CAPTIVE PROPAGATION AND BROOD BEHAVIOR OF GREATER PRAIRIE CHICKENS

A Thesis

by

DAVID DRAKE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 1994

Major Subject: Wildlife and Fisheries Sciences

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May 1994

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ABSTRACT

Captive Propagation and Brood Behavior of

Greater Prairie Chickens. (May 1994)

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Chair of Advisory Committee: Dr. Nova J. Silvy

The Attwater's prairie chicken (Tympanuchus cupido attwateri) is an endangered prairie chicken indigenous to the gulf coastal prairies of Texas. Currently, there are less than 500 individuals in 3 populations that are expected to be extinct by the year 2000.

Using non-endangered greater prairie chickens (T. c. pinnatus) as surrogates, objectives of my research were: (1) to develop propagation techniques that would retain the "wild" behavior in pen-reared greater prairie chickens; and, (2) to describe brood behavior in pen-reared greater prairie chickens to determine which propagation technique was the most successful in retaining "wild" behavior. The long-term goal for the pen-reared greater prairie chickens and, ultimately, the Attwater's, is to reintroduce the birds to their natural habitat. Thus, the purpose in retaining the "wild" behavior is to facilitate reintroduction to the wild.

I studied 4 captive propagation methods. A control group consisting of 8, day-old greater prairie chickens was placed with and reared by a domestic bantam hen. Treatment groups included: (1) hand-rearing 12 greater prairie chicken young; (2) introducing 3, day-old greater prairie chickens to 2, week-old domestic bantam chicks that were used as trainers; and, (3) letting a greater prairie chicken hen incubate and rear her own clutch of 3.

The behavior of the 3 chicks reared by the greater prairie chicken hen differed

statistically ($P < 0.05$) from the other groups only during the evening observation period of week 1. A statistical difference ($P < 0.05$) was noted in the brooding behavior for the 2 groups of chicks reared without a hen, most notably in that they brooded about one-half less during the first week than the broods with a hen. There was no difference ($P > 0.05$) between any of the groups in the consumption of insects, underscoring the importance of insects in the diet of young prairie chickens at least through the fourth week of life.

The behavior of all young after 7-10 weeks did not differ ($P > 0.05$) from wild-caught adult greater prairie chickens. The most important behavior for reintroduction purposes that I was unable to quantify was predator avoidance.

From my research concerning captive propagation of greater prairie chickens, I recommend that Attwater's prairie chickens be reared indoors by disease-free domestic bantam hens during the first week of life. Hand-rearing should continue until chicks are placed in outdoor pens at approximately 4-5 weeks of age.

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INTRODUCTION

The Attwater's prairie chicken (Tympanuchus cupido attwateri) historically numbered approximately 1 million and occupied an estimated 2.4 million ha of gulf coastal prairie from southwestern Louisiana to Cameron County at the southern tip of Texas (Lehmann 1941). When the first official census was conducted in 1937, the species had become extinct in southwest Louisiana, and its range in Texas had been reduced to a little over 182,000 ha supporting 8,700 birds (Lehmann 1941). The Attwater's prairie chicken was listed as endangered in 1967, and by that time, the population had dwindled to 1,070 with about 94,700 ha of suitable habitat (Jurries 1979, U. S. Fish and Wildlife Service 1992). By 1992, range degradation, agriculture, and urban expansion were primarily responsible for limiting suitable habitat to 80,130 ha for 456 individuals in 3 isolated populations (U. S. Fish and Wildlife Service 1992). Should the downward population trend continue, the Attwater's prairie chicken is projected to go extinct by the year 2000 (U. S. Fish and Wildlife Service 1992).

While much has been written about grouse in general (Johnsgard 1983, Atwater and Schnell 1989), relatively few studies have focused solely on prairie chickens. Studies detailing the life history of wild Attwater's prairie chickens were authored by Lehmann (1941) and Jurries (1979). A number of researchers have attempted, with varying degrees of success, to breed, rear, and maintain Attwater's, greater, and lesser prairie chickens (T. c. pallidicinctus) in captivity. Kubena et al. (Unpubl. data 1969) studied nutritional requirements for maximum reproduction and hatchability of fertile eggs of captive Attwater's prairie chickens, while Creger and Irby (Unpubl. data 1971) and Watkins (1971) researched in-season and out-of-season egg production with the same

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species. In addition, Creger and Irby (Unpubl. data 1971) also identified incubation parameters for field collected eggs, and explored the nutritional requirements needed to raise day-old Attwater's to maturity. The most recent study concerning the captive propagation of Attwater's prairie chickens occurred at Fossil Rim Wildlife Center in Glen Rose, Texas (Unpubl. data 1993). Handley (1935), McEwen et al. (1969), Kruse (Unpubl. data 1972, 1984), and Kruse and Lee (Unpubl. data 1973) developed methods for breeding and rearing captive greater prairie chickens, and Coats (1955) developed similar captive propagation techniques using lesser prairie chickens.

One solution to extinction of the Attwater's prairie chicken is to institute a research program focusing on captive propagation. Using a sister subspecies, the greater prairie chicken (T. c. pinnatus), as surrogates due to the endangered status of the Attwater's prairie chicken, the immediate objectives of my research were: (1) to develop propagation techniques that would retain the "wild" behavior in pen-reared greater prairie chickens, and (2) to describe brood behavior in pen-reared greater prairie chickens. The long-term goal is to reintroduce captive-reared Attwater's prairie chickens and, ultimately, restore the wild population to pre-endangered numbers. Due to the endangered status of the Attwater's, reintroduction strategies will first be attempted with captive-reared greater prairie chickens. Thus, the purpose in retaining the "wild" behavior is to facilitate reintroduction to the wild. Determining which propagation method was the most successful in retaining "wild" behavior was accomplished through the quantification of Objective 2.

METHODS

I conducted research at the Small Upland-bird Research Facility (SURF), located on George Bush Drive 0.6 km west of Wellborn Road in College Station, Texas. The SURF consists of 4 triangular pens each measuring 416 m^2, 2 adjacent square pens each measuring 832 m^2, and 4 indoor-brood pens each measuring 32 m^2.

My research subjects were 9 adult greater prairie chickens and their progeny. Of the 9 adult birds, 1 male and 1 female were captive-reared and acquired from Cliff Steinhower of Thief River Falls, Minnesota. I caught the remaining 7 birds (1 male, 6 females) using drop-nets in the Flint Hills of southeastern Kansas. Seven of these birds were adults and 2 were juveniles when brought to the SURF during spring 1992.

I studied 4 specific captive propagation methods. Three of these methods involved removing eggs from individual nests and incubating the eggs in a Petersime forced-air incubator located at Texas A&M University's Poultry Science farm. The control group consisted of 8, day-old greater prairie chickens that were placed with and reared by a domestic bantam hen. The treatment groups included: (1) hand-rearing 12 greater prairie chicken young; (2) introducing 3, day-old greater prairie chickens to 2, week-old domestic chicks that were used as trainers; and, (3) a greater prairie chicken hen who incubated and reared her own clutch of 3. The only group not housed in an indoor-brood pen was the greater hen and her clutch, who were isolated in an outdoor pen within the SURF. In addition, the domestic bantam hen and chicks were used for the purpose of "training" the prairie chicken young to eat commercial feed. Coats (1955) reported that the most challenging problem in rearing prairie chickens in captivity hinged upon feeding the young because they did not readily eat commercial chick starter.

Prairie chicken hens will renest in a different location from the original nest site if the first nest is destroyed (Lehmann 1941). I did not want to disrupt the laying schedule of

hens by removing all eggs from an individual nest and risk hens moving their nests. To ensure that hens returned to their original nest site, eggs were allowed to accumulate in a nest for 1 week. Newly deposited eggs in each nest were marked chronologically, and at the end of 1 week, the first 3-4 eggs layed earlier in the week were collected from each nest and immediately set in the Petersime incubator. The dry-bulb temperature in the incubator was maintained at 38 C with the wet-bulb reading 28-30 C, as recommended by Watkins (1971). The incubator was equipped with automatic rotating trays that turned the eggs every 90 min. All artificially incubated eggs were candled and weighed prior to incubation and every week thereafter until they hatched. A chart was kept on each egg to follow weekly weight loss. Once the chicks had broken into the air cell of the egg, they were transferred to a non-rotating hatcher set at 36 C with a wet-bulb reading of 31-33 C (McEwen et al. 1969). After hatching, the chicks were moved to an upper tray within the same hatcher and placed in a cloth "nest", where they remained for 24-36 hours to dry.

When completely dry, the chicks were brought to the SURF, placed in either the control group or 1 of the treatment groups, and then each group was housed in a separate pen. Although each brooder pen measured 4 x 2.3 m, chicks were restricted to an area measuring 1.3 m^2 during their first week. The smaller area forced them to remain near the heat source, be it the 75 watt reflector lamp or the domestic hen. Each pen was supplied with at least 1 water container and 1 feed pan. Marbles were placed in the trough of the water container through the end of the chick's second week, and served 2 purposes. First, the multi-colored marbles drew the chick's attention to the water, and second, the marbles filled in the water trough which prevented the chicks from getting stuck in the water and drowning. White, short-napped towels were layed on the floor of the 1.3 m^2 area to provide a non-slip surface for the chicks and to provide a contrasting

background color, making it easier for the chicks to locate insects. At the beginning of the second week, the chicks' restricted space was increased to 2.6 x 1.3 m and the towels were replaced with sand. Chicks were given access to the entire 4 x 2.3-m area by the middle of their third week. By this time, chicks were sufficiently large and mobile enough to move around freely, and while they still depended on the heat source, it was not as vital as when they were younger. Old sand was replaced with fresh sand once a week to control fecal load, and water and food containers were cleaned and refilled daily. Chicks remained inside until the sixth week, when they were transferred to the 416 m^2 triangular pens outside.

Chicks were provided a 28% protein turkey starter diet (Appendix 1) ad libitum through 6 weeks of age. The turkey starter was supplemented with whole and crumbled hard-boiled egg yolk, a variety of insects, mealworms, shredded lettuce, Bermuda grass (Cynodon sp.) and Johnson grass (Sorghum sp.). From 7-12 weeks of age, chicks were fed a 23% protein turkey developer (Appendix 2) ad libitum, and after week 12 were given an 18% protein turkey grower (Appendix 3) ad libitum. Since chicks were put into outdoor pens after 6 weeks of age, they also had dietary supplements such as vegetation and insects.

The greater prairie chicken and her 3 chicks were housed in isolation from the rest of the adults in an outdoor pen measuring 832 m^2. Unlike the groups housed indoors, no part of the outdoor pen was sectioned off. A water container with marbles was provided, as was a feed tray. Chicks in this group were provided the same commercial feeds as the chicks housed indoors.

The control group and the treatment groups were isolated to facilitate observing brood behavior. Since prairie chickens are most active before 1000 hours and after 1600 hours (Lehmann 1941), observations occurred from 0630-0930 hours and from 1630-

1930 hours. Behavioral observations on randomly chosen chicks were recorded for 5 consecutive min out of each 15 min for every given observational period. Brood behavior was recorded at 20-sec intervals during each 5-min period, and the action performed at each interval was noted on a daily behavioral chart.

I observed and recorded brood behavior associated with feeding, pecking, drinking, brooding, roosting, resting, grooming, dust bathing, locomoting, flight, aggression, and sexual activity. Brood behaviors were defined as follows: feeding behavior was defined as the actual ingestion of food, and when possible, the choice of diet was noted (i.e. insects, vegetation, or commercial feed). If the observed chick was picking at a food source without ingesting it, or pecking at the ground, the action was recorded as pecking. Drinking behavior was defined as the actual ingestion of water, and when applicable, the source of water was noted (i.e. water from container, or vegetation). A chick was considered to be brooding if it was laying down on its stomach - obscuring it's feet from view - and directly under or immediately adjacent to a heat source. For the experimental groups that were raised without a hen, the 75 watt reflector lamp was considered the hen. If the observed chick was laying down - again obscuring it's feet from view - but away from a heat source, the behavior was recorded as roosting. A chick was termed resting if standing and it's legs were motionless, whereas locomoting was defined as the chick either running or walking. If the observed chick's feet were off the ground and it's wings were flapping, that behavior was recorded as flight. Maintenance behaviors such as scratching and preening were termed grooming, while dust bathing was recorded as the chick laying prone and throwing sand or dirt upon itself with either it's feet, beak, or wings. Behaviors that qualified as aggressive included 1 chick pecking at or chasing another chick. And finally, sexual activity was recorded. Sexual activity was defined according to booming, mounting, and performing nuptial bows. Booming entailed foot

stomping, attempts at air sac inflation, wings drooping and away from the body, and/or erect pinnae. Mounting was recorded if the observed chick placed at least 1 foot on the back of a second bird, and a nuptial bow was recorded when a bird lay prone to the ground with it's wings outspread. I observed and recorded behavior of the separate brood groups each day from 4 June-28 August 1993.

Specific behavioral categories were grouped for analysis. For example, brooding, resting, and roosting behaviors were combined under a heading of resting. Likewise, consumption of insects, vegetation, or commercial chick starter by chicks was combined to form the category feeding. Aside from the 2 categories just described, additional behavior categories included locomotion, grooming, and "other", which contained any behavior that did not fall into the aforementioned headings. "Other" behaviors included drinking, dust bathing, sexual activities such as booming and mounting, aggression, pecking, and flight. For every 5-min observation period, treating morning and evening observation periods separately, I counted the number of times a behavior was observed and noted the total under the appropriate behavior heading for each group. I then assigned ranks to each observation total and calculated a weekly rank total per group. I used the Kruskal-Wallis 1-way analysis of variance statistical test (Siegel 1956) to determine if there were differences in the behavioral categories among the brood groups. If a significant difference was found, a Kruskal-Wallis multiple comparisons test (Conover 1980) was used to determine which brood groups differed.

RESULTS AND DISCUSSION

Adult Mortality

In April 1992, 15 greater prairie chickens (5 males, 10 females) were trapped, using drop nets, on 3 separate leks in the Flint Hills of southeastern Kansas. These birds were transported in an air conditioned car, within a 24-hour period after capture, to the SURF at Texas A&M University. The previous year, greater prairie chickens were trapped in Kansas and transported to the SURF via same-day air. Delays in the air transport resulted in the birds overheating, causing most of the birds to arrive dead or seriously ill. By keeping the birds in a temperature controlled automobile and transporting within a 24-hour period after capture, all 15 of the trapped birds arrived in good health. Three additional captive-reared greater prairie chickens (2 males, 1 female) were acquired by over-night airmail from a breeder in Minnesota.

Seven of the 15 Kansas birds were placed in a pen that was sparsely vegetated, and the remaining 8 birds were housed in an adjacent pen that was heavily vegetated. The 3 birds from Minnesota were placed in a third pen that also was heavily vegetated. Each pen contained a water container and 2 trays of crumbled commercial game bird feed. Within 10-14 days upon arrival at the SURF, 6 of the wild-caught birds in the heavily vegetated pen died. One to 2 days prior to their death, it was observed that they had become emaciated and were having difficulty walking due to their weakened condition. Necropsy results revealed that the birds died from an impacted gut.

Only the wild-caught birds in the heavily vegetated pen died from impaction. Rather than sustaining themselves on the commercial game bird feed that was provided, these birds remained in the cover of the overgrown grass and ate available vegetation. Bermuda and Johnson grasses in the pens appeared to be more mature and fibrous than those found on the prairies of Kansas. At the time birds were trapped, Kansas prairies

had not begun to green up. Moreover, some prairies were burned, leaving little or no vegetation. In contrast, the growing season had started in Texas, so when birds were put into the SURF, all grasses were green and readily eaten by certain birds. The birds that ate coarse vegetation at the SURF were unable to digest it, thus becoming impacted. The 7 wild-caught birds in the sparsely-vegetated pen did not have dense vegetation for cover or food and were forced to eat the game bird feed provided, avoiding impaction problems. Likewise, the captive-reared birds did not become impacted even though they too were housed in a heavily vegetated pen. Rather than feeding on vegetation, the Minnesota birds ate the commercial feed, a diet they were raised on and accustomed to.

To prevent further impaction problems and to encourage the birds to eat the commercial game bird feed, pens were mowed on a regular basis. A variety of shrubs were planted for cover in lieu of tall grass, including yopans (Ilex sp.), nandinas (Nandina sp.), arborvitae (Platycladus sp.), and junipers (Juniperus sp.). Once all birds were consistently eating the commercial feed, clumps of unmowed grass were interspersed in the mowed areas for extra cover and nesting habitat.

Three additional birds died later in the spring of 1992. The deaths of 2 subordinate males (1 captive-reared and 1 wild-caught) seemed to be indirectly related to territorial and breeding competition, and the third death was related to capillaria (Capillaria sp.). Breeding competition was reduced to a nominal level by either housing a single male per pen or, if housing multiple males per pen, allowing for adequate escape space. Instead of having access to only 1 pen, doors have been added so that adjacent pens are accessible, adding escape areas. Capillaria, and subsequently, coccidia (Eimeria sp.), were treated/prevented with feed additives. Capillaria is treated with nitarsone and coccidia is treated with phenbendazole.

Another problem that posed a health threat the first spring birds were in captivity was

lice (Mallophaga) build-up. Lice were thick around the eyes, head, and neck of the birds, causing weight loss and impaired vision in some instances. Lice build-up was remedied within a week after placing dust boxes in each pen. A mixture of approximately 80% fine sand and 20% Sevin dust placed in dust boxes was adequate to rid birds of any ectoparasites.

Breeding

Although the breeding season was disrupted for all greater prairie chickens brought into the SURF during spring 1992, certain mating displays were observed. Males had developed their full breeding coloration by the time they were acquired, and sporadic booming was seen. Seventeen eggs were layed that spring, albeit infertile. Fourteen of the 17 eggs were layed in a nest bowl, with the remaining 3 eggs layed as dump eggs. No booming was witnessed during fall 1992.

In spring 1993, nine (2 males, 7 females) of the original 18 birds had survived the year and were divided into 2 groups. One group consisted of the Minnesota acquired male and female, and 2 of the Kansas-caught females. The second group contained the Kansas-caught male and 4 Kansas-caught females. Each group had access to 2 pens, and the 2 groups were separated by a mesh fence that allowed for visual contact. The diet of the birds was changed in the middle of February 1993, from an 18% protein turkey grower (Appendix 3) to a 20% protein turkey breeder (Appendix 4). Furthermore, oyster shell grit was provided ad libitum to increase the females' calcium supply for stronger egg shells.

On 11 March 1993, the first signs of sexual activity were noticed. The Kansas male approached a female and displayed toward her by erecting his pinnae, and exactly 1 week later, both the Kansas and Minnesota males began to boom. At the time of first booming,

neither male had developed the characteristic bright yellow air-sac or yellow patches above the eye, but both males did show a pinkish-red air-sac.

In the wild, greater prairie chickens gather in the spring and perform a group display on a mating area, with an average of 7-9 males visiting 1 booming ground (Robel 1966). Since a concern was the lack of competition with only 2 males, I broadcast a taped recording of booming prairie chickens every morning to stimulate the males. The 45-min tape began approximately 20 min before sunrise and continued to the end of the tape.

Although both males began booming on the same day, the intensity of the booming throughout the breeding season was not equal. By 5 April, the male from Kansas had developed a bright yellow air-sac, even though the eye patches were not evident for another 10 days. The male from Minnesota did not fully develop the bright yellow air-sac until 3 May, and he never developed the yellow patches above the eye. The Kansas male added foot stomping and the erecting of his pinnae with the booming on 8 April, whereas the Minnesota male did not stomp and erect his pinnae while booming until 16 April. The intensity and frequency of the booming and displaying by the Kansas male increased up to 24 April, when he boomed and displayed, non-stop, the entire morning. This intensity continued through the end of May, at which time the frequency began decreasing until the booming and displaying ceased altogether on 10 June. In contrast, the male from Minnesota did not match the displaying and booming of the Kansas male until 3 May, and then the intensity and frequency was short-lived, waning about 2 weeks later and completely ending 24 May.

Six of the 7 hens established nests and layed a combined total 79 eggs between 21 April and 9 June 1993 (Table 1). The first egg was layed by green-band #82 on 21 April. Her nest, designated as nest A, was completed on 9 May with a clutch of 17 eggs. Because she had such a large clutch and her's was the first nest of the year, green-band

Table 1. Greater prairie chicken nest chronology and clutch size at the SURF during spring 1993.

Nest	Hen	Date started	Date completed	Clutch size
A	Green-band #82	21 April	9 May	17
B	Green-band #76	9 May	23 May	12
C	Green-band #80 Blue-band #99	9 May	29 May	18
D	Green-band #78	10 May	25 May	11
E	Copper-band #200	26 May	9 June	11

#82 was selected as the hen who would incubate and rear her own clutch. Green-band #82 began incubation on 6 May, and on 15 May, 10 eggs were removed and placed in the artificial incubator. The 10 eggs were removed to prevent the loss of all 17 eggs should the nest be destroyed for any reason. Following the removal of the 10 eggs, the hen resumed incubating her clutch.

As nest A was beginning the incubation period, 3 additional nests were being established. Nest B was established by green-band #76 on 9 May and was completed on 23 May with a clutch of 12 eggs. Two hens (blue-band #99 and green-band #80) shared a nest designated as nest C. This nest was started on 9 May as well and had a total of 18 eggs when it was completed on 29 May. It was determined that nest C was being used by 2 separate hens because at times 2 eggs were layed on the same day, and there were noticeable weight discrepancies between the eggs. On 10 May, nest D was started by green-band #78, and she finished laying her clutch of 11 eggs on 25 May. The last nest,

nest E, was not started until 26 May. The female from Minnesota (copper-band #200) laid 11 eggs in nest E and completed her clutch on 9 June. Aside from the 5 nests described, 10 dump eggs were found scattered throughout the SURF pens.

All eggs layed in nests B, C, D, and E were collected and set in the artificial incubator. Originally, I collected eggs daily and set wooden eggs similar in shape and size to prairie chicken eggs in the nests. Dummy eggs were placed in nests to ensure that hens would continue to use their original nest site as opposed to moving the nest. After setting the dummy eggs in the nests, I discovered the following day that the wooden eggs had been rolled out of the nests, and in 1 instance, a nest had been moved. The wooden eggs were returned to the nests, but the result was the same as the previous day and the wooden-egg method was abandoned. Infertile greater prairie chicken eggs also were tried as dummy eggs in a separate nest, and again, the same result as with the wooden eggs. I decided to let the eggs in each nest accumulate for a week and at the end of every 7-day period, remove the first 3-4 eggs. This proved to be the most successful method because it guaranteed that each nest would always contain at least 3 eggs layed by the hen on that specific nest.

I weighed and candled each collected egg prior to incubation and every week thereafter to chart the development of the embryo. After 1 week of artificial incubation, I discovered that the eggs in nests B and D were infertile. Green-bands #76 and #78, the hens who established nests B and D, respectively, and the female from Minnesota, were paired with the male from Minnesota. The infertile eggs were either due to the Minnesota male being sterile, or never having bred the 2 egg-laying females. Because of the infertility problems, the 9 adults were given access to each other rather than continuing to keep them segregated. Since the eggs in nests A and C were fertile, and those nests were established by 3 of the 4 hens paired with the Kansas male, it was

known that the Kansas male was capable of successfully breeding hens. Therefore, by combining birds it was possible that hens with the Minnesota male would be successfully bred by the Kansas male and re-nest. Even though green-band hens #76 and #78 did not re-nest, the Minnesota female, originally with the Minnesota male, was bred by the male from Kansas and established the nest designated as nest E.

Sixty-seven percent (53 of 79 eggs) of all the eggs layed in the spring of 1993 were fertile (Table 2). Subtracting the 23 infertile eggs layed from nests B and D, however, significantly raises the fertility percentage to 95% (53 of 56 eggs). Twenty-six eggs hatched, resulting in 33% (26 of 79 eggs) of all eggs hatching, or 46% (26 of 56 eggs) not including nests B and D. Of the 26 chicks that hatched, 14 survived to adulthood, equaling a 54% survival rate.

A number of researchers have noted that nests established later in the reproductive season have lower clutch sizes and a lower hatching percentage. The average greater prairie chicken clutch size in the wild is 12, and hatch success under natural conditions ranges from 46-50% (Johnsgard 1983). Ballard and Robel (1974) found that greater prairie chicken nests in the wild initiated after 5 May had lower clutch sizes (10.2 vs. 12.1 eggs) and a lower probability of successful hatching (10% vs. 44%). Svedarsky (1988) noticed that greater prairie chicken clutch sizes in Minnesota decreased after 1 May, and Robel (1970) found a similar inverse relationship in Kansas greater prairie chickens for both clutch size and hatching success compared to time of year.

The clutch size of hens at the SURF decreased for nests established after 1 May, and overall, the hatching success was low compared to other captive prairie chicken studies. The only nest established prior to 1 May was nest A, belonging to green-band #82. Her nest had a clutch size of 17 eggs, compared to clutches of 12 or less eggs for the nests

initiated after 1 May. The hatching percentage (33%) in my study is low compared to 52.6% in the McEwen et al. (1969) study in Colorado and 55% in Kruse's (Unpubl. data 1976) study which occurred in North Dakota. Kruse and Lee (Unpubl. data 1975) also

Table 2. Number of eggs per greater prairie chicken nest, number of fertile eggs, number of eggs that hatched, and number of surviving chicks at the SURF during spring 1993.

Nest	Number of eggs	Number of fertile eggs	Number of hatched eggs	Number of surv. chicks
A	17	17	9	1
B	12	0	0	0
C	18	18	11	8
D	11	0	0	0
E	11	11	6	5
Dump eggs	10	7	0	0
Total	79	53	26	14

recorded a low hatch of 39.2%, but the hens in their North Dakota study layed late in the spring, with the last egg being layed on 30 June.

The fact that only 1 of 5 nests were started before 1 May and the hatching percentage in my study was low may be attributable to photoperiod. The length of daylight is the factor most responsible for triggering the reproductive cycle in birds (Follett et al. 1985). Svedarsky (1988) observed greater prairie chicken males to begin booming around 15 March, and the peak-nesting period for hens in Minnesota to last from the middle to end

of April. A second, smaller peak indicating renesting hens occured from approximately the middle to end of May. Robel (1970) witnessed a similar scenario with greater prairie chickens in Kansas. The amount of daylight, from sunrise to sunset, during the middle of March in both Kansas (Kansas State Climatology Office pers. commun. 1993) and Minnesota (Minnesota State Climatology Office pers. commun. 1993) is about 12 hours, and about 13.5 hours in the middle of April. By the end of April, daylight has increased to about 14 hours in both states. There are a little more than 15 hours of daylight in Minnesota in the middle of May, and this increases to almost 16 hours by the end of May. In Kansas, slightly more than 14 hours of daylight are seen in the middle of May, increasing to 14.5 hours by the end of the month.

Both the captive-reared Minnesota male and the wild-caught Kansas male began to boom in the middle of March. Like the states of Minnesota and Kansas, there were about 12 hours of daylight at the SURF. As spring progressed, however, the contrasts in daylight hours between Minnesota, Kansas, and the SURF became more apparent (Table 3). The locations of Wichita, Kansas and Crookston, Minnesota were selected because they were the 2 weather stations nearest the area of natural habitat of the birds brought to the SURF. The first nest at the SURF, nest A, was started on 21 April, but the nesting peak did not occur until 9-10 May, at which time 3 of the 5 nests were initiated. On 21 April, College Station received just over 13 hours of daylight, and approximately 13.5 hours by 9 May (Texas State Climatology Office pers. commun. 1993). The height of nesting at the SURF took place when the second peak, or renesting, occurred in Minnesota and Kansas. The last hen to nest was the captive-reared hen from Minnesota. She started nesting 26 May, at which time there was about 14 hours of daylight.

If the photoperiod is the most important stimulator, there was enough daylight to stimulate the 2 captive males to begin booming at about the same time of the year as if

they were in their natural area. However, as spring progressed, the length of day increased at a greater rate in the more northern latitudes than in College Station. The lack of sufficient daylight until later in the spring may have caused a delay in the nesting of all hens at the SURF, resulting in smaller clutch sizes. In addition to smaller clutch

Table 3. Total daylight hours in College Station, Texas, Wichita, Kansas, and Crookston, Minnesota during the 1993 greater prairie chicken breeding season.

College Station, TX		Wichita, KA		Crookston, MN	
Date	Total daylight hours min	Date	Total daylight hours min	Date	Total daylight hours min
18 Mar (beg. booming)	12 04	15 Mar (beg. booming)	11 53	15 Mar (beg. booming)	11 45
21 Apr (first egg layed)	13 05	15 Apr (nesting peak)	13 10	15 Apr (nesting peak)	13 40
9 May (nesting peak)	13 34	15 May (renesting peak)	14 12	15 May (renesting peak)	15 10

sizes, hatch rates also were lower due to apparent pre-incubation of eggs prior to being set in the incubator. By the time most hens at the SURF layed, ambient temperatures were sufficient to begin incubating eggs while in the nest. This will be discussed in more detail in the section titled chick mortality. The wild-caught Kansas male did not come into full breeding coloration until 15 April. Because of this, the breeding of and subsequent nesting by the wild-caught Kansas hens was delayed by almost 1 month from the peak of nesting in Kansas. Likewise, the captive-reared Minnesota male never did come into full breeding coloration in spring 1993. The captive-reared Minnesota hen was

finally bred by the Kansas male and initiated her nest about 1 month after the peak nesting time in Minnesota. The peak nesting period of the hens in my study corresponded with the renesting period in Minnesota and Kansas. Assuming the delayed nesting peak in my study resulted in smaller clutch sizes and lower hatch rates, the obvious solution is to begin the reproductive cycle earlier in the spring. Artificial lighting would provide the greater prairie chickens from the more northern latitudes ample amounts of daylight in order to stimulate the birds to boom, breed, and nest earlier in the spring.

Chick Mortality

Eggs removed from nest A and set in the artificial incubator were the first eggs of the spring to hatch. Six of the 10 eggs set in the incubator hatched 3 June, and on 4 June, 3 of the 7 eggs left in nest A for the hen to incubate hatched. The group of 6 chicks were transferred to the indoor brood pens at the SURF and served as 1 of the 2 experimental groups that were hand-reared. Three of the chicks, however, were afflicted with physical disabilities. Two chicks suffered from spradle leg and 1 chick suffered from a curvature of the spine. I observed the chicks that appeared to be spradled moving excessively inside the hatcher during the first 24-36 hours after hatching. Excessive movement may not have allowed the birds' joints and bones to set, thus causing the birds legs to spread outward rather than remaining directly under their bodies. As for the chick with the curvature of the spine, it was the first chick to pip but the last to actually hatch, nearly 72 hours later. Had I not helped the chick out of the egg, I doubt that it would have lived. The delayed hatching caused the chick to remain in a curled position within the egg, causing its bones to cure which resulted in the curved vertebrate. Despite intensive care, the 3 afflicted chicks were euthanized at 14 days of age because they were having extreme difficulty surviving.

Two of the remaining 3 chicks later died of blackhead (Histomonas sp.) disease, 1 at 42 days of age and the other at 56 days of age. None of the other prairie chickens, young or old, fell ill to the disease since they were subsequently treated for blackhead by administering 6 g of the drug Metronidazole per 3.8 L of water for a 1-week period. By the end of the eighth week, only 1 prairie chicken young remained of the original 6 in the first hand-reared group.

Another treatment group consisted of 3 chicks that hatched under the hen sitting on nest A. Following hatching, the hen continued to sit on the chicks for about 1.5 days, forcing the chicks to remain immobile. The immobility appeared to allow their bones and joints to properly strengthen since none of the chicks in this group experienced the physical problems the 3 chicks in the hand-reared group experienced. By the end of the first week, however, the chicks with the greater hen had died from starvation.

Eight greater prairie chicken chicks were placed with a domestic bantam hen to serve as the control group. Two of these chicks, however, died within the first week from exposure. Due to a staggered hatch, 2 chicks were introduced to the bantam hen over a 2-day period, and then 6 more were introduced 3 days later over another 2-day period. Introducing the chicks over a wide range of time posed a problem since the older chicks had depleted their yolk sac and were actively searching for food while the younger chicks were attempting to brood under the hen. Rather than sitting still so the younger chicks could brood beneath her for warmth, the hen was moving around the brood pen looking after the more active chicks. The problem was further complicated since 1 of the chicks that died suffered from spradle leg and had it's legs hobbled in an attempt to correct the spradle condition.

A third treatment group involved pairing 2, week-old domestic bantam chicks with 3, day-old greater prairie chicken chicks to determine if the older domestic chicks would

"train" the prairie chicken chicks to eat commercial feed. One of the 3 prairie chicken chicks died at the age of 9 days from a bacterial infection in the throat. The infection was caused when the chick, then 8-days old, ate a katydid (Microcentrum sp.) approximately 5 cm in length that scratched the walls of the chick's throat upon ingestion. After this incident, more caution was exercised in regard to size of insects fed compared to age of chicks.

The last group of 6 chicks that I raised at the SURF also were hand-reared, similar to the first treatment group. One of these chicks experienced spradle leg, making it necessary to euthanize the chick despite attempts to correct the affliction with hobbles and intensive care.

One of 2 problems related to the mortality of 6 of 12 chicks that died was the fact that spradle leg hindered the ability of the afflicted chicks from competing for food and warmth. The other overriding problem was the staggered hatch, resulting in eggs set in the incubator at supposedly the same stage of development not hatching at the same time. First, the spradle-leg problem. Svedarsky (1988) reported that, after hatching, wild greater prairie chicken hens in Minnesota sat on their broods for about 24 hours before leading the chicks away from the nest. Lehmann (1941) reported the same findings for Attwater's prairie chickens in the wild. The greater hen in my study who incubated her own eggs remained on the nest for approximately 24-36 hours after the chicks hatched before the chicks moved away from the nest. In contrast, a number of the first 6 chicks that hatched in the artificial hatcher moved about freely almost immediately after they hatched. The chicks that moved excessively appeared to be the ones that suffered from spradle leg. Spradle leg has been identified in a wide range of avian species, but no definite etiology has been isolated (Flammer and Clubb 1994). In the egg, a bird's bones must be very pliable to enable the chick to remain in a curled position. Once hatched, it

probably takes some time - 24-36 hours - for the bones and joints of the chick to strengthen. Most likely, trying to stand or move within 24 hours after hatch puts too much stress on the weak bones and joints, causing the chicks' legs to splay. To counter this, I placed all chicks who hatched subsequent to the first batch in a cloth "nest" while drying in the hatcher. The cloth nest was a nest bowl constructed of cotton towels with a towel over the top. This arrangement restricted the chicks' movement and kept them in a dark environment, which seemed to calm them, while at the same time providing added warmth. With the cloth "nest", I attempted to assimilate sitting under a hen in order to keep the chicks still for the first 24-36 hours and allow their bones and joints to properly strengthen. From my experience, it seems very important to limit the space available to the newly hatched chicks as much as possible. Two additional chicks suffered from spradle leg later in the spring, but I am convinced it was because their movement was not restricted enough within the cloth nest.

The staggered hatch was the second problem resulting in chick mortality. I set eggs in the incubator at supposedly the same stage of development, yet the eggs did not hatch at the same time. Furthermore, once an egg had been pipped, it took some chicks longer to hatch than others. Some of chicks would hatch within 24 hours after pipping, whereas other chicks, such as the one with the curved spine, took upwards of 72 hours. Wild Attwater's prairie chicken young hatch within 24 hours after pipping (Jurries 1979). It appeared that eggs were being pre-incubated, thereby causing them to hatch over a 4-5 day period, such as with the 8 chicks introduced to the bantam hen. Because the hens established nests later in the spring, the ambient temperature was sufficient to incubate eggs during both the day and night (Table 4). A temperature of 20.2 C or greater is adequate to begin incubation of an egg (Proudfoot and Hamilton 1990). Only near the end of the nesting peak in Minnesota and Kansas does it get above 20.2 C (Table 4).

Table 4. High and low temperatures (C) during the 1993 greater prairie chicken nesting season in College Station, Texas, Wichita, Kansas, and Crookston, Minnesota.

College Station, TX			Wichita, KA			Crookston, MN		
Date	High	Low	Date	High	Low	Date	High	Low
21 Apr	21.3	9.5	15 Apr	11.2	3.4	15 Apr	7.3	0.6
(first egg layed)			(beg. nesting peak)			(beg. nesting peak)		
			30 Apr	23.5	8.4	30 Apr	23.0	8.4
			(end nesting peak)			(end nesting peak)		
9 May	28.0	18.5	15 May	28.6	3.4	15 May	23.0	5.6
(nesting peak)			(beg. renesting)			(beg. renesting)		
			30 May	29.1	16.8	30 May	25.8	12.3
			(end renesting)			(end renesting)		
9 Jun	33.6	24.6						
(last egg layed)								

Even then, the temperature range is great enough that it probably does not stay above 20.2 C for an extended length of time. Svedarsky (1988) did find, however, that wild greater prairie chicken nests in Minnesota in late June and early July hatched about 2 days faster than those hatching in early June. During the nesting peak in my study, the temperature was constantly near or above 20.2 C. Although hens were not sitting on their respective nests, the ambient temperature was sufficient to begin incubating the eggs. Had the peak nesting period for hens at the SURF occurred from mid to late April, as is usual for wild greater prairie chicken hens, the ambient temperature would have been much cooler (Table 4). Implementing an artificial lighting regimen, as discussed in the preceding section, would increase the photoperiod so the hens are bred earlier in the

spring. The hens, would, in turn, establish nests earlier in the spring when the temperature is cooler, thus avoiding pre-incubation of eggs and staggered hatchings.

Brood Behavior

Statistically, there was no difference ($P > 0.05$) in resting, locomoting, grooming, feeding, or "other" behavior between brood groups during the morning observation periods throughout the duration of the study. Concerning evening observations, resting, locomoting, grooming, feeding, and "other" behavior between brood groups differed significantly ($P < 0.05$) only during week 1. During week 1, the group that differed statistically ($P < 0.05$) was the prairie chicken young that were in the outdoor pen with the prairie chicken hen. In the morning of week 1, all brood groups spent most of their time resting, ranging from 62.57% for the treatment group containing the trainer chicks to 80.35% for the control group. The percent time spent resting during the evening observation period ranged from 71.9% for the control group to 77.65% for the treatment group with the trainer chicks. The chicks in the outdoor pen rested only 32.08% during the same time. Rather than resting, the 3 young with the greater hen locomoted 58.75% of the time in the evening of week 1, compared to an average of about 15% for all other groups combined. Furthermore, the chicks with the greater hen did not groom or perform "other" behaviors at all, while over the same period, the average percent of time spent by the other groups grooming and performing "other" behaviors was about 2% and 1%, respectively.

One of the reasons for a high percentage of locomotion by the chicks with the greater hen may have been due to the amount of space available to the chicks. Rather than confining the chicks to a small area and expanding the area with age, as was done with the brood groups indoors, the 3 chicks outside had unrestricted access to an area measuring 832 m^2. In retrospect, the probable reason for the chicks with the greater hen

locomoting nearly 3 times as much as other brood groups is that they were starving to death. The broods housed indoors were constantly supplied with insects collected by myself and other volunteers. At times, the insects in the brood pens were so thick they were crawling on the satiated chicks. In contrast, it was logistically impossible to supply insects to the chicks outside because of the area available to them. Moreover, in my original experimental design, the 3 chicks and the greater hen were to serve as the control group. My intention was to take a complete hands-off approach and let the hen raise the chicks as she would if still in the wild.

Studies of prairie chicken hens in the wild indicate that hens lead their broods into pockets of insects (Lehmann 1941, Svedarsky 1988). The greater hen in my study did not interact with the chicks other than to brood them or call them closer if they strayed too far. At no time while her brood was being observed did she lead the chicks or attempt to pass on to them any feeding behavior. Therefore, the chicks wandered throughout the pen foraging on their own, sometimes getting as far away from her as 30 m. Moreover, there did not appear to be many insects in the pen housing the 3 chicks, even though the pen was outside. There is little information in the literature as to prairie chicken hen\brood interactions, so the manner in which the hen in my study behaved may be typical of hens in the wild. A second explanation is that the hen was inexperienced and this was her first brood. Inexperience seems more plausible to me, especially considering that in 1992, her first year in captivity, the breeding season was interrupted.

Excluding behaviors during the evening observaton period of week 1 for the brood group housed outdoors, there were no statistical differences in the behavior of the 4 brood groups. Therefore, I combined morning and evening observations and averaged the resting, locomoting, grooming, feeding, and "other" categories of all groups by week (Fig. 1). The 2 most dynamic behaviors were resting and grooming (Fig. 2). The young

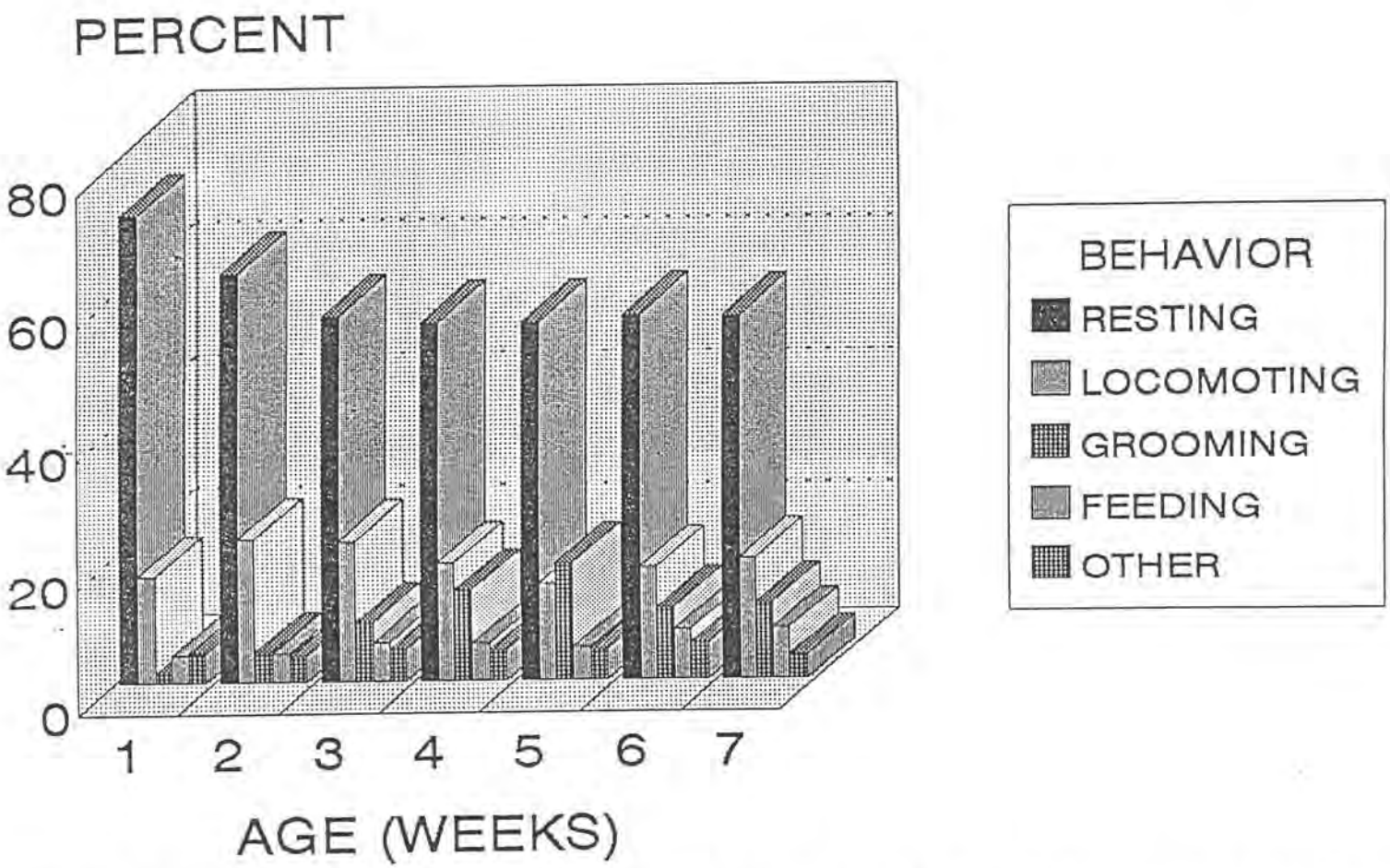

Fig. 1. Average percent of time greater prairie chickens 1-7 weeks old rested, locomoted, groomed, fed, and performed "other" behaviors at the SURF during spring 1993.

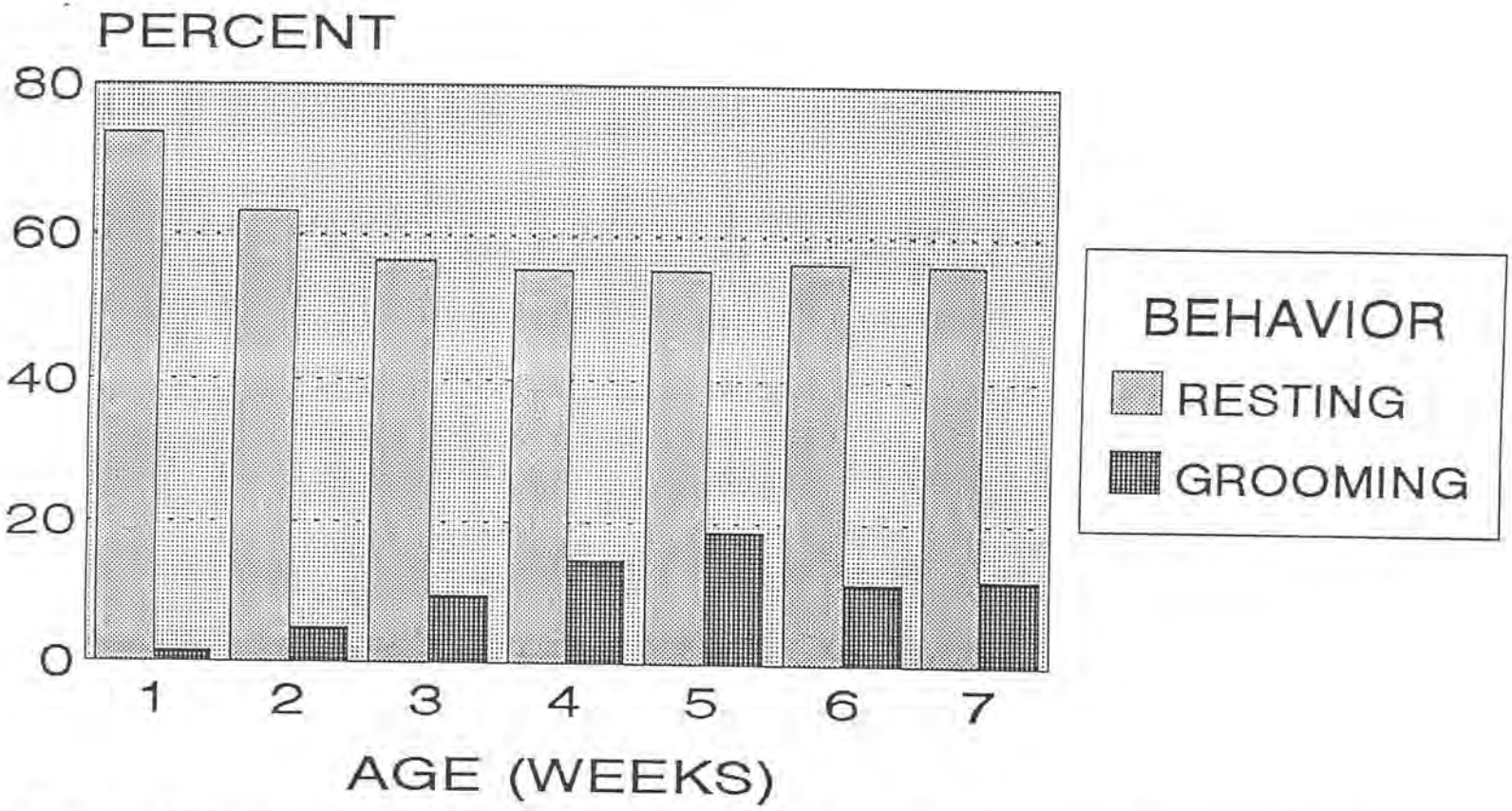

Fig. 2. Average percent of time greater prairie chickens 1-7 weeks old rested and groomed at the SURF during spring 1993.

spent about 72% of their time resting the first week, 63% the second week, and about 55-56% from the third week on. The decrease in the resting category primarily occurred as chicks were brooded less with increasing age. Contrary to a decrease in resting, the young bird's grooming increased with age. Chicks spent an average 1.6% of their time grooming the first week, but by week 5 were grooming almost 19% of the time. The increase in grooming was due to feather growth and the "need" to preen growing feathers. Barring minor fluctuations, locomoting, feeding, and "other" behaviors were relatively constant over time (Fig. 3).

The categories termed resting, locomoting, grooming, and feeding covered nearly all actions performed by the young birds. Any behavior that did not fit into those categories was placed in the "other" category. "Other" behaviors ranged from 3.9-5.8% of all behaviors performed.

One of the behaviors in the "other" category that is worth noting is aggression. Over the entire study period, I observed acts of aggression less than 1% of the time. Behavior as aggressive as cannibalism has been witnessed in captive-reared Attwater's prairie chicken young (Bob Smith Unpubl. data 1992). I was able to curtail the chicks' aggression by varying their environment. For example, instead of chicks pecking at each other, they pecked at insects that drew their attention. They also pecked at flats of vegetation, and crawled over and around objects such as wood blocks and feed trays.

Besides the lack of aggression, the amount of innate behavior that young chicks possessed is noteworthy. Without ever being exposed to an adult greater prairie chicken, chicks found and caught insects from day 1, dust bathed, and performed various mating behaviors such as booming and nuptial bowing, to name a few. Chicks attempted booming by day 4, and while they did not have the coloration of adult male prairie chickens, they went through the necessary motions. Later in the spring, some of the

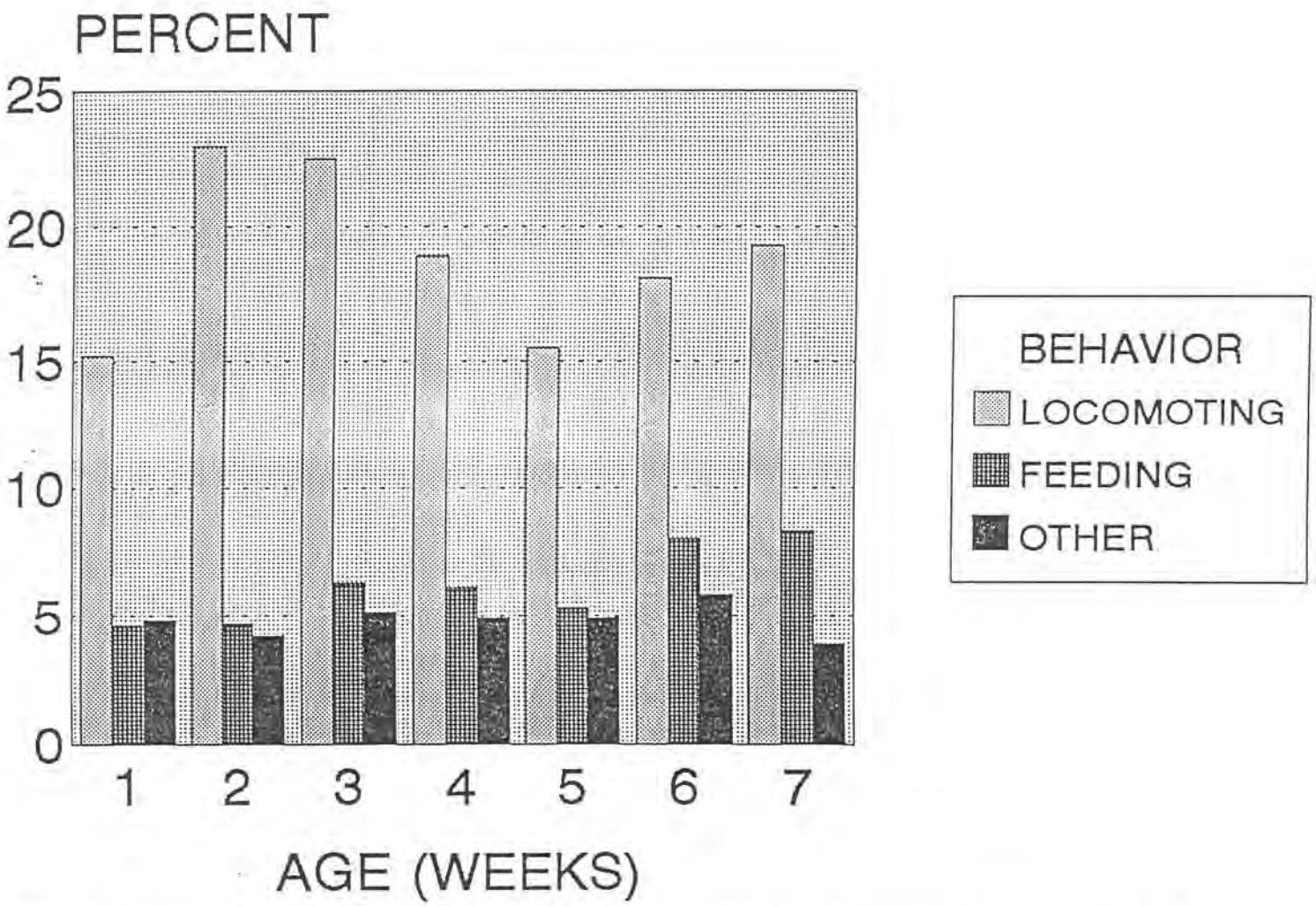

Fig. 3. Average percent of time greater prairie chickens 1-7 weeks old locomoted, fed, and performed "other" behaviors at the SURF during spring 1993.

young even performed nuptial bows.

Since the ultimate objective is to reintroduce captive-reared prairie chickens, a concern was how the chicks not reared by a greater hen would react to predators. The greater hen who reared the 3 chicks outside would call to them when a large bird flew overhead, and the chicks would freeze. Once outside, the young housed indoors and without a greater prairie chicken hen reacted similarly, either remaining motionless, or if near cover, darting into the cover. It appeared that predator response to avian predators was also innate.

Since I grouped brooding, resting, and roosting into 1 category termed resting, and the feeding category was a consolidation of diets (insects, vegetation, and commercial feed), I analyzed the components of these 2 categories separately, again using Kruskal-Wallis (Table 5). A statistical difference ($P < 0.05$) was noted in brooding for 5 of the 7 weeks for the hand-reared group, and for 2 of the 4 weeks for the group of chicks with the "trainer" chicks, compared to the control group. Because these 2 groups were without a hen, the differences may be attributed to either observor error or the presence of a hen. Observor error may come into play in that I considered the chicks to be brooding only if directly under the cone of the heat lamp. However, there may have been sufficient heat to keep the chicks warm adjacent to the cone of the lamp, in which case I would have recorded the behavior as roosting instead of brooding. A second possible explanation is that the chicks in groups with a hen brooded more because a hen was present.

Lehmann (1941) estimated that in the wild, Attwater's prairie chicken young less than 1 week old brooded about 50% of the daylight period. In my study, the largest percent of time spent brooding by chicks in all groups was the first week. During this week, only the brood groups with a hen brooded close to or more than 50% of the time. The 2

Table 5. Differences in brood behavior percentages between treatment groups and the control group at the SURF during spring 1993.

Week	Group	Brood	Rest	Roost	Insects	Veg.	Com. feed
1	Control	58.3 A[a]	10.7 A	7.2 A	4.1 A	A	0.2 A
	Hand-rear	26.3 A	38.0 B	7.6 A	3.6 A	A	0.3 A
	W/ trainers	24.2 A	32.7 B	12.7 A	6.2 A	A	B
	W/ hen	45.3 A	4.8 A	B	3.3 A	A	B
2	Control	17.5 A	17.1 A	12.4 A	3.5 A	A	A
	Hand-rear	27.3 B	26.3 A	14.6 A	2.5 A	1.2 B	0.9 B
	W/ trainers	11.8 B	26.2 A	23.7 A	5.9 A	A	A
3	Control	0.4 A	22.7 A	24.0 A	3.9 A	A	0.8 A
	Hand-rear	17.0 B	23.8 A	18.2 A	4.0 A	1.0 B	1.5 A
	W/ trainers	4.0 B	29.9 A	27.5 A	5.3 A	1.0 B	1.9 A
4	Control	2.4 A	24.4 A	31.4 A	5.2 A	0.5 A	1.1 A
	Hand-rear	6.4 A	27.3 A	22.7 B	2.2 A	0.5 A	2.5 A
	W/ trainers	3.6 A	35.3 A	12.3 B	2.2 A	1.4 A	3.8 B
5	Control	0.6 A	28.4 A	27.0 A	1.3 A	1.6 A	4.0 A
	Hand-rear	5.2 B	32.9 A	16.9 A	1.8 A	0.4 A	2.0 A
6	Control	A	32.7 A	17.9 A	2.3 A	3.7 A	4.9 A
	Hand-rear	2.6 B	38.1 A	21.7 A	2.3 A	0.5 A	2.6 A
7	Control	A	35.5 A	15.6 A	0.6 A	9.5 A	2.0 A
	Hand-rear	1.2 B	38.6 A	21.4 A	1.4 A	0.9 B	2.1 A

[a]Values with different letters within columns are different at $P < 0.05$ (Kruskal-Wallis test).

groups without a hen brooded an average 25.3%, or about half as much as the chicks with a hen. A possible advantage to the chicks spending a large portion of their time brooding, especially the first 2-3 days, is that their bones and joints have a chance to strengthen.

Because of the high percentage of time spent brooding during the first week, 1 option might be to use hens in the rearing of prairie chicken young the first week to take advantage of the time spent brooding. From the second week on, hand-rear the young until they are put outside. I am convinced it would be too difficult to rear chicks from the start in outdoor pens because there is no way to constantly supply insects to the young outside. Therefore, if hens are used they would need to be domestic brood hens. From my observations, even if captive-reared prairie chicken hens were used, they would be too wild for the small, indoor brood pens at the SURF. The down side to using domestic brood hens is the risk of introducing disease into the facility. However, disease concerns could be solved by quarintining hens before they enter the facility or using hens that have been reared disease-free.

There was no statistical difference ($P > 0.05$) in the percent of insects consumed for any of the groups. The fact that there was no difference underscores the importance of insects in the diet of young prairie chickens.

After 1 August 1993, I combined all young to form 1 group and compared their behavior to that of the wild-caught adult greater prairie chickens (Fig. 4). The age of the young at the beginning of the 2-week comparison ranged from 7-10 weeks. There were no statistical differences ($P > 0.05$). The behaviors portrayed in Figure 4 constituted 97.1% of all behaviors performed by the young and 98.2% of all behaviors performed by the adults. The 2 most realistic differences in the behavior of the young and adults were reflected in the locomoting and grooming behaviors. The young locomoted approximately twice as much as the adults, and the adults groomed about twice as often as the young. The young were still growing at the time of comparison, and spent nearly 24% of their time locomoting in search of food, accounting for the difference in locomoting percentages. In addition, chicks had been recently transferred from

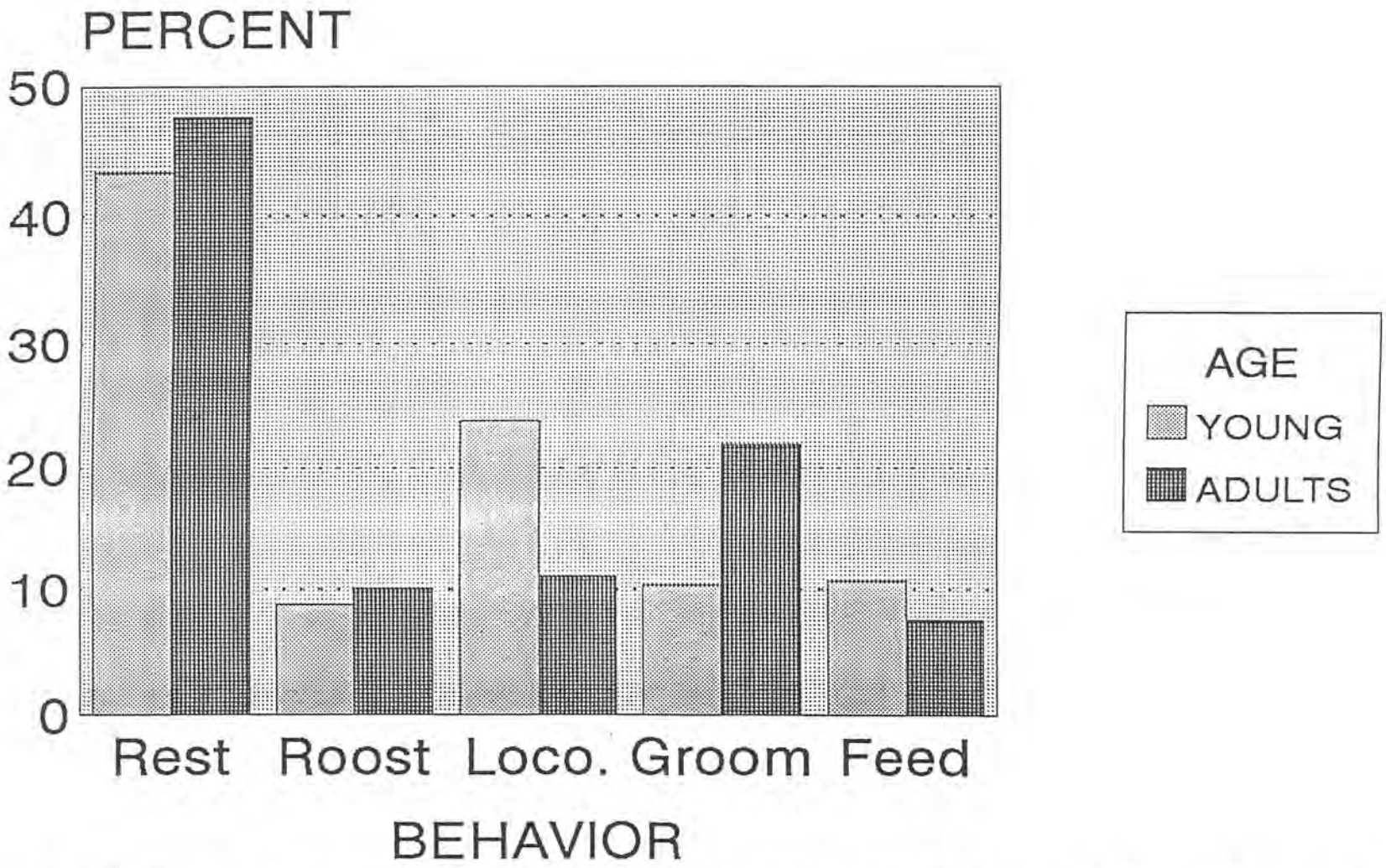

Fig. 4. Resting, roosting, locomoting, grooming, and feeding behavior of young and adult greater prairie chickens at the SURF over a 2-week period during summer 1993.

indoor to outdoor pens. Some of their locomotion may have been directed at investigating their new environment. As for grooming, the adults were molting at the time of comparison, resulting in them grooming almost 22% of the time, accounting for the difference in grooming percentages.

An initial objective of my study was to develop propagation techniques that would retain the "wild" behavior in pen-reared greater prairie chickens. The control group was to consist of the chicks that were incubated and reared by the wild-caught hen. I was going to assume that the hen's behavior would be most similar to the "wild" condition, therefore, the behavior of her clutch would be defined as "wild" behavior. However, when the 3 chicks reared by the greater hen died, my objective changed from rearing "wild" birds to simply rearing birds in captivity. The control group also changed to the brood being reared by the domestic bantam hen. I was still interested in determining if the behavior of the young could be classified as "wild", so I compared the behavior of the young to that of the wild-caught adults.

While the behavior of the young and wild-caught adults did not differ statistically ($P > 0.05$), I use the term "wild" behavior with caution. Perhaps the most important behavior that I did not quantify was predator avoidance. With the behaviors that were recorded, I was certain when they occurred. For example, I could see the young feeding or locomoting or resting. On the other hand, when the young ran for cover or froze, I was not sure as to what caused their reaction. During the observation period, the only type of predator the birds were exposed to were avian. However, I could not be certain that a shadow cast on the ground from a bird flying overhead was the cause of the bird's reaction. Therefore, while it appeared that the young did respond when a bird flew overhead, I could not rule out that another factor caused their reaction.

I combined all brood groups' diets by week in age regardless of statistical differences to produce an overall picture of their diet (Fig. 5). During the first week, 96% of the diet consisted of insects, yet even in the fourth week, nearly 50% of the diet still consisted of insects. It appeared that during the first week, leaf hoppers (Cicadellidae) were selected for over all other available insects, most likely because they did not have a chitinous exoskeleton and were easily digested. After the first week, however, the chicks must have developed the ability to digest chitin, because insects such as grasshoppers (Acrididae), which have chitinous exoskeletons, were preferred instead of soft-bodied insects. With increasing age, the amount of insects in their diet decreased and vegetation became dominant. The consumption of vegetation increased from 25% during week 6 to 53% by week 7. This increase occurred as young were moved from indoor brooder pens to outdoor pens where vegetation was much more abundant and insects less abundant. The consumption of commercial feed reached a peak of 53% of the total diet during week 5, but overall, appeared to serve the purpose of a supplementary food source to insects and vegetation.

Johnson and Boyce (1990) found captive sage grouse (Centrocercus urophasianus) chicks required insects for survival at least through 3 weeks of age. Every sage grouse chick hatched in captivity and not provided insects died between 4 and 10 days of age. In general, Johnson and Boyce (1990) showed that as the quantity of insects in the diet increased, survival and growth rates also increased. Kobriger (1965) studied diets of young sharptailed grouse (Pedioecetes phasianellus) in the Nebraska sandhills. He found that the diet of young grouse to 7 weeks of age consisted of 60% insects, ranging from 91.5% insects at 3 weeks of age to 62.6% at 7 weeks of age. At 12 weeks of age, Kobriger noted the diet of young sharptails to be similar to adult sharptails, over 90% vegetable matter.

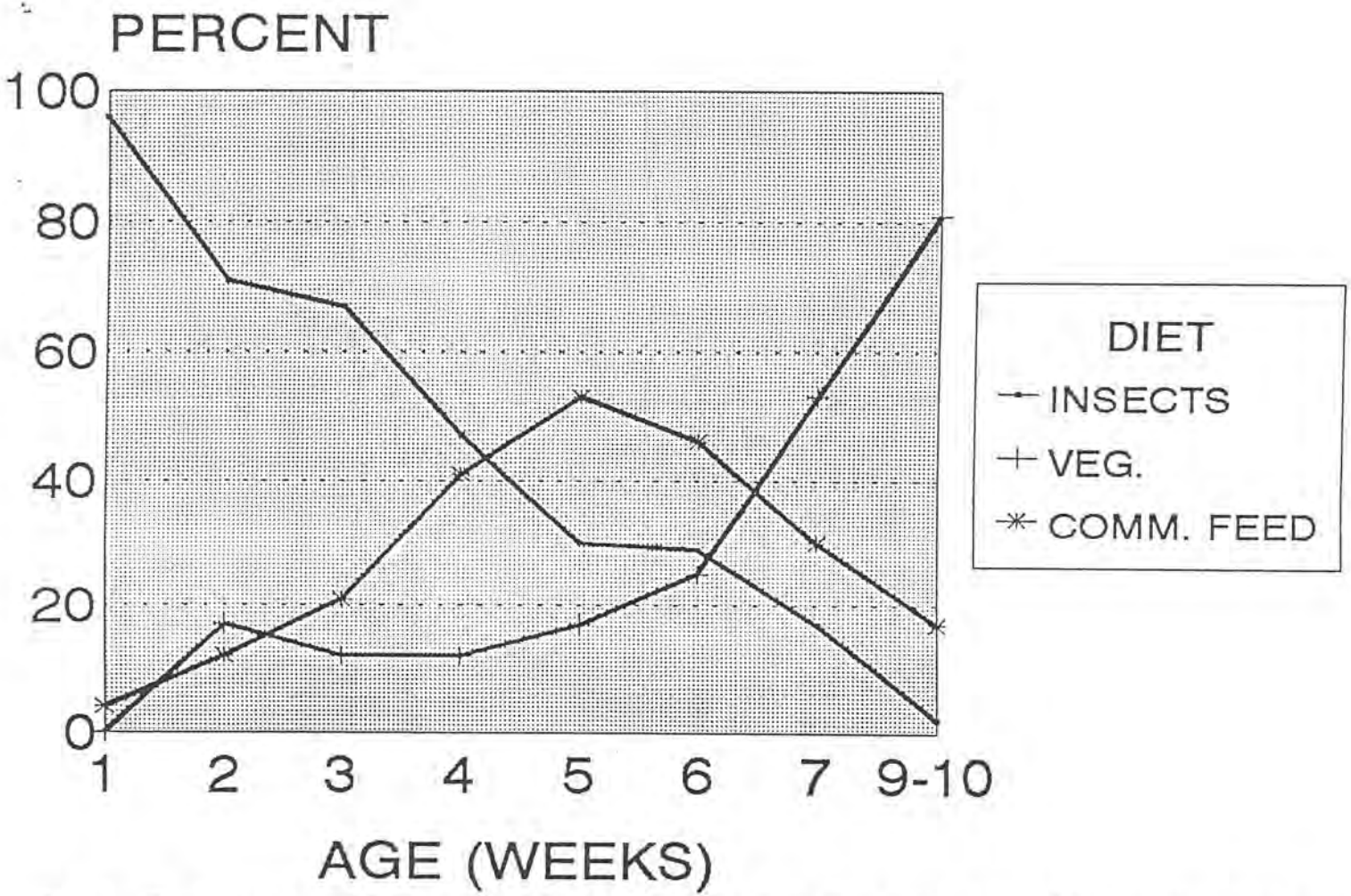

Fig. 5. Diet of greater prairie chickens at the SURF through the age of 10 weeks during spring 1993.

Traditionally, researchers raising grouse in captivity have fed the young birds mostly commercial chick starter (Coats 1955, Fay 1963, Kruse Unpubl. data 1976). The type of diet, at least through the first 3 weeks, in combination with grouse morphology, may be the reason past studies reported limited success (Coats 1955, Kruse Unpubl. data 1976). Leopold (1953) discovered that browsing grouse have caeca 136% longer, large intestines 28% longer, and small intestines 30% longer than seed-eating quails, partridges, pheasants, and turkeys. He proposed that morphological differences permit grouse to winter on low quality bulk food, partly by providing storage room for microbial decomposition of cellulose and perhaps in part by allowing for more complete absorption of all essential elements in the diet. With this hypothesis in mind, it is possible that young prairie chickens less than 3-4 weeks of age are physically incapable of digesting vegetable protein because they lack the proper type and amount of bacteria in their gut cavity. All commercial chick starters that I am familiar with contain vegetable protein rather than animal protein, which would explain the low survival in studies that raised young grouse on mainly chick starter. In contrast , the diet of the young prairie chickens in my study was rich in animal protein, evidenced by the high percentage of insects consumed through week 4 (Fig. 5). By consuming insects, which sustain themselves on vegetation, it is possible the prairie chicken chicks were indirectly growing the gut bacteria necessary to digest vegetable protein as they digested the insects. By week 3-4, I propose that the prairie chicken young had sufficient levels of bacteria in their intestinal tract to digest chick starter and vegetation in large amounts, indicated by the increased consumption of chick starter and vegetation from week 3-4 on (Fig. 5) .

A second important reason to feed insects in the early stages of life other than for digestive purposes is that eventually, captive reared birds will be reintroduced into the

wild. It has been documented that approximately 88% of the diet of wild Attwater's prairie chicken young consists of insects (Lehmann 1941). Catching and eating insects in captivity teaches/reinforces foraging behavior so when the young females become adult hens, they are cognizant of the proper food sources for their own chicks.

Because of the high protein diet, the young prairie chickens in my study experienced consistent weight gain, with the average gain per group per week being 65 g (Fig. 6). I did not combine the 2 hand-reared groups in order to show the plateau in the weight line for the group entitled hand-reared 1. The leveling off in weight gain between weeks 7 and 10 was due to this group being stricken with blackhead. Two of the 3 chicks that remained in the first hand-reared group died during this time, and the 1 chick that did survive lost 70 g.

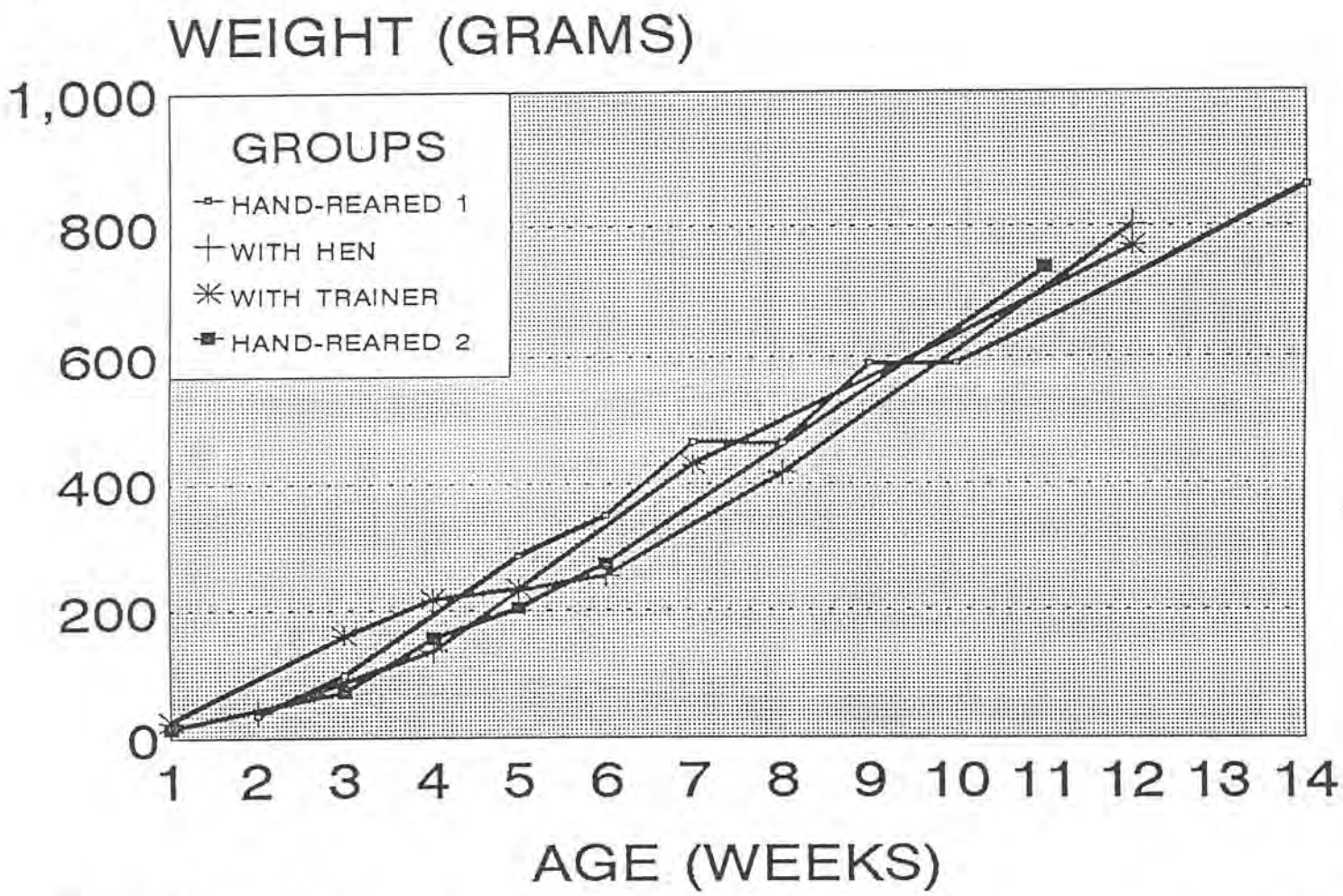

Fig. 6. Average weights (g) for greater prairie chickens through 14 weeks of age for 5 different brood groups at the SURF during spring 1993.

SUMMARY

The initial objectives of my study were: (1) to develop captive propagation techniques that would retain the "wild" behavior in pen-reared greater prairie chickens; and, (2) to describe brood behavior in pen-reared greater prairie chickens. With the death of my original control group, my first objective changed from retaining "wild" behavior in pen-reared greater prairie chickens to simply propagating pen-reared greater prairie chickens.

Six of 7 greater prairie chicken hens at the SURF layed a total of 79 eggs during spring 1993. Fifty-three of the 79 eggs (67%) were fertile, 26 eggs hatched (33%), and 14 chicks survived (54%).

A number of problems most likely related to the photoperiod were encountered, including a delayed peak nesting period and a low hatch percentage. These problems may be remedied by stimulating greater prairie chickens to begin reproduction earlier in the year through artificial lighting.

Six of the 12 chicks that died suffered from spradle leg, a condition that can be avoided by restricting as much as possible the chicks' movement the first 24-36 hours after hatch. I restricted their movement by placing newly hatched chicks in a cloth "nest", which assimilated sitting under a hen for the brood groups being raised without a hen. A second problem causing chick mortality was a staggered hatch. I believe the staggered hatch was a result of eggs pre-incubating in the nest because of the high ambient temperatures late in the spring. Instituting an artificial lighting regimen may cause nesting to begin earlier in the spring when the ambient temperatures would be cooler, thus avoiding pre-incubation of eggs and averting a staggered hatch.

I used the Kruskal-Wallis statistical test to determine if the behavior differed between brood groups, treating morning and evening observation periods separately. Of the 4

brood groups whose behavior I observed, the 3 prairie chicken young with the greater prairie chicken hen were the only group who differed statistically ($P < 0.05$). A significant difference was noted during the evening observation period of week 1. They locomoted nearly 3 times more often than any other brood group, primarily because they were constantly foraging for food.

Excluding the evening behavior observations of chicks with the greater hen that differed statistically, I combined morning and evening observations and averaged the behaviors of all brood groups into 5 categories. The categories included resting, locomoting, grooming, feeding, and "other", with resting and grooming being the 2 most dynamic behaviors. The resting category was a general heading which included brooding, roosting, and resting. The average percent of time spent resting by all brood groups decreased from a high of 72% the first week to 63% the second week, and leveled off at 55-56% from the third week on. Grooming increased from an average 1.6% the first week to nearly 19% by the fifth week. The increase in grooming was primarily due to preening new feathers.

I analyzed the components of the resting (brooding, roosting, and resting) and feeding (insects, vegetation, and commercial feed) categories separately. The 2 most notable behaviors under the general headings of resting and feeding were brooding and the consumption of insects. The brood groups that were reared without a hen brooded about half as much during the first week as the brood groups with a hen.

There was no statistical difference ($P > 0.05$) between any of the brood groups in the amount of insects consumed. Insects are a vital component in the diet of young prairie chickens, at least through the fourth week of life. Ninety-six percent of the diet during the first week was insects, and even in the fourth week of life, 47% of the diet included

insects. The high protein diet led to an average weight gain of 65 g per brood group per week.

After 8 weeks of age, I combined all young to form 1 group and compared their behavior to that of the wild-caught adult greater prairie chickens. There were no statistical differences ($P > 0.05$) in any of the behaviors observed, which included resting, roosting, locomoting, grooming, and feeding.

From my research with the greater prairie chickens, my recommendations for the captive propagation of Attwater's prairie chickens in spring 1994 are as follows: (1) hand-rear the chicks indoors for the first 5 weeks, using disease-free domestic bantam hens for brooding purposes during the first week only, (2) while the chicks are housed indoors, vary their environment as much as possible, and keep human contact to a bare minimum to prevent any possible domestication of the birds; (3) feed unlimited insects through at least the fourth week of life; and, (4) move birds to outside pens where access to adult birds is available as soon as possible, thereby facilitating any adult-to-young training that may be necessary for successful reintroductions.

LITERATURE CITED

Atwater, S., and J. Schnell, editors. 1989. The wildlife series: Ruffed grouse. Stackpole Books, Harrisburg, Pa. 370pp.

Ballard, W. B., and R. J. Robel. 1974. Reproductive importance of dominant male greater prairie chickens. Auk 91:75-85.

Coats, J. 1955. Raising prairie chickens in captivity. Kansas For., Fish and Game Comm., Pratt, Kans. 6pp.

Conover, W. J. 1980. Practical nonparametric statistics. Second ed. John Wiley & Sons, New York, N. Y. 493pp.

Fay, L. D. 1963. Recent success in raising ruffed grouse in captivity. J. Wildl. Manage. 27:642-647.

Flammer, K., and S. L. Clubb. 1994. Neonatology. Pages 805-838 in B. W. Ritchie, G. J. Harrison, and L. R. Harrison, eds. Avian medicine: Principles and application. Wingers Publishing, Inc., Lake Worth, Fla.

Follett, B. K., R. G. Foster, and T. J. Nicholls. 1985. Photoperiodism in birds. Pages 93-105 in D. Evered and S. Clark, eds. Photoperiodism, melatonin, and the pineal. Ciba Foundation Symposium 117. Pittman Publishing, Ltd., London.

Handley, C. O. 1935. Raising prairie chickens in captivity. North Am. Game Conf. 1:220-223.

Johnsgard, P. A. 1983. The grouse of the world. Univ. Nebraska Press, Lincoln. 413pp.

Johnson, G. D., and M. S. Boyce. 1990. Feeding trials with insects in the diet of sage grouse chicks. J. Wildl. Manage. 54:89-91.

Jurries, R. W. 1979. Attwater's prairie chicken. Texas Parks Wildl. Dept., F. A. Series No. 18, Austin. 36pp.

Kobriger, G. D. 1965. Status, movements, habitats, and foods of prairie grouse on a sandhill refuge. J. Wildl. Manage. 29:788-800.

Kruse, A. D. 1984. Simplified methods for mass propagation of greater prairie chickens. Game Bird Breeders Gaz. Oct:8-15.

Lehmann, V. W. 1941. Attwater's prairie chicken: Its life history and management. U. S. Fish Wildl. Serv., Washington, D. C., North Am. Fauna 57. 65pp.

Leopold, A. S. 1953. Intestinal morphology of gallinaceous birds in relation to food habits. J. Wildl. Manage. 17:197-203.

McEwen, L. C., D. B. Knapp, and E. A. Hilliard. 1969. Propagation of prairie grouse in captivity. J. Wildl. Manage. 33:276-283.

Proudfoot, F. G., and R. M. G. Hamilton. 1990. Care of hatching eggs before incubation. Agric. Can. Publ. 1573/E. 18pp.

Robel, R. J. 1966. Booming territory size and mating success of the greater prairie chicken (Tympanuchus cupido pinnatus). Anim. Behav. 14:328-331.

_____. 1970. Possible role of behavior in regulating greater prairie chicken populations. J. Wildl. Manage. 34:306-312.

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., New York, N. Y. 312pp.

Svedarsky, W. D. 1988. Reproductive ecology of female greater prairie chickens in Minnesota. Pages 193-239 in A. T. Bergerud and M. W. Gratson, eds. Adaptive strategies and population ecology of northern grouse. Vol. 1. Univ. Minnesota Press, Minneapolis.

U. S. Fish and Wildlife Service. 1992. Attwater's prairie chicken recovery plan. Albuquerque, N. M. vii + 48pp.

Watkins, R. M. 1971. The propagation of the Attwater prairie chicken in captivity.

M. S. Thesis, Texas A&M Univ., College Station. 38pp.

APPENDICES

Appendix 1. Twenty-eight percent protein turkey starter diet fed to greater prairie chicken young at the SURF up to 6 weeks of age during spring 1993.

Weight (kg)	Ingredient
479.5	Soybean 48%
300.0	Corn
45.5	Alfalfa
35.6	Fat A&V blend
18.2	Bentonite
11.4	Deflourinated
9.1	Oyster shell
3.3	Methionine 98%
2.3	Vitamin
2.0	Salt
0.9	Lysine 98%
0.5	Trace minerals
908.3	

Add 100 g Oxytetracycline and remove weight from corn.

Appendix 2. Twenty-three percent turkey developer diet fed to greater prairie chickens at the SURF from 7-12 weeks of age during spring 1993.

Weight (kg)	Ingredient
636.4	Corn
132.7	Soybean 48%
45.5	Alfalfa
45.0	Oats
18.2	Deflourinated
18.2	Bentonite
6.4	Oyster shell
2.3	Vitamin
2.0	Salt
1.2	Methionine 98%
0.5	Trace minerals
908.4	

Add 0.01875% Nitarsone (Histostat 50) and remove weight from corn.

Appendix 3. Eighteen percent turkey grower diet fed to greater prairie chickens at the SURF after 12 weeks of age during spring 1993.

Weight (kg)	Ingredient
472.7	Corn
314.5	Soybean 48%
45.5	Alfalfa
27.4	Fat A&V blend
18.2	Bentonite
11.8	Deflourinated
9.1	Oyster shell
3.3	Methionine 98%
2.3	Vitamin
2.0	Salt
0.9	Lysine 98%
0.5	Trace minerals
908.2	

Add 0.01875% Nitarsone (Histostat 50) and remove weight from corn.

Appendix 4. Twenty percent turkey breeder diet fed to greater prairie chickens at the SURF during 1993 breeding season.

Weight (kg)	Ingredient
444.1	Corn
320.0	Soybean 48%
45.5	Alfalfa
31.4	Oyster shell
30.5	Deflourinated
18.2	Bentonite
13.6	Fat A&V blend
2.3	Vitamin
2.0	Salt
1.2	Methionine 98%
0.5	Trace minerals
909.3	

Add 100 g Oxytetracycline and remove weight from corn.

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