddlers (ages 3-5) than parents or other caregivers (Bronson, 2000). Harris (1998) has also postulated that peers influence a child's behaviour much more than their parents do. Furthermore, children who interact with peers develop superior cognitive, social and linguistic skills (Doise, 1990; Parker & Gottman, 1989). And, "if children have little access to peers or are rejected by them, important sources of learning are lost" (Bronson, 2000, p. 74).

Bruce and Shapiro (1977b) have shown that broods are preferred more than hens without broods by subject ducklings. As well, Lickliter and Gottlieb (1986a, b) have noted that when ducklings are reared together they do not imprint properly on mallard hen models and, instead, follow duckling models and brood mates. Collias and Collias (1956) have reported that broods of ducklings show a strong tendency to keep together. It has also been shown that ducklings prefer broods of ducklings to a hen of the same species or to an empty quadrant (Bruce & Shapiro, 1977b). Also, Bruce and Shapiro

(1977a) have shown that ducklings reared together are unable to distinguish their brood from an unfamiliar brood of the same size.

It seems appropriate that ducklings prefer broods due to various adaptive benefits that broods serve. A brood can huddle together for heat if the hen is not available (Lorenz, 1970). Also, when brood mates are together in shallow water, more food can be disturbed and brought to the surface for consumption. By staying with a group of similar age mates, an individual decreases its likelihood of being captured by a predator if, when brood mates disperse, the predator hesitates, even briefly, in its attack (Alcock, 1993, pp. 369-372; Beaudoin & Shapiro, 2003; Krebs & Davies, 1993, pp. 120-122). Lastly, the presence of brood mates may provide additional socialization benefits for later correct sexual behaviour (Lorenz, 1970).

### **BROOD SURVIVAL**

The young of precocial species leave the nest shortly after hatching. In the case of mallards, ducklings typically leave the nest (with the hen) within 24 hrs of hatching. In order to survive, the brood requires two items, food and brooding (Gill, 1989). Typically, ducklings fulfill these requirements by means of the maternal hen. Although ducklings do not require the delivery of food from the hen, ducklings do rely on the hen for the location of food (Gill, 1989).

Brooding is important to ducklings as they cannot effectively thermoregulate on their own. The heat that a hen provides while brooding her ducklings protects the brood from cool weather and the hot sun (Gill, 1989). As brood size increases, ducklings can rely on brood mates for mutual thermoregulation and, thus, the requirements placed on the hen are reduced.

Some factors affecting duckling survival are poorly understood (Hoekman, Gabor, Maher, Murkin, & Armstrong, 2004), however, it would seem that since the hen is present to care for her young, she may play a pivotal role in ensuring their survival. It has been found that hens who initiate and hatch nests earlier in the spring have brood that are more likely to survive (Dzus & Clark, 1998). As well, Mauser and Jarvis (1994) have found that orphaned ducklings will seek out foreign hens with broods. It is thought that that these lone ducklings join other hens and broods for an increased chance of survival.

### **THE PURPOSE OF THESE EXPERIMENTS**

An argument can be made that the two stimuli that produce the strongest approach and follow response in an individual duckling are a live, vocalizing hen and a brood of ducklings (Storey, 1976). It has been noted above that the hen (specifically her maternal call) and the brood are important to the survival of an individual duckling in the natural environment. In the natural environment, young hatchlings are exposed to both the hen and the brood simultaneously (Darcewska, 1999, Moriyana, 1987), yet this stimulus combination has rarely been tested in the laboratory.

The major components that a duckling encounters in its immediate post-hatch environment have been examined extensively on their own. Gottlieb (1971, 1988) has maintained that it is the hen and her maternal vocalizations that are the critical factor in the development of avian attachments. Shapiro (1971; Storey & Shapiro, 1979) asserted that it is the stimulation of the brood that is most important for this process to occur. Both of these factors are normally presented together to a duckling in the wild. "The young organism interacts with the environment and its behaviour is influenced by many factors, the contributions of which are not simply additive" (Sluckin, 1972, p. 150).

Therefore, in order to fully understand duckling attachment preferences one must study these two powerful stimuli independently and simultaneously to determine their combined effectiveness as attractants. Three experiments have been conducted. In Experiment 1 a brood was contrasted with a recording of a mallard maternal call. In Experiment 2 a brood was contrasted with a maternal call paired with a live brooding hen. In Experiment 3 a brood was contrasted with a maternal call paired with a live hen and a brood.

## GENERAL METHOD

### *Subjects*

Egg source. The subjects were 70 mallard ducklings (*Anas platyrhynchos platyrhynchos*), hatched from eggs obtained from an indoor breeding flock in the Avian Behaviour Laboratory, in the Department of Psychology at the University of Manitoba in the fall of 2005.

The flock consists of 34 hens and 16 drakes, all of whom are 36 months of age and have been through three breeding cycles. Members of the flock were chosen on the basis of how closely they resembled attributes that are considered characteristic of wild mallards (for a full description of normal attributes of mallards see Drilling, Titman & McKinney, 2002). The flock is contained in an aviary having a total area of 29.07 square metres. It contains a three-tiered wooden structure containing 20 nesting boxes. The aviary also houses a 1.2 m x 1.8 m, 920 L pond with a surface area of 2.16 m<sup>2</sup> for swimming and drinking. There is approximately 10.16 cm of water in the pond at all times. Fresh water replaces dirty water in the pond approximately every 15 min. The floor of the aviary is covered with wood shavings and is cleaned once a week. Red plastic balls are found throughout the aviary. These balls are used to provide environmental

enrichment as well as to distract the ducks from pecking at any eggs that have been laid outside of the nest boxes. The ducks are fed an 18% laying ration on an *ad libitum* feeding schedule during the breeding season. During the non-breeding season, the ducks are fed a 15% developer ration on the same *ad libitum* feeding schedule.

The ducks in this indoor flock come into a breeding condition twice every calendar year (once in the spring and once in the fall) with the use of a controlled lighting schedule. The flock's shortest day occurred on July 1, 2005 and the amount of light occurring during a 24-hour period increased at a rate of approximately 7 min a day until it reached a peak of 16 hr.

Egg collection. Eggs were collected from the indoor flock twice daily. Upon collection, eggs were cleaned and washed using a solution of 50% Hibitane and water solution in lukewarm water. This procedure is done to disinfect eggs and remove any debris clinging to them. After the eggs had been cleaned and towed dry, each egg had the date of its collection written in pencil on its large end.

After being washed, the eggs were placed in cardboard egg cartons in a refrigerator maintained at 10 °C and stored for no more than 7 days. Refrigerating eggs for at least 24 hr after collection ensured that all eggs were at the same developmental stage when they were placed in the incubator (Gottlieb, 1963). When enough eggs had been collected, they were taken out of the refrigerator and allowed to warm to room temperature. Eggs were then transported in cardboard egg containers to an incubation room located within the Avian Behaviour Laboratory.

Incubation. Eggs were placed in a Model 1 Petersime wooden incubator (Petersime Incubator Co., 300 North Bridge, Gettysburg, OH 45328). The incubator

contains eight trays and has the capacity to hold 600 duck eggs. A motor turned the egg trays 120° in the incubator every 2 hr. The incubator was set at a temperature of 37.5 °C with a relative humidity level of approximately 70%.

Once a day the incubators were shut off and the egg trays removed for a cooling period of 15 min. This procedure simulated natural conditions where a hen will leave the nest for short periods to feed. After 15 min, the eggs were sprayed with luke-warm water and the trays were then replaced inside the incubator. The incubator doors were shut then and the incubator re-activated.

Egg fertility was checked once a week for three weeks. An electric candler was used in determining fertility. Eggs that were infertile (those that appear clear when candled) or contained dead embryos (those eggs that contained a blood ring when candled) were removed from the egg trays and were disposed of appropriately.

*Hatching.* On the 24.5<sup>th</sup> day of incubation, the eggs were transported to an opaque Petersime Model H145 hatcher. The temperature of the hatcher was set at 37.5 °C on day 24.5 and reduced to 36.5 °C when pipping began. The hatcher was set for a humidity level of approximately 90%. The hatcher was checked every 2 hr, 19 hr after pipping had started so that the age of each duckling could be determined. Hatching was defined as having occurred when a duckling had completely separated itself from the shell without any help from the experimenter. Once the ducklings had hatched and dried they were removed from the hatcher.

*Leg banding.* After hatching, subjects were banded on their right leg using size four plastic bandettes from the National Band and Tag Company (721 York St., Newport, KY, 41072) for identification purposes. Two experimenters banded the subjects. One

experimenter held the subject while the other experimenter banded the subject. Banding was conducted in a darkened room to minimize exposure to the experimenter and to keep stress to the ducklings at a minimum. One experimenter used a flashlight to locate the bands and place them on subjects correctly. Subjects were then randomly assigned to broods, each containing 10 subjects. Subjects were placed in communal brood units located in the Avian Behaviour Laboratory.

*Brooding.* Subjects were transported to a Petersime Model 2SD communal brood unit in a wooden transport box (29.0 cm X 24.0 cm X 14.0 cm). The communal brooder consists of 12 compartments. Each unit is constructed of 1.5 cm wire mesh and is 1 m x 70 cm x 24 cm, and is covered with 1.5 cm wire mesh. These units allow the ducklings to be reared with continuous access to food and water and have physical contact with other members of an individual's brood. The brood units are designed so that cleaning and food and water replacement can be done with minimum exposure to an experimenter. Brood units were cleaned daily. A 12-12 day-night light cycle was maintained with the lights coming on at 0800 hr. Heaters located within the brood units were set at 32 °C at the beginning of the week and were gradually reduced to 30 °C by the end of the week. The subjects could regulate their own temperature by moving closer to or farther from the heaters. The temperature in the room in which the brooders were stationed was set at 30 °C and gradually reduced through the week to 27 °C. Subjects were fed non-medicated chick starter, containing 21 % protein obtained from Feed Rite (17 Speers Road, Winnipeg, Manitoba, R2J 1M1).

Randomization of subjects. The selection of subjects and their assignment to the three broods was random.

Experimental subjects. Subjects in one of the communal brood units were randomly selected to serve as experimental subjects. In Experiments 1, 2, and 3, the experimental brood also served as one of the stimulus objects. One of the two remaining broods was randomly selected to serve as a spare experimental brood. From this brood subjects could be replaced if there were any fatalities or illnesses from the experimental group. No fatalities or injuries occurred.

Stimulus objects. The stimulus objects were a brood of ducklings, a recorded mallard maternal call, and a live brooding hen, depending on the experiment being run. Empty quadrants (no stimulus object present) were also considered possible stimuli for the ducklings to approach.

### ***Apparatus***

Inside the laboratory was a heat-controlled, sound-deadened experimental chamber (2.4 m x 2.4 m x 2 m) (Shapiro, 1970). In the centre of this chamber was a 1.5 m square sand-covered table divided into four equally sized quadrants separated by a shallow groove in the sand (Figure 2). A 1 cm wire mesh fence, 21 cm high, was attached to a 9 cm high wooden barrier surrounding the table. This fence prevented a subject from jumping off the table. The temperature within the experimental chamber was set at 32 °C and was gradually reduced through the week to 30 °C. Circular restraining pens composed of 2.5 cm wire mesh 45cm high x 40 cm in diameter were located in each corner of the sand covered table. On both sides of the restraining pens were 0.5 cm wire mesh barrier fences (29 cm x 10 cm). These fences eliminated the right angle formed by

the sides of the table and prevented subjects from being able to approach the corners of the table. Darczewska and Shapiro (1998) have shown that ducklings prefer corners and this preference may bias results. The experimental chamber was diffusely lit by four 32-W fluorescent bulbs. A one-way window allowed the experimenter to observe the experimental subject while testing was taking place.

Behind each restraining pen was a white Sanyo speaker (12.7 cm X 13.4 cm X 15.7 cm). These speakers were removable. The speakers were individually wired to a control box and a CD player located outside of the chamber. To operate the speakers, the experimenter turned on the control unit, inserted the CD into the player, and switched the knob to the "on" position that corresponds with the speaker she would like to activate. Then the experimenter could press the "play" button on the CD player and the recording began. Each speaker can be turned on separately or all speakers can be used at the same time. The experimenter controlled the volume by using the volume setting on the CD player. The CD that was used for all three experiments had a 30-min recording of a mallard maternal call. The recording was digitalized to a CD from a cassette recording in the winter of 2004. The original recording of the mallard maternal call was received from Gilbert Gottlieb some 35 years ago when auditory preferences of ducklings were first being investigated at the Avian Behaviour Laboratory in the Department of Psychology at the University of Manitoba.

A computer program was used that allowed the experimenter to record data accumulated during a 15-min trial. Turning on the lights inside the experimental chamber began a 15-min testing session. By pressing corresponding keys, the experimenter recorded the cumulative time spent in each quadrant. If a subject sat on a line, and was

parallel to it, the experimenter would stop recording the time spent in quadrants, but the session clock would continue. If a subject sat on a line, and was perpendicular to it, time was recorded in the quadrant where most of the subject's body was located. Once the 15-min trial was completed, the computer turned off the lights in the experimental chamber and the session ended. The computer program measured the amount of time a subject spent in each quadrant, its latency, and the number of times the subject entered each quadrant during the testing session.

### *Procedure*

Subjects were tested in the experimental chamber for 15 min once a day for seven days. Before testing began, stimulus objects were brought into the experimental chamber and placed in their respective quadrants. Although no preferences for any of the four quadrants has previously been found (Shapiro & Agnew, 1975; Shapiro, 1977), stimulus objects were rotated randomly so that each model occupied each quadrant at least once and in most cases twice. Quadrants containing no stimulus objects still contained restraining pens. A water-filled glass bottle was located in the centre of the sand-covered table. Experimental subjects were brought into the testing room individually in the wooden transport box just prior to the beginning of the trial. The experimenter would replace the water-filled glass bottle with a duckling in the centre of the table. The subject was placed on the sand-covered table facing an empty quadrant (subjects were placed facing the quadrant to the left of the live hen in half of the trials and facing the empty quadrant to the right of the live hen in the other half of the trials). Once the chamber door was shut, and the experimenter positioned in front of the one-way window, the speakers were turned on, and the computer program started. Lights in the

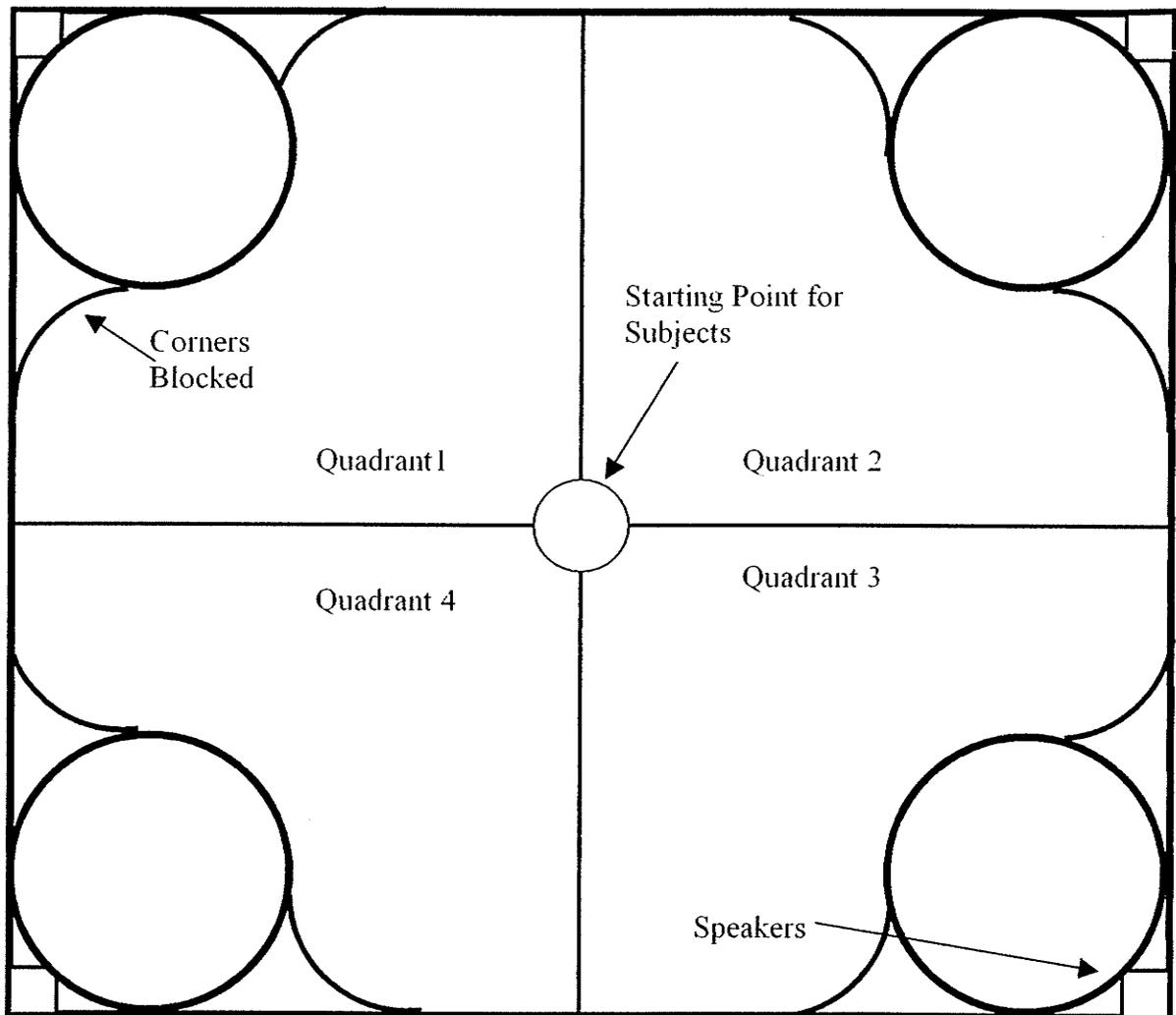


Figure 2. The experimental platform as seen from above.

experimental chamber were turned on, the recording began to play, and the test trial began. The behaviour of each subject was recorded for 15 min. After each subject was tested, it was returned to its restraining pen and a new subject was taken from the restraining pen for testing.

When testing of the experimental subjects was completed for the day, and the broods had been returned to their communal brood units, the spare experimental group was brought to the experimental chamber and placed in one of the circular restraining pens for 15 min. The spare subjects were exposed to the experimental chamber in case one or more of them was needed at some point during the experiment.

The amount of time the experimental subject spent in each quadrant, as well as the number of times a subject entered each quadrant, was recorded by the computer. The computer also recorded the latency of the subject. That is, the computer recorded the amount of time it took for a subject duckling to move from their initial position at the centre of the apparatus into a table quadrant. Behavioural observations for each trial were noted by the experimenter observing from the one-way vision window.

*Stimulus object placement.* Before testing began in Experiment 2 and 3, the live hen was removed from the indoor aviary and placed in a pillowcase. The hen was then carried to the experimental chamber where she was removed from the pillowcase in the dark and placed into a retaining pen in the corner of a randomly determined quadrant.

After the hen had been placed in her restraining quadrant in Experiment 3, the experimental brood was removed from its communal brood unit in the dark and placed in

a wooden transport box. The subjects were brought to the experimental chamber in the dark and placed in the restraining pen with the live hen.

*Experimental subject placement.* When testing was to occur, the experimental subjects were removed from their communal brooders and brought to the experimental chamber in the same manner as the stimulus brood. In the experimental chamber, the subjects were placed in the restraining pen directly opposite the live hen in Experiments 2 and 3 and directly opposite the quadrant from which the maternal call recording was emitted in Experiment 1.

### *Statistical Analysis*

Results were analyzed using a two-way analysis of variance with repeated measures on two factors (subjects and stimulus objects). If main effects were observed, a post-hoc analysis was conducted. If an interaction effect was obtained, a simple effects analysis of variance was conducted.

Latency measures were used as a diagnostic tool and were not analyzed. By observing the mean latencies of the experimental subjects' over the 7-day testing period, one can determine the health of the subjects and the appropriateness of the stimuli being used. Low latency scores, for example, indicate that subjects are healthy, capable of responding, and do so quickly if appropriate stimuli are being used.

## **EXPERIMENT 1: PREFERENCES FOR A BROOD OF MALLARD**

### **DUCKLINGS OR A MALLARD MATERNAL CALL**

Much of the literature concerning attachment formation in young precocial birds assumes that it is either the maternal call or the brood that directs the formation of an attachment (for examples see Beaudoin & Shapiro, 2004, Bolhuis & Van Kampen, 1992;

Bruce & Shapiro, 1977a, b; Dyer & Gottlieb, 1989, 1990). This study was conducted to determine which of these stimuli is more attractive to ducklings. It examined the preferences of mallard ducklings for a recording of a mallard maternal call or a brood of mallard ducklings.

## **Method**

### ***Subjects***

*Experimental subjects.* Experimental subjects were obtained in the manner described in the General Method section. After incubation and hatching, 20 ducklings were randomly assigned to one of two broods, each containing 10 subjects. Subjects were placed in a communal brood unit in the manner described in the General Method section.

*Stimulus objects.* This experiment utilized two stimulus objects, a recording of a mallard maternal call and a brood of mallard ducklings. Two quadrants remained empty. The brood of ducklings served as both the stimulus brood and the experimental subjects.

The recorded mallard hen maternal call was transmitted through speakers located in the corners of the testing apparatus (for a further description of the speakers, see the Apparatus section). The recording was digitalized and re-recorded into a CD format for increased sound quality.

### ***Apparatus***

Testing took place in the experimental chamber as described in the General Methods.

### ***Procedure***

Before testing began, the quadrant that contained the mallard call was randomly determined and the corresponding quadrant speaker was turned on. When testing was to

occur, broods were taken out of their communal brood unit, placed in the wooden transport box and transported to the experimental chamber. The brood, consisting of the experimental subjects, was brought into the experimental chamber and placed in the restraining pen in the quadrant directly opposite to the speaker from which the maternal call was emitted. Testing occurred as outlined in the General Method section.

### ***Results and Discussion***

*Time spent in each quadrant.* The amount of time each subject spent within each of the four quadrants was calculated. Total time spent in each quadrant, regardless of which stimulus object was located in a particular quadrant, was the dependent variable. Results were analyzed using a two-way analysis of variance with repeated measures on two factors (days and quadrants). No main effect for days ( $F(6, 54) = 2.48$ ,  $p > 0.05$ ,  $\eta^2 = 0.120$ ) or quadrants ( $F(3, 27) = 3.81$ ,  $p > 0.05$ ,  $\eta^2 = 0.132$ ) was observed and there was no interaction effect. These results indicate that there was no position effect present in this experiment.

*Latency.* Latency and the number of entries into each quadrant were not analyzed. They were used as a diagnostic measure of the health of the subjects and the appropriateness of the stimuli being used. Many decades of research conducted at the Avian Behaviour Laboratory have provided a latency response baseline indicating typical responses in similar situations.

By observing the mean latencies of the experimental subjects' over the 7-day testing period (Figure 3), one sees that the subjects responded almost immediately when trials began (mean = 12 sec). These latencies indicate that the subjects were healthy and that biologically appropriate stimulus objects were being used.

*Time spent with models.* The data represented in Figure 4 indicate that subject ducklings spent more time in the quadrant containing the brood of nine ducklings than the quadrant containing the recording of the mallard maternal call or the two empty quadrants. A two-way analysis of variance with repeated measures on two factors (days and stimulus objects) was used to analyze the data.

A main effect for quadrants was observed ( $F(3, 51) = 2416.81, p < 0.001, \eta^2 = 0.993$ ). No main effect for days was found ( $F(6, 102) = 2.47, p > 0.05, \eta^2 = 0.553$ ) and there were no interaction effects ( $F(18, 162) = 0.939, p > 0.05, \eta^2 = 0.094$ ). Pairwise comparisons indicate that these ducklings showed a statistically significant preference for the brood over a recording of the mallard maternal call ( $F(1,9) = 4486.864, p > .001, \eta^2 = 1.00$ ). The quadrant containing the brood was preferred more than the empty quadrants ( $F(1,9) = 1727.997, p < .001, \eta^2 = 0.996$ ), however, the quadrant containing the recording of the maternal call was not preferred significantly more than the empty quadrants ( $F(1,9) = 1.213, p > 0.05, \eta^2 = 0.067$ ).

### Discussion

The subjects were attracted to the brood of ducklings and preferred it significantly more than the recording of the mallard maternal call and empty quadrants over all seven days of testing. This result indicates that the brood is a more attractive stimulus than the mallard maternal call. This result supports Shapiro's position concerning the importance of a brood to a mallard duckling (for example, see Wereha & Shapiro, 2004).

FIGURE 3. Experiment 1: Latency

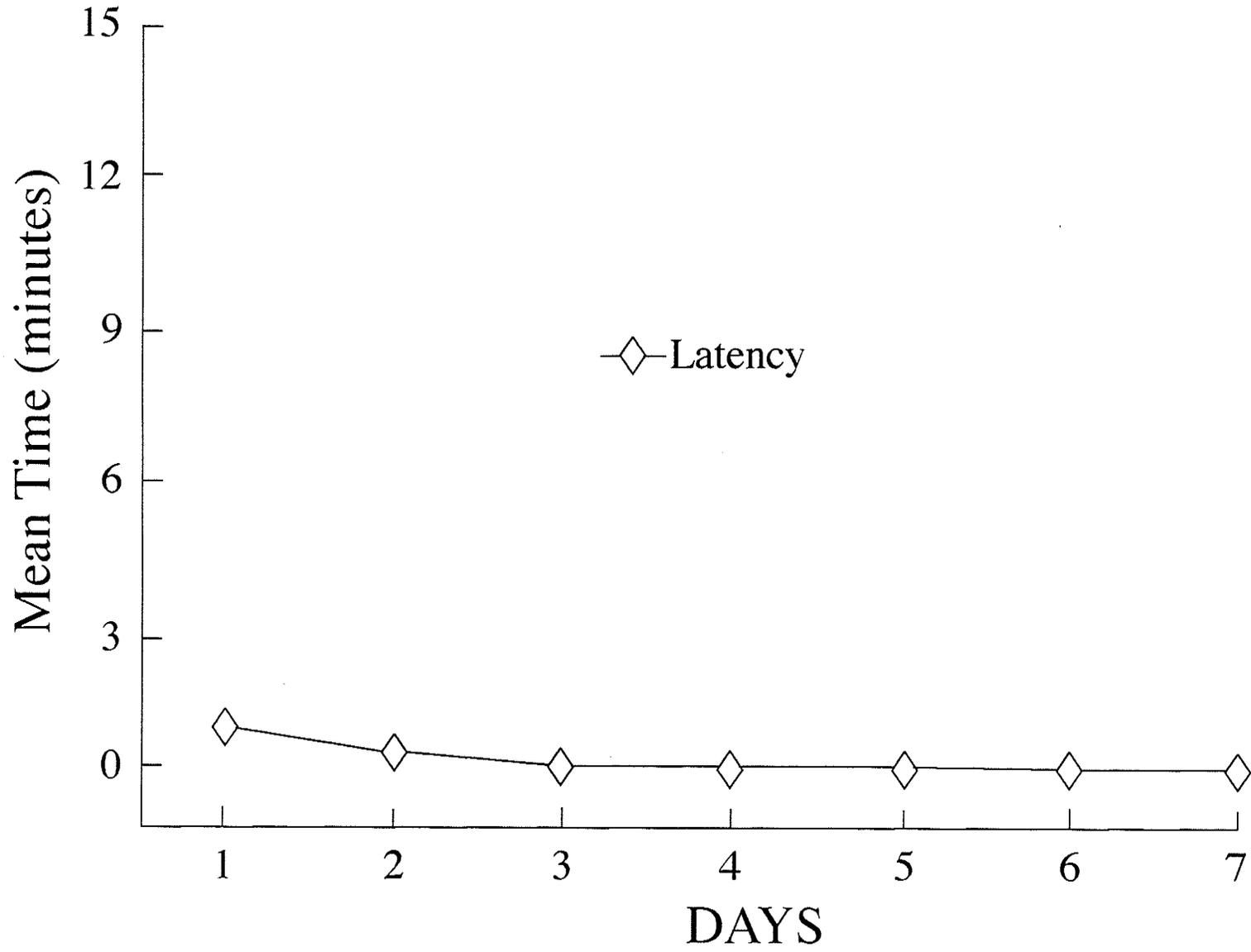
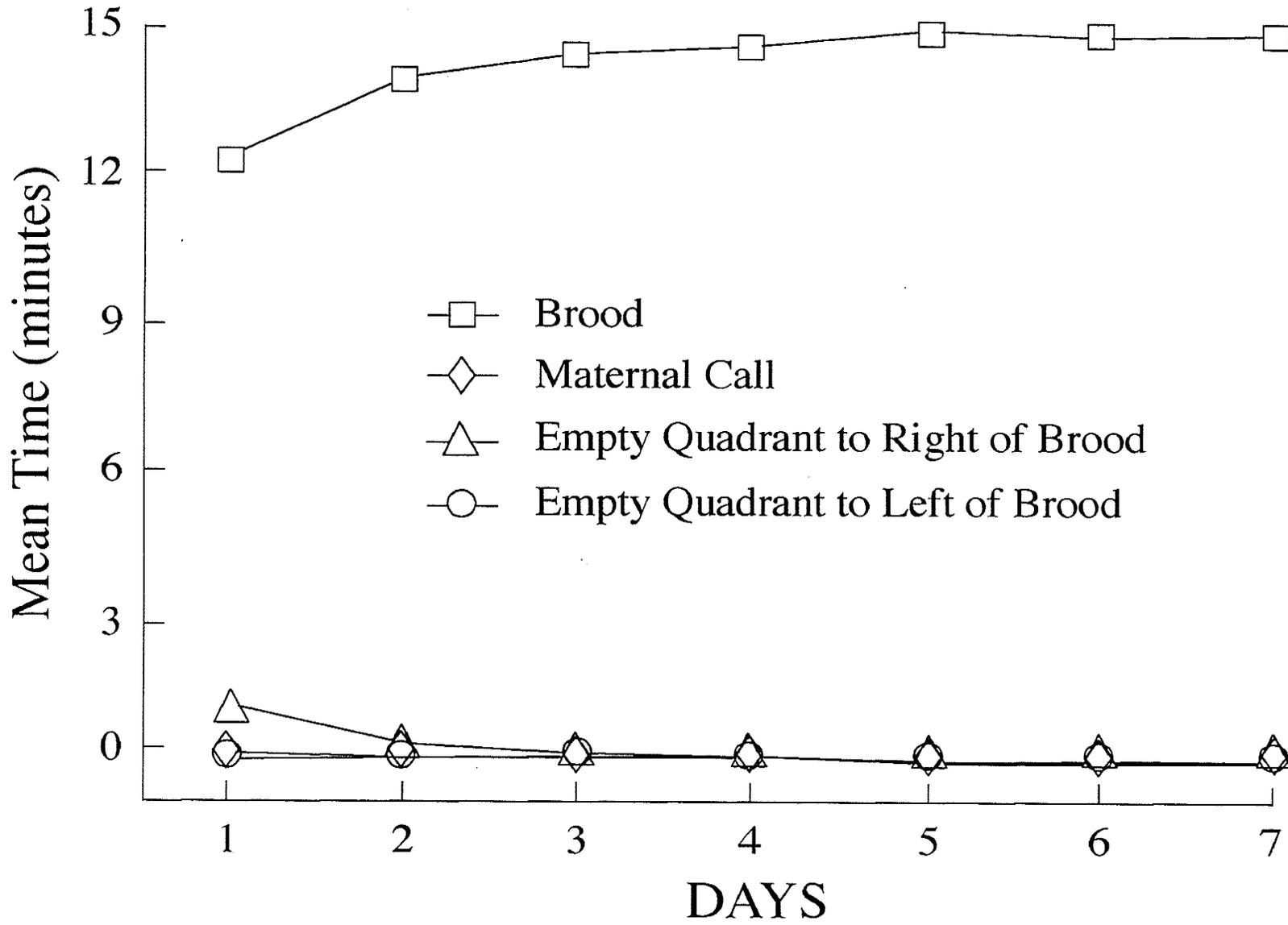


FIGURE 4. Experiment 1: Preferences for a brood of mallard ducklings or a mallard maternal call.



**EXPERIMENT 2: PREFERENCES OF MALLARD DUCKLINGS FOR A  
BROOD OF MALLARD DUCKLINGS OR A MALLARD MATERNAL CALL  
PAIRED WITH A MALLARD HEN**

Experiment 1 found that subject ducklings preferred a brood of ducklings over a speaker emitting the mallard maternal call. This preference may be due to the fact that the maternal stimulus was incomplete. This experiment introduced the visual component of the maternal stimulus to the maternal call in order to examine duckling preferences when two naturally occurring stimuli are used. The purpose of this experiment was to determine if ducklings prefer a stimulus brood or a live mallard hen paired with a speaker emitting a maternal call.

**Method**

***Subjects***

Experimental subjects. Experimental subjects were obtained in the manner described in the General Method section. After incubation and hatching, 20 subjects were randomly assigned to one of two broods, each containing 10 subjects. Subjects were placed in communal brood units in the manner described in the General Method section. The members of one brood served as both a stimulus brood and the experimental brood. The remaining brood was kept as a spare brood.

Stimulus objects. This experiment utilized two stimulus objects. One was a recording of a mallard maternal call paired with a live mallard hen. The other was a brood of mallard ducklings. Two quadrants remained empty. The brood of 10 ducklings served as the source of the experimental subjects and also served as the stimulus brood in

this experiment. The recorded mallard maternal call was used as described in Experiment 1.

The live brooding female was habituated to the testing apparatus, the maternal call, and a brood of ducklings one month prior to the beginning of the experiments to minimize the probability that she would behave abnormally during testing. Habituation occurred gradually. The hen was taken out of the indoor breeding flock and brought to the experimental chamber in a pillowcase. She was then placed in a restraining pen in a randomly selected quadrant of the experimental apparatus. Habituation initially lasted for 15 min each day. The time the hen spent in the experimental chamber increased at a constant rate until she was spending 3 hr in the chamber. The hen was habituated to the testing platform first. The recording of the maternal call was then added. When the hen had become habituated to both the testing apparatus and the recording, a brood of ducklings was added to the testing apparatus and placed in the quadrant directly opposite to the hen. The hen was then gradually habituated to the presence of the brood.

### *Apparatus*

Testing took place in the experimental chamber described in the General Method section of this paper.

### *Procedure*

Before testing began, members of the experimental brood were brought to the experimental chamber in the wooden transport box and placed in a randomly selected quadrant. The maternal hen was then brought into the experimental chamber and its accompanying speaker activated. The live hen and speaker were located in the quadrant

opposite to the stimulus brood. Testing occurred as outlined in the General Method section.

### ***Results and Discussion***

*Time spent in each quadrant.* The amount of time each subject spent within each of the four quadrants was calculated. Total time spent in each quadrant, regardless of which stimulus object was located in a particular quadrant, was the dependent variable. Results were analyzed using a two-way analysis of variance with repeated measures on two factors (days and quadrants). No main effect for days ( $F(6, 54) = 1.227, p > 0.05, \eta^2 = 0.120$ ) or quadrants ( $F(3, 27) = 0.502, p > 0.05, \eta^2 = 0.120$ ) was found and there was no interaction effect ( $F(18, 162) = 0.939, p > 0.05, \eta^2 = 0.094$ ). These results indicate that there was no position effect present in this experiment.

*Latency.* Latency and the number of entries into each quadrant were not analyzed. They were used as a diagnostic measure of the health of the subjects and the appropriateness of the stimuli being used. Many decades of research have provided a baseline indicating typical responses in similar situations.

By observing the mean latencies of the experimental subjects' over the seven day testing period (Figure 5), one sees that the subjects responded almost immediately when trials began (mean = 8 sec). These latencies indicate that the experimental subjects were healthy and that appropriate stimulus objects were used.

*Time spent with models.* Figure 6 indicates that the subjects spent most of their time in the quadrant containing the brood of ducklings.

A two-way analysis of variance with repeated measures on two factors (days and stimulus objects) was used to analyze the amount of time subjects spent in the quadrants

FIGURE 5. Experiment 2: Latency

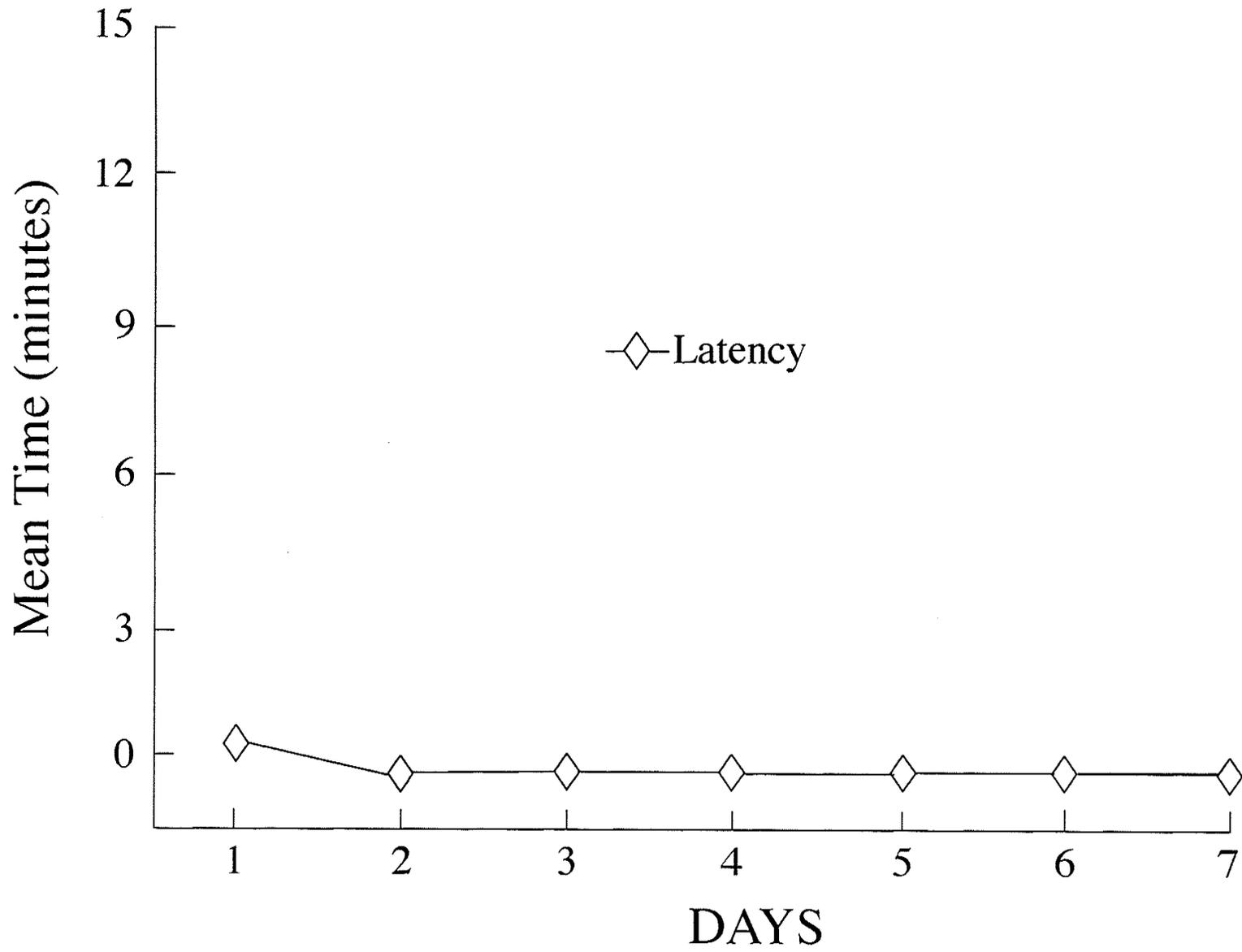
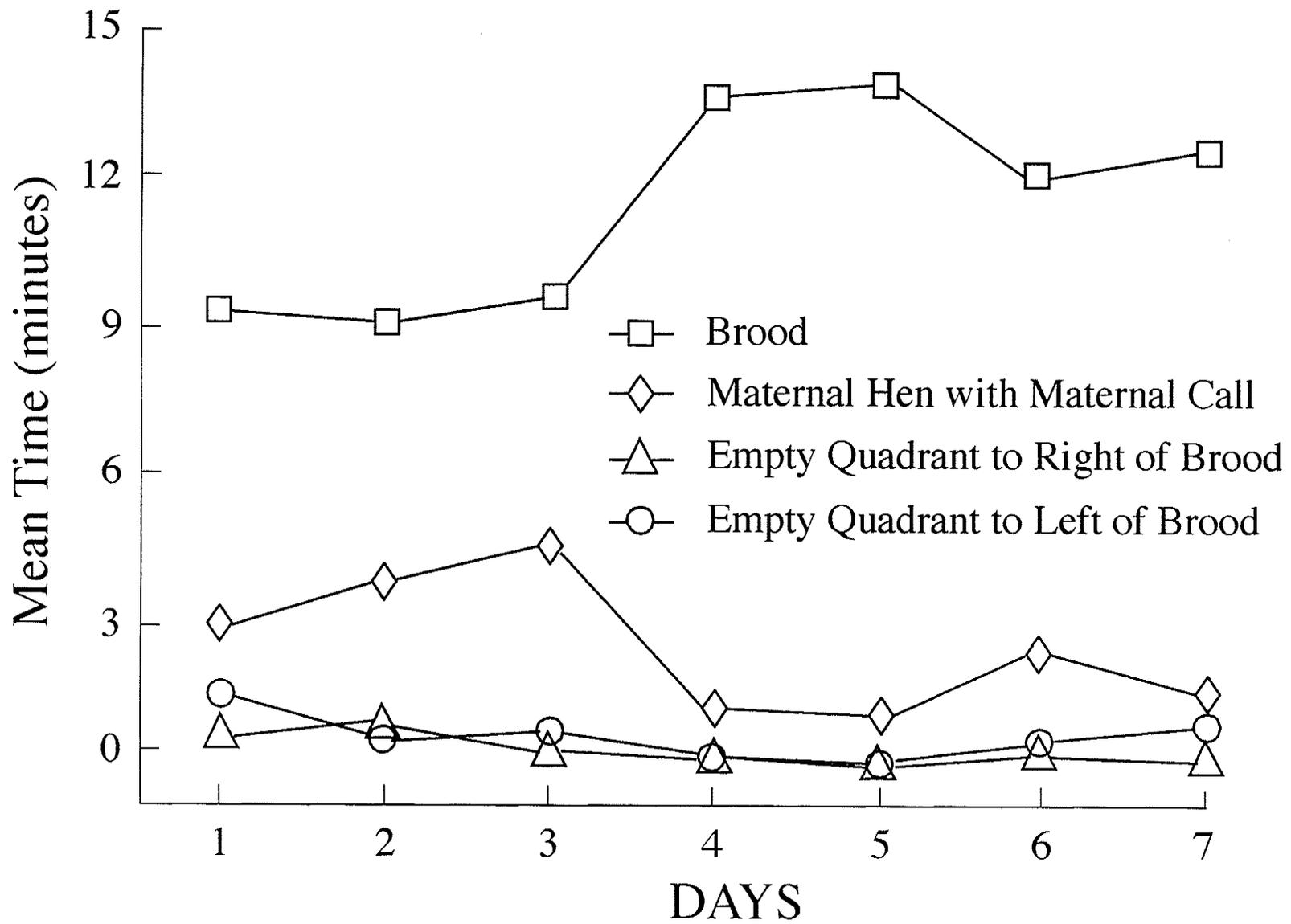


FIGURE 6. Experiment 2: Preferences of mallard ducklings for a brood of mallard ducklings or a mallard maternal call paired with a mallard hen.



(the dependent variable). A main effect for quadrants was observed ( $F(3, 27) = 1162.16$ ,  $p < 0.01$ ,  $\eta^2 = 0.998$ ). No main effect for days was found ( $F(6, 54) = 1.227$ ,  $p > 0.05$ ,  $\eta^2 = 0.120$ ) and there was no interaction effect. Pairwise comparisons indicate that the ducklings showed a statistically significant preference for the brood over the hen paired with a recording of the mallard maternal call ( $F(1,9) = 289.001$ ,  $p < 0.05$ ,  $\eta^2 = 0.970$ ) and both empty quadrants ( $F(1,9) = 1.367$ ,  $p > 0.05$ ,  $\eta^2 = 0.132$ ). The quadrant containing the maternal call and hen was not preferred significantly more than the two empty quadrants ( $F(1,9) = 4.401$ ,  $p > 0.05$ ,  $\eta^2 = 0.126$ ).

### Discussion

The brood was preferred significantly more than the maternal call paired with a hen and the two empty quadrants. Darczewska & Shapiro (1997) found that a brood is preferred over a live, silent hen. As well, Experiment 1 found that a brood is also preferred over a recording of a mallard maternal call.

Because the subject ducklings preferred the brood of ducklings significantly more than the maternal call paired with a hen, it may be assumed that the brood plays a major role in the development of avian attachment behaviour. Because the brood of ducklings was preferred significantly more than the maternal call paired with the hen, it is unlikely that the maternal auditory stimulus is a primary cue for eliciting attachment behaviour in ducklings. This result may indicate that auditory stimuli emanating from the hen are not a critical cue for development of attachment behaviour in young waterfowl. Results of this experiment contradict results obtained by Gottlieb (1971) and his colleagues in similar experiments involving the maternal call.

**EXPERIMENT 3: PREFERENCES OF MALLARD DUCKLINGS FOR A  
BROOD OF MALLARD DUCKLINGS OR A MALLARD MATERNAL CALL  
PAIRED WITH A MALLARD HEN AND A BROOD OF MALLARD  
DUCKLINGS**

In the natural post-hatch environment, a duckling encounters its brood, a hen and the maternal call simultaneously, or almost simultaneously. This experiment was conducted to determine if the combination of the hen, the maternal call and a brood are more attractive to an individual duckling than a brood of mallard ducklings. The purpose of this experiment was to determine if the combined natural stimuli perceived in the post-hatch environment is more attractive to a duckling than a brood of ducklings, a very powerful stimulus found in many studies done in the Avian Behaviour Laboratory.

**Method**

*Subjects*

*Experimental subjects.* The experimental subjects were obtained in the manner described in the General Method section. After incubation and hatching, 20 subjects were randomly placed into one of two broods and housed in communal brood units. One brood contained the experimental subjects; the other brood served as stimulus objects and as a spare brood.

*Stimulus objects.* One stimulus model used in this experiment was a brood of four ducklings. Another stimulus model was a live hen with a brood of four ducklings and a speaker emitting the maternal call. Unlike previous experiments, where 10 subjects were used as stimulus subjects, only four subjects were used as stimulus objects in each of the two stimulus quadrants in this experiment. There are two reasons for this reduction in

brood size. The first reason is because one stimulus brood of ducklings was to be paired with a live hen and available room in the restraining pen was, therefore, reduced. Limiting the pen to four ducklings ensured that the mallard hen and the brood of ducklings would fit comfortably within the restraining pen. The second reason is related to the first. Because the brood to be paired with the live hen contained only four ducklings, the brood being presented alone also had to contain four ducklings. Prior studies conducted in the Avian Behaviour Laboratory have found that individual ducklings prefer to remain near a brood containing the largest number of ducklings in it. Thus, brood numbers had to remain equal to ensure there was no bias toward a brood containing a larger number of ducklings.

One quadrant contained the experimental subjects while a second quadrant contained a combination of stimuli. A live brooding female was put in a restraining pen along with a brood of four ducklings and a recording of a mallard maternal call. The mallard maternal call was used as described in Experiment 1. The female was habituated to the testing apparatus, the maternal call, and a brood of ducklings as described in Experiment 2. Two quadrants remained empty in this experiment.

### *Apparatus*

Restraining pens. Three of the restraining pens used in this experiment are as outlined in the Apparatus section in the General Method section of this paper. The fourth restraining pen was modified to house the live hen and the brood of four ducklings. The circular restraining pen is made of 2.5 cm wire mesh and is 45 cm high x 40 cm in diameter. A 1 cm wire mesh barrier was inserted to separate the restraining pen into two parts. One part housed the hen and the other part housed the ducklings. This separation

prevented the ducklings from being obscured by the hen and prevented any possible aggression between the hen and the brood of ducklings.

### ***Procedure***

Testing took place in the experimental chamber as described in the General Method section of this paper.

Before testing began, four randomly selected members from the stimulus brood were brought into the experimental chamber in a wooden transport box and placed into a restraining pen in a randomly selected quadrant. The live hen was then brought into the experimental chamber and placed in the restraining pen with the four members of the stimulus brood. The appropriate speaker was then activated. Five randomly selected members of the 10 subjects of the experimental brood were then brought to the experimental chamber in a wooden transport box and placed in the quadrant directly opposite to the live hen, speaker, and the brood of ducklings. Testing occurred as outlined in the General Method section. When testing had concluded for those five members of the experimental brood, they were transported back to their communal brood unit and the five remaining experimental brood members were taken to the experimental chamber for testing.

### **Results and Discussion**

*Time spent in each quadrant.* The amount of time each subject spent within each of the four quadrants was calculated. Total time spent in each quadrant, regardless of which stimulus object was located in a particular quadrant, was the dependent variable. Results were analyzed using a two-way analysis of variance with repeated measures on two factors (days and quadrants). No main effect for days ( $F(6, 54) = 0.502, p > 0.05, \eta^2 =$

0.430) was observed and there was no interaction effect ( $F(18, 162) = 0.939, p > 0.05, \eta^2 = 0.094$ ). These results indicate that there was no position effect present for this experiment.

Latency. Latency and the number of entries into each quadrant were not analyzed. They were used as a diagnostic measure of the health of the subjects and the biological appropriateness of the stimuli being used. Many decades of similar research have provided a latency response baseline indicating typical responses in similar situations.

By observing the mean latencies of the experimental subjects' over the 7-day test (Figure 7), one sees that the subjects responded almost immediately when trials began (mean = 18 sec). These latencies indicate that the subjects were healthy and that appropriate stimulus objects were being used.

Time Spent with Models. The data represented in Figure 8 indicate that subject ducklings spent more time in the quadrant containing the brood of four ducklings and in the quadrant containing four ducklings plus the hen and maternal call than in the two empty quadrants. A two-way analysis of variance with repeated measures on two factors (days and stimulus objects) was used to analyze the data.

A main effect for stimulus objects was observed ( $F(1, 9) = 11652.16, p < 0.05, \eta^2 = 0.909$ ). No main effect for days was found ( $F(6, 54) = 1.227, p > 0.05, \eta^2 = 0.120$ ) and there was no interaction effect ( $F(18, 162) = 0.939, p > 0.05, \eta^2 = 0.094$ ). Pairwise comparisons on the stimulus objects factor indicated that the subject ducklings showed a statistically significant preference for the quadrant containing a brood ( $F(1, 9) = 289.001, p < 0.01, \eta^2 = 0.970$ ) and the quadrant containing a brood, hen, and maternal call ( $F(1, 9) =$

FIGURE 7. Experiment 3: Latency

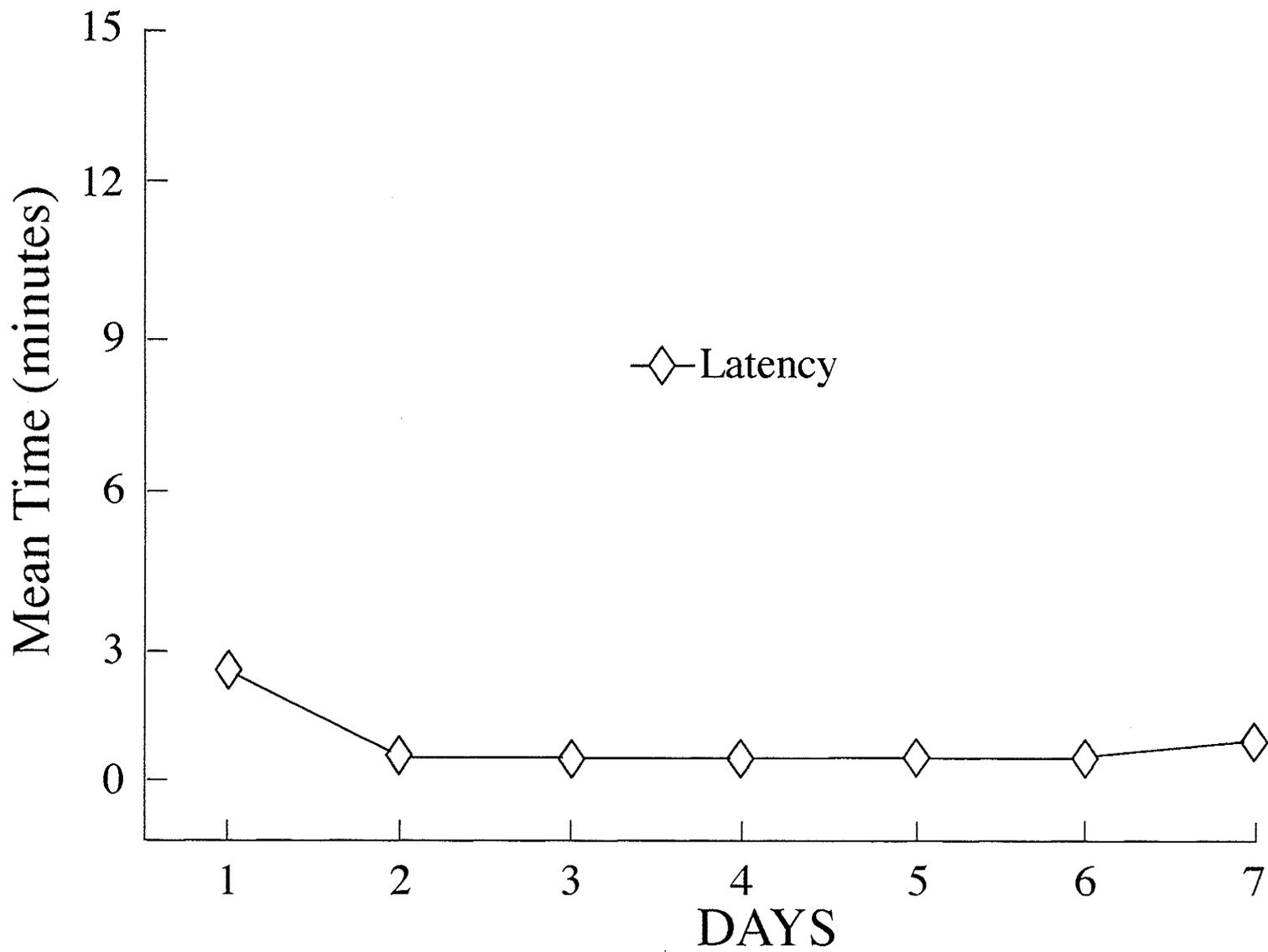
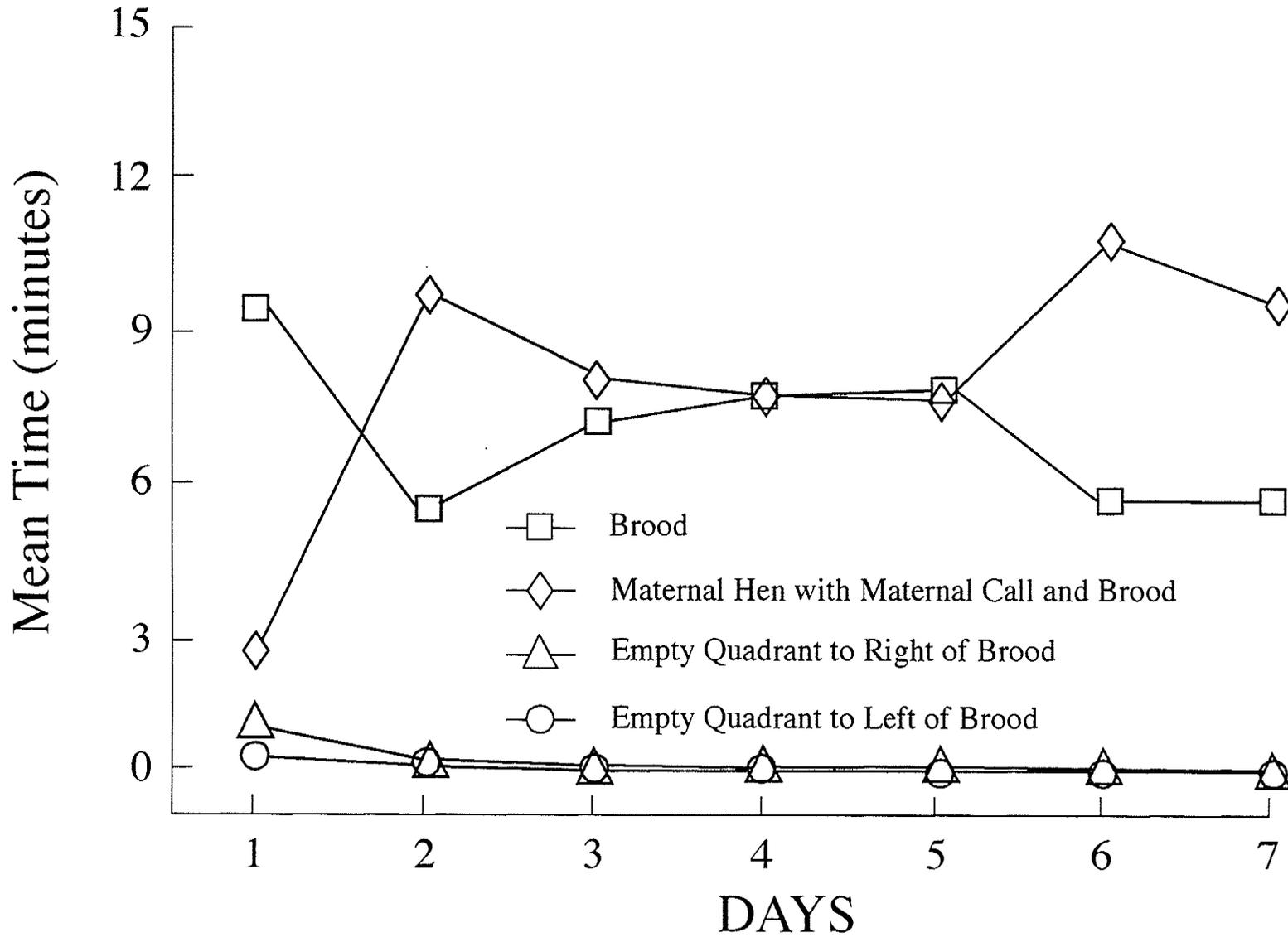


FIGURE 8. Experiment 3: Preferences of mallard ducklings for a brood of mallard ducklings or a mallard call paired with a mallard hen and a brood.



281.431,  $p < 0.01$ ,  $\eta^2=0.969$ ) over the empty quadrants. The quadrant containing the brood, hen, and maternal call was not preferred significantly more than the quadrant containing the brood of four ducklings ( $F(1,9)= 1.367$ ,  $p > 0.05$ ,  $\eta^2=0.132$ ).

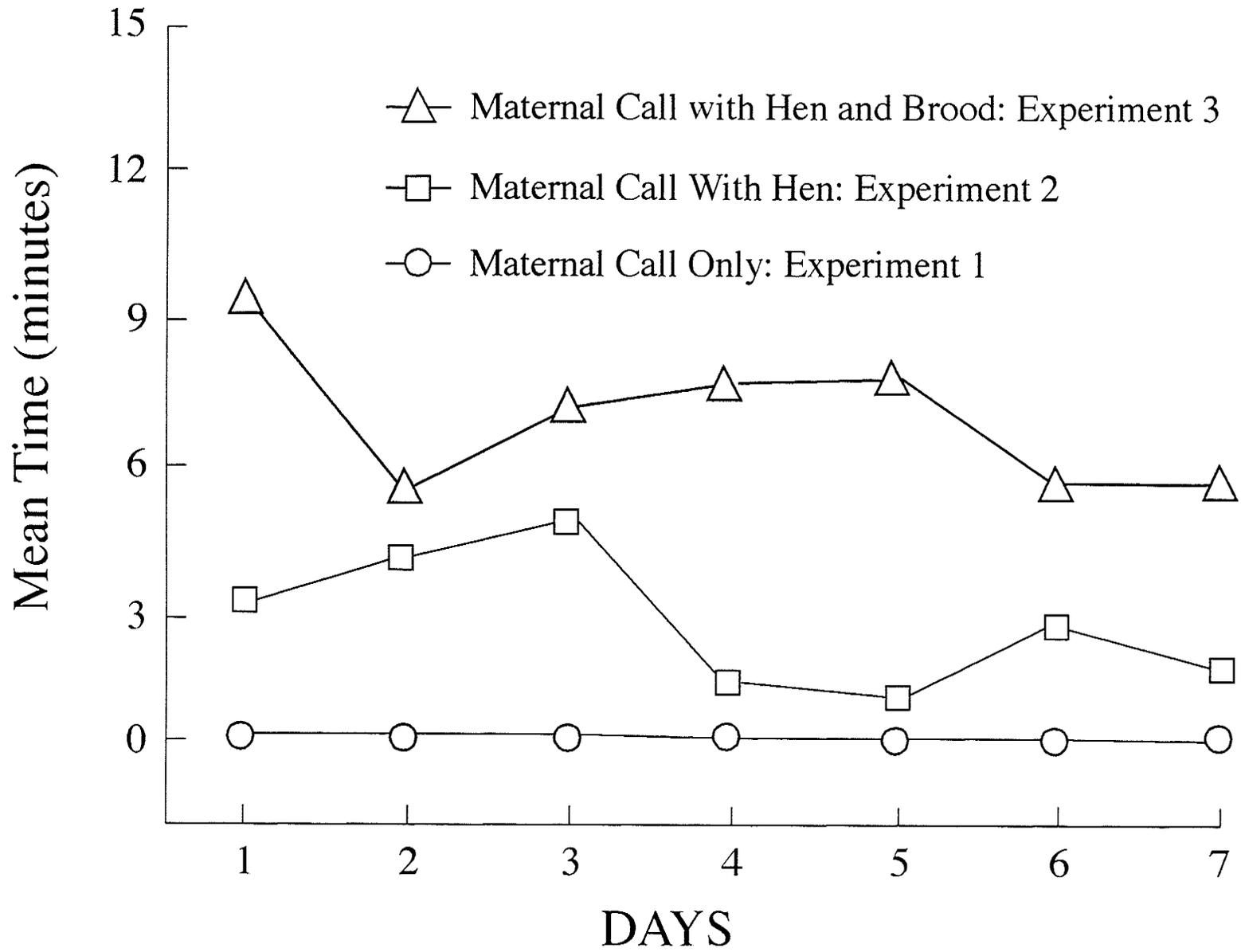
### Discussion

In the natural environment, ducklings are part of a brood and are normally accompanied by a parent (Beard, 1964). It was assumed that the quadrant containing the brood of ducklings, a live hen and the speaker emitting the maternal call would be most attractive to subject ducklings. However, this was not the case. Although subjects spent time in both quadrants containing stimulus models, neither stimulus quadrant was preferred over the other.

Because the maternal call alone was not attractive in Experiment 1 and the hen and maternal call combination was not as attractive to ducklings as a brood in Experiment 2, it would appear that the addition of a brood to the hen-call dyad made it a great deal more attractive to subject ducklings (see Figure 9). It is possible that a newly hatched duckling seeks a complete maternal stimulus for the protection provided by a hen and the advantages of staying with a brood as outlined earlier. It is not entirely clear, however, why subject ducklings found the brood alone as attractive as the combination stimulus, since, from an ecological perspective, the brood alone offered fewer fitness advantages than the brood with the hen.

As in the first two experiments, it can be concluded that the brood is a very powerful attractant to a young duckling. This outcome supports Shapiro's position that the brood is an important stimulus for an individual mallard duckling. As well, it can also be concluded that a combination of all stimuli found in the natural post-hatch

FIGURE 9. Comparison of Maternal Stimulus Preferences across experiments.



environment is also a very powerful stimulus for ducklings. On the other hand, it can be argued that the preference exhibited by subjects for the quadrant containing the hen, maternal call and ducklings is the result of having a brood of ducklings in that quadrant and not because of the presence of the hen and maternal call. Thus, it could be concluded that as you add attractive stimuli to the mallard maternal call (i.e., a live hen and specifically a brood of ducklings) it becomes more attractive to individual ducklings. Alternatively, it may be that the familiarity with the brood overcomes the neophobia associated with hen alone. Thus, it is not unreasonable to find that subject ducklings found the quadrant containing the hen, brood, and maternal call an attractive stimulus.

### **GENERAL DISCUSSION**

Shapiro (1972) claimed that a majority of research concerning avian attachment may have been done erroneously due to the use of artificial laboratory settings, the use of inappropriate training objects, and the misinterpretation of results. Due to these complications, much of the theory surrounding the process of attachment formation may be at best confusing and, at worst, completely incorrect. As noted earlier, the concept of "imprinting" is hypothetical and is based largely on the behaviours observed in the laboratory and not in the natural environment. Thus, the model of "imprinting" consists of an inferred mechanism with little credible evidence for it.

To address the issue of the non-generalizable results obtained from many of the traditional visual and auditory "imprinting" experiments, a study using a wild species in a more naturalistic setting should be done. Such a study may yield more useful results in determining the factors mediating attachment formation in the natural environment. In the present study, semi-wild, untrained mallards were used.

Attachment behaviour evolved in response to diverse selective processes found in nature. The studies conducted in this paper were an attempt to re-examine the stimuli found in a mallard duckling's natural environment. Shapiro (1977) wrote "we may be able to unravel some of the mysteries of imprinting if we use live models in the more naturalistic setting and if we examine the complex, dyadic interaction between parent and offspring" (p. 857).

In all of the current experiments, subjects preferred live models over empty quadrants or a quadrant containing only the maternal call. These results mirror those found in many previous investigations of attachment behaviour (Beaudoin & Shapiro, 2002, 2004; Bruce & Shapiro, 1977a, b; Buss & Shapiro, 1987; Levy & Shapiro, 2003; Shapiro, 1970, 1971; Storey, 1976).

Experiments 1 and 2 were designed to look at what are often considered the two most important cues to a young mallard duckling. Experiment 1 attempted to examine the relative importance of a brood of ducklings when pitted against the mallard maternal call. This experiment demonstrated that the brood is a more attractive stimulus to individual ducklings than the mallard maternal call.

Experiment 2 examined the preferences of ducklings for a brood of ducklings or a live mallard hen accompanied by a recording of the mallard maternal call. Like Experiment 1, this experiment also showed that the brood was a more attractive stimulus to individual ducklings. Subjects, however, did spend a small portion of time in the quadrant containing the maternal call and hen, indicating that the hen-call dyad is not an unattractive stimulus.

Gottlieb (1971, 1981, 1988) has maintained that the hen, and specifically the audio stimulus of a hen, is a critical cue for the commencement of attachment. In both Experiments 1 and 2, however, the quadrant containing the brood was significantly preferred. Thus, these results support work completed by Shapiro, who has found evidence that the brood may play a prominent role in the development of attachment (Shapiro, 1970; Storey, 1979). Indeed, based on the results of Experiments 1 and 2, the role brood-mates play in the formation of an attachment would seem to be of great importance.

Experiment 3 was the first study to incorporate the three important elements normally present in a duckling's natural post-hatch environment, namely, the brood, the hen and a maternal call. There is compelling evidence in the first two experiments of the current series, as well as from previous studies conducted in the Avian Behaviour Laboratory, that the brood is the most attractive stimulus object to an individual duckling (Beaudoin & Shapiro, 2003; Bruce & Shapiro, 1977a, b; Darczewska, 1999; Wereha & Shapiro, 2003, 2004). As well, there is also an abundance of literature indicating the importance of a hen and the importance of the maternal call for the formation of an attachment (Bateson, 1971; Dyer & Gottlieb, 1989, 1990; Gibson & Shapiro, 1972; Gottlieb, 1971; Hess, 1964; Johnston & Gottlieb, 1981; Lickliter & Gottlieb, 1986a, b; Shapiro, 1970, 1971; Storey, 1979; Storey & Shapiro, 1972) as well as the importance of the brood in the natural environment (Beard, 1964). The results of Experiment 3 indicated that both the brood and the hen-brood-maternal-call combination were strong attractants to an individual duckling and both stimuli were preferred.

Because the quadrant containing the brood was as attractive to individual ducklings as the quadrant containing the hen-maternal-call and brood, it may be speculated that the bond that individual ducklings form with the brood, rather than the bond they form with the hen, is a primary bond unifying the family unit. The ecological benefits of staying with a brood are numerous. As mentioned earlier, brood mates can provide mutual warmth, provide a decreased likelihood of being caught by a predator, and may increase food production.

It is important to remember that the development of attachments in the natural environment may involve entirely different processes than what is observed in a laboratory setting. Lorenz (1935/1957) stated, "unless we know the natural behaviour of a species, experiments are largely useless" (p.93). Without doubt, there are factors in the natural environment which influence the development of attachment behaviour in young organisms. In order to fully evaluate the mechanisms mediating the development of attachment behaviour, one must look at individual stimuli mediating the phenomenon to determine the relative importance of each. After that, one can recombine all of these factors as they are seen in the natural environment. Once all the components concerning the development of attachment behaviour are known, and the interactions between these components are fully recognized, we will be able to observe subjects in their natural environment with a greater understanding of the processes involved in forming attachments.

References

- Alcock, J. (1993). *Animal behavior: An evolutionary approach* (5th ed). Sunderland, Massachusetts: Sinauer Associates.
- Allen, H. (1977). The response of willow grouse chicks to auditory stimuli. 1. Preferences for hen grouse calls. *Behavioral Processes*, 2, 27-32.
- Abraham, R.L. (1974). Vocalizations of the mallard (*Anas Platyrhynchos*). *Condor*, 76, 401-420.
- Banker, H., & Lickliter, R. (1993). Effects of early or delayed visual experience on perceptual development in Bobwhite quail chicks. *Developmental Psychobiology*, 26, 155-170.
- Bateson, P. (1966). The characteristics and context of imprinting. *Biological Review*, 41, 177-220.
- Bateson, P. (1971). Imprinting. In H. Moltz (Ed). *The ontogeny of vertebrate behavior* (pp. 369- 387). New York. Academic Press.
- Bateson, P., & Reese, E. (1969). The reinforcing properties of conspicuous stimuli in the imprinting situation. *Animal Behaviour*, 17, 692-699.
- Beard, E. (1964). Duck brood behavior at the Seney National Wildlife Refuge. *Journal of Wildlife Management*, 28, 494-521.
- Beaudoin L., & Shapiro, L. J. (2003, April). *Preferences for familiar or unfamiliar broods of the same size in the chick (Gallus gallus domesticus)*. Paper presented at the Prairie Undergraduate Psychology Research Conference, University of Winnipeg, Winnipeg, Manitoba.

- Beaudoin, L., & Shapiro, L.J. (2004, August). Preferences for a maternal call or a brood of ducklings in the mallard duckling (*Anas platyrhynchos platyrhynchos*). Paper presented at the annual meeting of the Animal Behaviour Society, Snowbird, Utah.
- Bolhuis, J., & Honey, R. (1994). Within event learning during filial imprinting. *Journal of Experimental Psychology: Animal Behaviour Processes*, 20, 240-248.
- Bolhuis, J., & van Kampen, H. (1992). An evaluation of auditory learning in filial imprinting. *Behaviour*, 122, 195-230.
- Bowlby, J. (1969). *Attachment and loss : Vol. 1. Attachment*. New York: Basic Books.
- Boyd, H., & Fabricius, E. (1965). Observations on the incidence of following of visual and auditory stimuli in naive mallard ducklings. *Behaviour*, 25, 1-15.
- Bronson, M.B. (2000). *Self regulation in early childhood: Nature and nurture*. New York: The Guilford Press.
- Bruce, M., & Shapiro, L.J. (1977a). *Brood recognition in ducklings*. Paper presented at the Meeting of the Animal Behavior Society, University Park, Pennsylvania.
- Bruce, M., & Shapiro, L.J. (1977b). *The importance of the brood in the hen-brood dyad in eliciting an approach response in mallard ducklings*. Paper presented at the North-eastern Regional meeting of Animal Behavior Society, St. Johns, Newfoundland.
- Buss, T., & Shapiro, L. J. (1987, April). *Preferences of mallard ducklings (Anas platyrhynchos) for broods of one, two or three*. Paper presented at the meeting of the Psychology Undergraduate Research Conference, University of Winnipeg, Winnipeg, Manitoba.

- Cofoid, D., & Honig, W. (1961). Stimulus generalization of imprinting. *Science*, *134*, 1692-1694.
- Collias, N. (1952). The development of social behavior in birds. *Auk*, *69*, 127-159.
- Collias, N., & Collias, E. (1956). Some mechanisms of family integration in ducks. *Auk*, *73*, 378-400.
- Colombo, J. (1982). The critical period concept: Research, methodology and theoretical issues. *Psychological Bulletin*, *91*, 260-275.
- Columbus, R. F., & Lickliter, R. (1998). Modified sensory features of social stimulation alter the perceptual responsiveness of bobwhite quail chicks. *Journal of Comparative Psychology*, *112*, 161-169.
- Darczewska, M., & Shapiro, L.J. (1997, June). *What do Mallard ducklings find more attractive, the hen or the brood?* Poster presented at the Brain, Behaviour and Cognition Conference, University of Manitoba, Winnipeg, Canada.
- Darczewska, M., & Shapiro, L.J. (1998). *Seeking comfort or seeking cover? Attraction to corners in mallard ducklings.* Poster session presented at the meeting of the Prairie Universities Biological Symposium, Winnipeg, Manitoba.
- Darczewska, M. (1999). Peer attraction in white peking ducklings (*Anas platyrhynchos*). Unpublished Master's Thesis, University of Manitoba.
- Deng, C., & Rogers, L. (2002). Social recognition and approach in the chick: Lateralization and effect of visual experience. *Animal Behaviour*, *63*, 697-706.
- Dethier, V. G. (1962). *To know a fly*. New York, McGraw-Hill Inc.

- Drilling, N., Titman, R., & McKinney, F. (2002). Mallard (*Anas platyrhynchos* *platyrhynchos*). In A. Poole, & F. Gill (Eds.), *The Birds of North America*, (Vol. 17, No. 658). Philadelphia: The Birds of North America.
- de Vos, G., & van Kampen, H. (1993). Effects of primary imprinting on the subsequent development of secondary filial attachments in the chick. *Behaviour*, 125, 245-263.
- Doise, W. (1990). The development of individual competencies through social interaction. In H. Foot, M. Morgan and R. Sure, (Eds.), *Children helping children*. New York, Wiley.
- Dyer, A., & Gottlieb, G. (1989). Maternal and peer imprinting in mallard ducklings under experimentally simulated natural social conditions. *Developmental Psychobiology*, 22, 463-475.
- Dyer, A., & Gottlieb, G. (1990). Auditory basis of maternal attachment in ducklings (*Anas platyrhynchos*) under simulated naturalistic imprinting conditions. *Journal of Comparative Psychology*, 104, 190-194.
- Dzus, E., & Clark, R. (1998). Brood survival and recruitment of mallards in relation to wetland density and hatching date. *The Auk*, 115: 311-318.
- Espmark, Y. (1971). Individual recognition by voice in reindeer mother-young relationship. Field observations and playback experiments. *Behaviour*, 60, 295-301.
- Evans, R. (1982). The development of learned auditory discrimination in the context of post-natal filial imprinting in young precocial birds. *Bird Behaviour*, 4, 1-6.

- Fabricius, E. (1951). Some experiments on imprinting phenomena in ducks. *Proceedings of The International Ornithological Congress*, 375-379.
- Fabricius, E., & Boyd, H. (1954). Experiments on the following reaction of ducklings. *Report of the Waterfowl Trust*, 6, 84-89.
- Feltenstien, M., Ford, N., Freeman, K., & Suka, K. (2002). Disassociation of stress behaviours in the chick social separation stress procedure. *Physiology and Behavior*, 75, 675-679.
- Fischer, G. (1966). Auditory stimuli in imprinting. *Journal of Comparative Physiological Psychology*, 61, 271-273.
- Gibson, R., & Shapiro, L. J. (1972, March). *The effect of the speculum on eliciting an approach response in white peking ducklings*. Paper presented at the meeting of the Southern Society for Philosophy and Psychology, St. Louis, Missouri.
- Gill, F.B. (1989). *Ornithology*. New York: W.H. Freeman and Company.
- Gottlieb, G. (1963). A naturalistic study of imprinting in wood ducklings (*Aix sponsa*). *Journal of Comparative and Physiological Psychology*, 56, 86-91.
- Gottlieb, G. (1965). Imprinting in relation to parental and species identification by avian neonates. *Journal of Comparative and Physiological Psychology*, 59, 345-356.
- Gottlieb, G. (1971). *Development of species identification in birds: An inquiry into the prenatal determinants of perception*. Chicago: University of Chicago Press.
- Gottlieb, G. (1973). Neglected developmental variables in the study of species identification in birds. *Psychological Bulletin*, 79, 362-372.

- Gottlieb, G. (1981). Roles of early experience in species specific perceptual development. In R.N. Aslin, J.R. Alberts & M.R. Peterson (Eds.), *Development of Perception, Vol.1* (pp. 5- 44). New York: Academic Press.
- Gottlieb, G. (1988). Development of species identification in ducklings: XV. Individual auditory recognition. *Developmental Psychobiology, 21*, 509-522.
- Gottlieb, G. (1993). Social induction of malleability in ducklings: Sensory basis and psychological mechanism. *Animal Behaviour, 45*, 707-719.
- Gottlieb, G., & Klopfer, P. (1962). The relation of developmental age to auditory and visual imprinting. *Journal of Comparative and Physiological Psychology, 55*, 821-826.
- Gottlieb, G., & Simner, M. (1969). Auditory versus visual flicker in directing the approach response of domestic chicks. *Journal of Comparative and Physiological Psychology, 67*, 58-63.
- Graves, H. (1973). Early social behavior in Gallus: functional analysis. *Science, 182*, 937-938.
- Grier, J., Counter, S., & Shearer, W. (1967). Prenatal auditory imprinting in chickens. *Science, 155*, 1692-1693.
- Guiton, P. (1959a). Socialization and imprinting on the agonistic and courtship responses of the brown leghorn cock. *Animal Behaviour, 9*, 167-177.
- Guiton, P. (1959b). Socialization and imprinting in brown leghorn chicks. *Animal Behaviour, 7*, 26-34.

- Gvaryahu, G., Snapir, N., & Robinzon, B. (1988). Pecking: Another measurement for filial attachment in group-reared domestic fowl chicks. *Applied Animal Behaviour Science*, 21, 357-362.
- Harlow, H. (1958). The nature of love. *American Psychologist*, 13, 673-685.
- Harlow, H., & Zimmermann, R. (1958). The development of affectional responses in infant monkeys. *Processes of American Philosophy and Sociology*, 102, 501-509.
- Harris, J.R. (1998). *The nurture assumption: why children turn out the way they do*. New York: Free Press.
- Heaton, M., Miller, D., & Goodwin, D. (1978). Species-specific auditory discrimination in bobwhite quail neonates. *Developmental Psychobiology*, 11, 13-21.
- Heinz, G. (1973). Responses of ring necked pheasant chicks (*Phasianus colchicus*) to conspecific calls. *Animal Behavior*, 21, 1-9.
- Heim, J., & Bjerke, T. (1983). Skinner about imprinting: An audiovisual test. *Behaviour Analysis Letter*, 3, 231-239.
- Hess, E. (1957). Effects of meprobamate on imprinting in waterfowl. *Annals of the New York Academy of Sciences*, 67, 724-732.
- Hess, E. (1958). 'Imprinting' in animals. *Scientific American*, 198, 81-90.
- Hess, E. (1959a). Imprinting. *Science*, 130, 133-141.
- Hess, E. (1959b). The relationship between imprinting and motivation. In M.R. Jones (Ed.), *Nebraska Symposium on Motivation*. Lincoln, University of Nebraska Press.
- Hess, E. (1964). Imprinting in birds. *Science*, 146, 1128-1139.

- Hess, E. (1972). The natural history of imprinting. *Annals of the New York Academy of Sciences*, 193, 124-136.
- Hess, E. (1973). Imprinting: Early experience and the developmental psychobiology of attachment. New York: Van Nostrand.
- Hess, E., & Petrovich, S. (1973). The early development of parent young interaction in nature. In: J.R. Nesselroade & H.W. Reese (Eds), *Life span developmental psychology: Methodological issues*. New York: Academic Press.
- Hess, E., Polt, J., & Godwin, E. (1959). Effects of cariprodol on early experience in learning. In: J.G. Miller (Ed.), *The Pharmacology and Clinical uses of Carisoprodol*. Detroit: Wayne State University Press.
- Hoekman, S., Gabor, T., Maher, R., Murkin, H., & Armstrong, L. (2004). Factors affecting survival of mallard ducklings in southern Ontario. *The Condor*, 106: 485-495.
- Hoffman, H., Ratner, A., & Eiserer, L. (1972). Role of visual imprinting in the emergence of specific filial attachments in ducklings. *Journal of Comparative and Physiological Psychology*, 81, 399-409.
- Hoffman, H., & Solomon, M. (1974). An opponent process theory of motivation III. Some affective dynamics of imprinting. *Learning and Motivation*, 5, 149-164.
- Honey, R., & Bolhuis, J. (1997). Imprinting, conditioning and within event learning. *Quarterly Journal of Experimental Psychology: Comparative and Physiological Psychology*, 50B, 97-110.
- James, H. (1959). Flicker: an unconditioned stimulus for imprinting. *Canadian Journal of Psychology*, 13, 59-67.

- James, H. (1960a). Imprinting with visual flicker: evidence for a critical period.  
*Canadian Journal of Psychology, 14*, 13-20.
- James, H. (1960b). Social inhibition of domestic chicks responses to visual flicker.  
*Animal Behaviour, 8*, 197-200.
- Jaynes, J. (1956). Imprinting: The interaction of learned and innate behavior. I.  
Development and generalization. *Journal of Comparative and Physiological  
Psychology, 49*, 201-206.
- Jaynes, J. (1957). Imprinting: The interaction of learned and innate behavior: II. The  
critical period. *Journal of Comparative and Physiological Psychology, 50*, 6-10.
- Jaynes, J. (1958a). Imprinting: The interaction of learning and innate behavior: III.  
Practice effects on performance, retention and Fear. *Journal of Comparative and  
Physiological Psychology, 51*, 234-237.
- Jaynes, J. (1958b). Imprinting: The interaction of learning and innate behavior: IV.  
Generalisation and emergent discrimination. *Journal of Comparative and  
Physiological Psychology, 51*, 238-242.
- Johnston, T., & Gottlieb, G. (1981). Development of visual species identification in  
ducklings: What is the role of imprinting? *Animal Behaviour, 29*, 1082-1099.
- Johnston, T., & Gottlieb, G. (1985). Effects of Social experience on visually imprinted  
maternal preferences in peking ducklings. *Developmental Psychobiology, 18*,  
261-271.
- Jones, R., Facchin, L., & McCorquodale, C. (2002). Social dispersal by domestic chicks  
in a novel environment: Reassuring properties of a familiar odorant. *Animal  
Behaviour, 63*, 659-666.

- Klopfer, P. (1959). An analysis of learning in young Anatidae. *Ecology*, 40, 90-102.
- Krebs, J.R., & Davies, N.B. (1993). *An introduction to behavioural ecology*. (3<sup>rd</sup> ed),  
Oxford: Blackwell Scientific Publications.
- Levy, L., & Shapiro, L. J. (2003, April) *Preferences for live or inanimate stimulus objects in the chick (Gallus gallus domesticus)*. Paper presented at the meeting of the Psychology Undergraduate Research Conference, University of Winnipeg, Winnipeg, Manitoba.
- Lickliter, R., & Gottlieb, G. (1986a). Visually imprinted maternal preference in ducklings is redirected by social interaction with siblings. *Developmental Psychobiology*, 19, 265-277.
- Lickliter, R., & Gottlieb, G. (1986b). Training ducklings in broods interferes with maternal imprinting. *Developmental Psychology*, 19, 555-566.
- Lickliter, R., & Virkar, P. (1989). Intersensory functioning in bobwhite quail chicks: Early sensory dominance. *Developmental Psychobiology*, 22, 651-667.
- Lockard, R. B. (1968). The albino rat: A defensible choice or a bad habit? *American Psychologist*, 23, 734-742.
- Lorenz, K. (1957). *Companionship in bird life*. In C. H. Schiller (Ed. & Trans.), *Instinctive behaviour* (pp. 83-128). New York: International Universities Press. (Original work published 1935)
- Lorenz, K. (1970). Companions as factors in the bird's environment: The conspecific as the eliciting factor for social behaviour patterns. In K. Lorenz *Studies in Animal and human Behaviour, Vol. 1* (pp. 101-258). London: Methuen.

- Marx, G., Leppelt, J., & Ellendorf, F. (2001). Vocalization in chicks (Gallus gallus domesticus) during stepwise social isolation. *Applied Animal Behaviour Science* 75, 61-74.
- Mausser, D., & Jarvis, R. (1994). Mallard recruitment in northeastern California. *Journal of Wildlife Management*, 58: 565-570.
- Moltz, H. (1960). Imprinting: Empirical basis and theoretical significance. *Psychological Bulletin*, 57, 291-314.
- Moltz, H., & Rosenblum, L. (1958). Imprinting and associative learning: The stability of the following response in Peking ducks. *Journal of Comparative and Physiological Psychology*, 51, 580-583.
- Moriyana, T. (1987). Effects of pairing chicks during the imprinting period of filial responses to an imprinting stimulus. *The Annals of Animal Psychology*, 37, 81-98.
- Nice, A. (1953). Some experiences in imprinting ducklings. *Condor*, 55, 33-37.
- Palmer, R. (1976). *Handbook of North American birds: Volume 2: Waterfowl*. New Haven, CT: Yale University Press.
- Parker, J.G., & Gottman, J.M. (1989). Social and emotional development in a relational context: Friendship interactions from early childhood to adolescence. In T. Berndt & G. Ladd (Eds.), *Peer relationships in child development*. New York: Wiley.
- Petro, M., Capretta, P., & Cooper, A. (1978). Auditory discrimination learning in chicks after exposure to auditory and visual stimuli. *Bulletin of the Psychonomic Society*, 12, 385-386.

- Poersch, B., & Shapiro, L. J. (1987, April). *Preferences of white peking ducklings (Anas platyrhynchos) for conspecific age-mate or empty quadrants*. Paper presented at the meeting of the Psychology Undergraduate Research Conference, University of Winnipeg, Winnipeg, Manitoba.
- Porter, R., & Stettner, L. (1968). Visual and auditory influences on following responses of bobwhite quail (*Colinus virginianus*). *Journal of Comparative and Physiological Psychology*, 66, 808-811.
- Portmann A., & Stingelin, W. (1961). The central nervous system. In A. J. Marshall *Biology & Comparative Physiology of Birds, Vol 2*, p 1-36. New York, Academic Press.
- Rajecki, D. (1973). Imprinting in precocial birds: Interpretation, evidence and evaluation. *Psychological Bulletin*, 79, 48-58.
- Ramsay, A. (1951). Familial recognition in domestic birds. *Auk*, 68, 1-16.
- Ramsay, A., & Hess, E. (1954). A laboratory approach to the study of imprinting. *Wilson Bulletin*, 66, 196-206.
- Salzen, E., & Meyer, C. (1968). Reversibility of imprinting. *Journal of Comparative and Physiological Psychology*, 66, 269-275.
- Salzen, E., & Sluckin, W. (1959a). An experiment in imprinting domestic fowl. *Bulletin of the British Psychological Society*, 38, 35A-36A.
- Salzen E., & Sluckin, W. (1959b). The incidence of the following response and duration of responsiveness in domestic fowl. *Animal Behaviour*, 7, 172-179.
- Schiller, C. H. (1957). *Instinctive behaviour*. New York: International Universities Press.

- Scott, J. P. (1973). The organization of comparative psychology. *Annals of the New York Academy of Sciences*, 223, 7-40.
- Shapiro, L. J. (1968). Periodicity in imprinting's critical period. Unpublished Master's Thesis, Texas Christian University.
- Shapiro, L. J. (1970, August). *The development of preferences for live female models of the same species or for other species in the white peking duckling*. Paper presented at the meeting of the Animal Behavior Society, Bloomington, Indiana.
- Shapiro, L.J. (1971, June). *The effects of rearing conditions on reactions to maternal calls in white peking ducklings*. Paper presented at the meeting of the Animal Behavior Society, Logan, Utah.
- Shapiro, L.J. (1972, April). Imprinting: Another look at the Cheshire cat. Paper presented at the meeting of the Southern Society for Philosophy and Psychology, St Louis, Missouri.
- Shapiro, L.J. (1977). Developing preferences for live female models of the same or other species in White Peking ducklings. *Animal Behaviour*, 25, 849-858.
- Shapiro, L.J. (1980a). Evidence suggesting that domestic chicks should not be used in "imprinting" research: Variability in performance during "imprinting's" critical period. *Bulletin of the Psychonomic Society*, 16, 421-424.
- Shapiro, L.J. (1980b). Species identification in birds: A review and synthesis. In M.A. Roy (Ed.), *Species Identity and Attachment* (pp. 69-111). New York: Garland STPM Press.
- Shapiro, L.J., & Agnew R.L. (1975). The development of preferences for live models in White Peking ducklings. *Bulletin of the Psychonomic Society*, 5, 140-142.

- Shillito, H., Walser, E., Walters, E., & Hague, P. (1982). Vocal communication between ewes and their own and alien lambs. *Behaviour*, *81*, 140-151.
- Sigman, S.E., Lovern, D.R., & Schulman, A.H. (1978). Preferential approach to conspecifics as a function of different rearing conditions. *Animal Learning and Behavior*, *6*, 231-234.
- Skutch, A.F. (1976). *Parent Birds and their young*. Austin, Texas: University of Texas Press.
- Sluckin, W. (1972). *Imprinting and early learning* (Rev. ed.). London: Methuen & Co.
- Sluckin, W., & Salzen, E. (1961). Imprinting and perceptual learning. *Quarterly Journal of Experimental Psychology*, *13*, 65-77.
- Sluckin, W., & Taylor, K. (1964). Imprinting and short-term retention. *British Journal of Psychology*, *55*, 181-187.
- Smith, F. (1960). Towards a definition of the stimulus situation for the approach response of the domestic chick. *Animal Behaviour*, *8*, 197-200.
- Smith, F., & Bird, M. (1963). The relative attraction for the domestic chick of combinations of stimuli in different sensory modalities. *Animal Behaviour*, *11*, 300-305.
- Smith, F., & Hoyes, P. (1961). Properties of the visual stimuli for the approach response in the domestic chick. *Animal Behaviour*, *9*, 159-166.
- Spalding, D. (1954). *Instinct*. With the original observations on young animals. Macmillian's Magazine, 1873, 27, 282-293. (Reprinted from *British Journal of Animal Behaviour*, 2, 2-11)

- Storey, A. (1976). The effects of live or inanimate models on the development of preferences in white peking ducklings. Unpublished Master's Thesis, University of Manitoba.
- Storey, A., & Shapiro, L. J. (1972, March). *Preferences of white peking ducklings for live or inanimate models*. Paper presented at the meeting of the Southern Society for Philosophy and Psychology, St. Louis Missouri.
- Storey, A., & Shapiro, L. J. (1979). Development of preferences in white peking ducklings for stimuli in the natural post-hatch environment. *Animal Behaviour*, 27, 411-416.
- Taylor, K., & Sluckin, W. (1964). Flocking of domestic chicks. *Nature*, 201, 108-109.
- Todd, F. (1996). *Natural history of the waterfowl*. Vista, California: Ibis Publishing Co.
- van Kampen, H., & Bolhuis, J. (1991). Auditory learning and filial imprinting in the chick. *Behaviour*, 117, 303-319.
- van Kampen, H., de Haan, J., & de Vos, G. (1994). Potentiation in learning about the visual features of an imprinting stimulus. *Animal Behaviour*, 47, 1468-1470.
- Watt, G. (1951). *The Farne Islands: Their history and wildlife*. London: Country Life.
- Waunters, A., & Richard-Yris, M. (2002). Mutual influence of the maternal hen's food calling and feeding behaviour on the behaviour of chicks. *Developmental psychobiology*, 41, 25-36.
- Weidmann, U. (1956). Some experiments on the following and flocking reaction of mallard ducklings. *British Journal of Animal Behaviour*, 4, 78-79.
- Wereha, T., & Shapiro, L.J. (2003, April). *The effect of brood size on eliciting an approach response in chicks (Gallus gallus domesticus)*. Paper presented at the

Meeting of the Prairie Undergraduate Research Conference, University of  
Winnipeg, Winnipeg, Manitoba.

Wereha, T., & Shapiro, L.J. (2004, April). *The effect of brood size on eliciting an  
approach response in chicks (Gallus gallus domesticus): Effects of time of day.*

Paper presented at the meeting of the Southern Society for Philosophy and  
Psychology, New Orleans, Louisiana.

White, N, & del-Rio-Pesado, M. (1983). Effects of visual and auditory stimuli on  
following in chicks. *Bird Behavior*, 4, 82-85.

**APPENDIX A**

**From: "Shaw, Rebecca" <XXXXXXXXXXXXXX>**

**To: "Laura Beaudoin"**

**Subject: RE: publication date of APA manual 1st Ed.**

**Date: Wednesday, April 06, 2005 8:34 AM**

**Dear Ms. Beaudoin,**

**Thank you for contacting APA Books. The first edition of the Publication Manual was released in 1953. First published as six pages of guidelines in The Psychological Bulletin in 1929, the manual was printed as a separate publication (considered the "First Edition") in 1953. For more information on the history and the future of the Publication Manual, please visit this link to an article in the APA Monitor:**

**<http://www.apa.org/monitor/sep01/pubmanual.html>.**

**Thank you.**

**Regards,**

**Rebecca Shaw**

**Editorial Assistant, APA Books**

-----Original Message-----

**From:** Laura Beaudoin

**Sent:** Monday, April 04, 2005 10:11 AM

**To:** Books

**Subject:** publication date of APA manual 1st Ed.

Hello,

I am writing a paper that deals with readability of psychological articles prior to the formation of the APA. Could you please email me the year that the first publication manual was released by the APA?

Thank you,

Laura Beaudoin

XXXXXXXXXXXXXXXXXXXXXXXXXX