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BREEDING AND POST-BREEDING MOVEMENTS OF BLUE-WINGED TEAL (ANAS DISCORS) IN SOUTHWESTERN MANITOBA

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1971

BREEDING AND POST-BREEDING MOVEMENTS OF BLUE-WINGED TEAL (ANAS DISCORS) IN SOUTHWESTERN MANITOBA

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CHAPTER I - INTRODUCTION

Even though many aspects of waterfowl biology are well known, McKinney (1965:93) points out that "surprisingly little is known about the daily movements of individual ducks during the breeding season." Even less is known about the behavior and movements of most duck species during the molt. Only by observing individually-marked birds can one begin to understand the actions and interactions of a breeding and molting population. With these thoughts in mind, I conducted in southwestern Manitoba a three-year study of the Blue-winged Teal (Anas discors), one of that province's most abundant waterfowl. Both wild-trapped and hatchery-reared birds, each individually marked, were used. The main objectives of the study were: (1) to investigate individual movements of males and females throughout the breeding season, (2) to ascertain post-breeding movements and molting behavior of both sexes, and (3) to study spacing in a natural population of Blue-winged Teal and the same population under crowded conditions accomplished by a seeding program. With the compilation of individual case-histories it was hoped that a more thorough understanding could be gained concerning breeding and post-breeding movements of Blue-winged Teal.

Description of Study Area

The grasslands in the glaciated portions of the north-central United States and the prairie provinces of Canada are prime waterfowl breeding habitat. According to Smith, Stoudt, and Gollop (1964: 39), this prairie pothole region covers only ten percent of the total continental waterfowl breeding grounds, yet produces fifty percent of the duck crop in an average year. It was from this region of northern plains that one square mile was chosen for intensive investigation of breeding Blue-winged Teal (see photo 1). Located in the famed "Minnedosa Pothole District" of southwestern Manitoba, the study plot (Section 28, Range 13, Township 18) was eight miles south of Minnedosa.

Geologically, the Minnedosa pothole district was an area of "glacial outwash," an area once studded with masses of ice. When the ice melted, depressions remained and lakes formed (Hochbaum, 1966:198). These water-filled depressions have come to be known by waterfowl biologists as potholes and are referred to as such by me. Although annual precipitation is light (about 21 inches at Winnipeg according to Munro, 1963:106), snow accumulates from November through March and the runoff is usually sufficient to fill these glacial depressions to a depth of from three to six feet.

Section 28 contained 244.11 acres of water--38.14% of the study area. Scattered woodlots of aspen (Populus tremuloides) covered 25 acres.

The rest of the section was cultivated farm land producing mainly spring wheat. The 164 potholes on Section 28 ranged in size from .04 acre to 8.95 acres, averaging 1.49 acres. Approximately one half of these potholes were dry by mid-July.

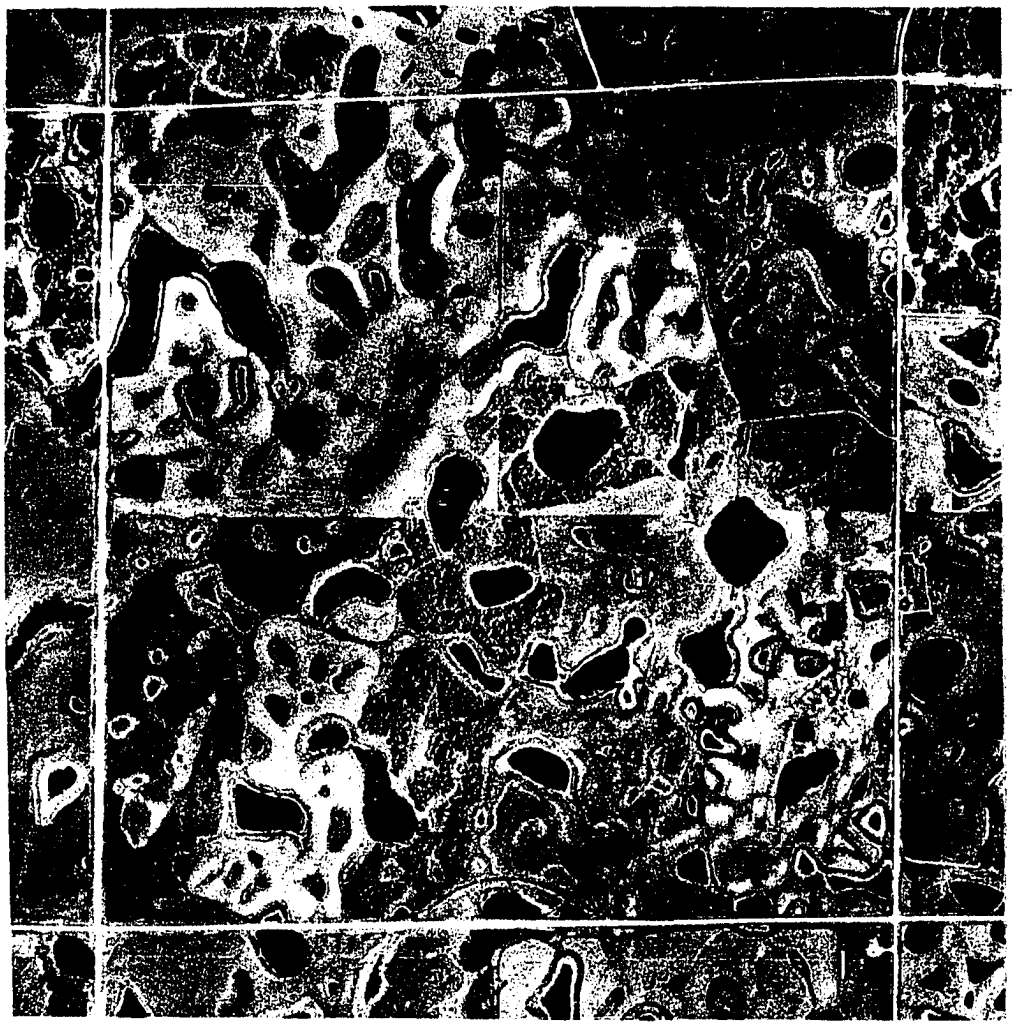


Photo 1. Aerial view of study plot (Section 28, Township 13, Range 18) near Minnedosa, Manitoba, Canada. Photographed 6 August 1965 by National Air Photo Library, Ottawa.

CHAPTER II - METHODS

Mapping

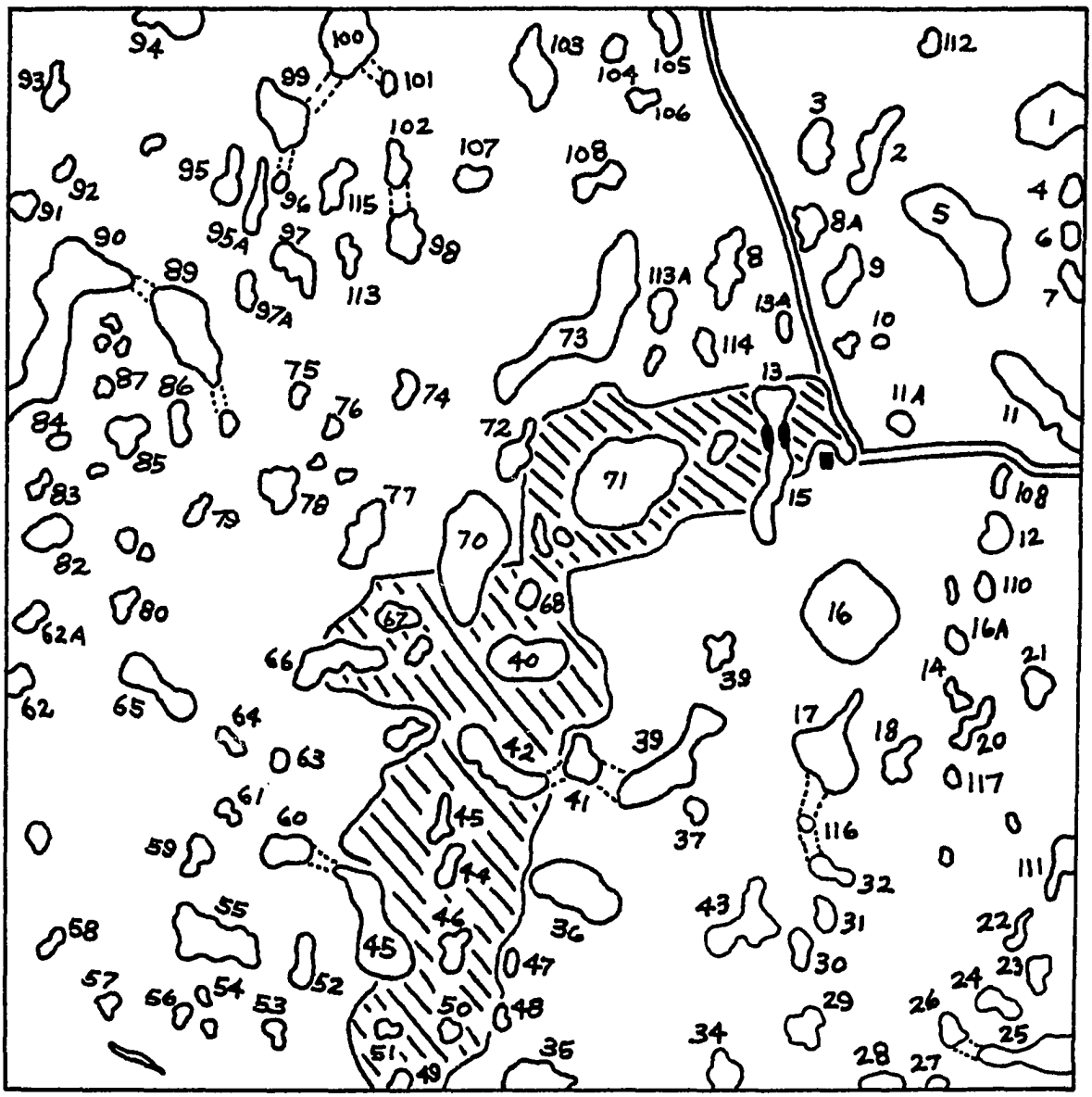


Figure 1. Map of Section 28, Township 13, Range 18 showing numbered potholes. (Shaded area denotes woodland)

A sketch of the study area was made to the scale of 6" =1 mile from an enlargement of a 1965 aerial photograph showing all woodlots, fence rows, and potholes; each pothole was given a number. This map was checked in the field to update any changes that had occurred since 1965 (see fig. 1).

Observations

Daily observations of waterfowl were made on the study area from the time of spring arrival through fall departure. Observations on Blue-winged Teal included: arrival, courting, aggression, feeding, nest building, egg laying, incubation, predation, drake movements, hen movements, molting behavior, and post-breeding behavior. Identification of individually-marked birds was possible at 150-200 yards using a 60X Bausch and Lomb spotting scope. A small brown canvas tent or an automobile served efficiently as a blind for close observations.

Trapping

A modification of Rogers's (1964) walk-in trap was used to capture drake Blue-winged Teal. Built on a circular plan, the inner compartment held a live female Blue-winged Teal which acted as a decoy to attract the drakes. Funnel entrances led into the outer circular compartment. Calls from a portable transisterized Panosonic tape

recorder further enhanced the effectiveness of the walk-in trap. Thirty minutes of pre-recorded calls attracted drakes, who tried to get to the female decoy and became trapped.

Capturing Females

Females were captured using a nest trap (Sowls, 1949). The trap was a frame of 3/8 inch iron rod two feet square over which was attached 1/2 inch mesh cord netting. Lead weights on the front of the trap made it drop heavily. The weighted side was propped up with a tripping stick while the opposite side was held firmly in place by two hinged rods pushed into the earth. To the tripping stick was attached a long twine so that the trap could be tripped from a distance. Traps were set over nests when the nests were first found and tripped about two hours later, a length of time sufficient for the hen to return and settle on the nest. Trapping success was good; very few hens deserted their nests.

Capturing Molting Birds

A corral or drive trap was used to capture flightless molters. An 8' x 8' pen with one side open was placed in dense cattails on a pothole known to harbor molting ducks. On the left and right of the open side was placed 50' of snow fence angling off in an ever widening span.

Persons, equipped with noise makers, walked abreast through the emergent vegetation forcing the flightless birds ahead of them into the funnel-shaped snow fence and finally into the corral or trap compartment.

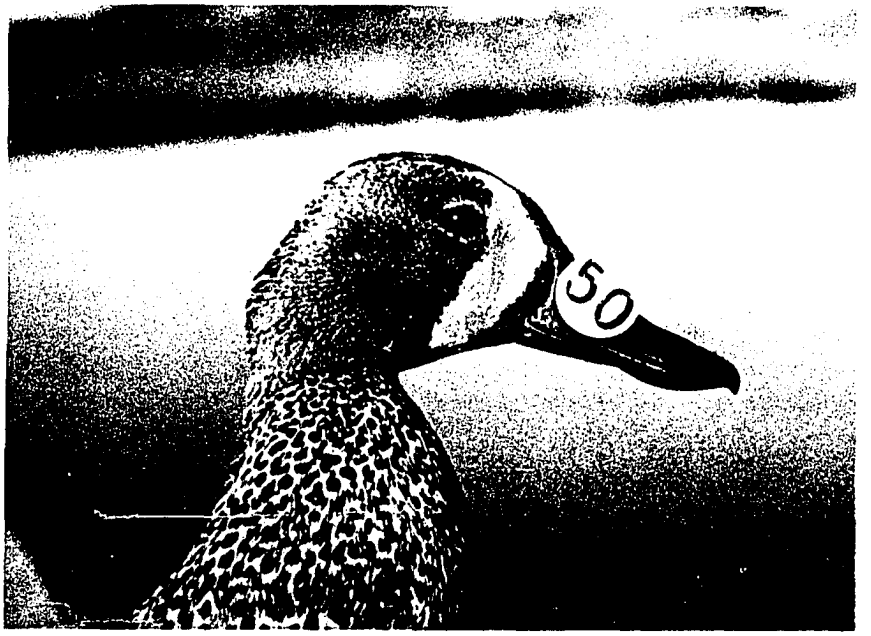


Photo 2. Drake Blue-winged Teal fitted with permanently numbered nasal discs. Trapped and marked near Minnedosa, Manitoba, on 13 June 1967.

One or two drives on one pothole usually made sufficient disturbance to cause the birds to move overland to the nearest pothole. Thus the drive trap had to be re-located after every two drives for efficient capturing of molters.

Marking of Individual Ducks

Ducks were individually marked using numbered nasal discs (see photo 2) as described by Bartonek and Dane (1964). One and two digit numbers and letter combinations were used on red, white, red-and-white, or yellow nasal discs. In addition the birds were banded using colored numbered leg bands (available through the National Tag Company, Louisville, Kentucky) carrying two digits on red, yellow, or green. U. S. Fish and Wildlife Service aluminum bands also were placed on the birds. In 1967, quick-drying luminescent paints were applied to the underside of the wings for individual identification of birds in flight. This was not practical in 1968 when a large number of birds were marked.

Nest Hunting

Nests were found by three methods: (1) use of a dog to find nests by scent, (2) dragging a long rope with a man at each end, and (3) direct observation of the hen.

A 75' length of rope to which tin cans were tied was dragged by two men through suitable nesting cover. In most cases, the noise of the tin cans and the rope movement caused the hen to flush off the nest. This method was ineffective if the hen sat tight--as was generally the case when incubation was nearing completion.

The most successful method was direct observation of the hen. The hen generally flew directly to her nest after feeding. Thus by watching a hen feeding and noting where she dropped into the grass following her flight from the water area, one could easily locate a nest.

Photography

Behavioral sequences were photographed from a blind using a Bell and Howell 8mm movie camera with zoom lens. A Mamiya-Sekor 35mm single lens reflex camera also was used.

Seeding Program

In 1966 I studied the breeding behavior of the Blue-winged Teal in the extensive marshlands at Delta. In 1967 I narrowed my study to the natural, "unseeded" breeding population of the species on Section 28 in the pothole district near Minnedosa. In 1968 I studied an unnaturally crowded teal population on this same Section 28. The crowded population was brought about by "seeding"-- i.e., by the releasing in late April and early May of 100 drake and 100 hen Blue-winged Teal that had been hatched, reared, and over-wintered at the Delta hatchery.

Six release cages, each 8' x 8' x 4', were placed on potholes throughout the study area. Each release cage, capable of holding temporarily 20-30 birds, was equipped with feeding platforms and float boards. Each group of birds was held for a period of two to four

days for orientation to the immediate surroundings. The door was then opened and the birds allowed to find their way out. Feeding platforms were maintained outside the cages as well. Three group releases were accomplished in this fashion. The period of orientation, maintenance of feeding platforms, and smallness of group releases induced many birds to remain. The released birds gradually scattered across the study plot and surrounding areas about the time the natural population was arriving from the south.

CHAPTER III

TERRITORIALITY, AGGRESSION AND SPACING

Territoriality

Blue-winged Teal, being gregarious by nature, congregate in large flocks prior to their fall migration and remain flocked throughout the fall and winter. Only after returning to the breeding grounds does this gregariousness break down as the pairs scatter over the nesting habitat. Territorial behavior may be the agent by which this spacing of pairs on the breeding grounds is accomplished.

Hochbaum (1944) was the first waterfowl biologist to apply to ducks the theory of territory, a theory propounded first by Altum (1868) about 100 years ago and later by Howard (1907-14, 1920), Mayr (1935), Noble (1939), Lack (1939), Tinbergen (1939), and Nice (1941, 1943). Many definitions have been given for territoriality but all writers agree on at least one essential element, namely, defense of an area. Noble's (1939:263-273) simple and inclusive definition that a "territory is any defended area" is the definition used in this paper. Occupation of a specific area does not constitute territoriality; only if that area is defended against intrusion by other members of the same species can it be classified as a territory. Occupation without defense indicates a home range relationship (see section on Home Range, p. 28).

Territorial behavior in waterfowl is extremely varied depending on species, range, and stage of breeding cycle. Several workers have noted territoriality in Blue-winged Teal (Bennett, 1938:51; Hochbaum, 1944:58-87; Harris, 1954; Johnsgard, 1955; Sowls, 1955:47-63; Evans and Black, 1956:44-45; Drewien, 1968; Dzubin, 1955:287-290, 292), but none have studied it in depth.

Sowls (1955) and Dzubin (1955), working with individually-marked ducks, found that territories of waterfowl were neither so restricted nor so tightly defended as Hochbaum (1944) had believed them to be. Dzubin (1955:278) observed that "defended areas did not always have definite boundaries." Moving territories have been described for Pintails (Anas acuta) by Smith (1955) and for Blue-winged Teal by Dzubin (1955:289, 292). A moving territory is an area of intolerance around the breeding pair, an area which moves as the pair moves.

> Johnsgard (1968:50) writes: "Exactly what aspect of the territory is actually defended is a debatable point. There is no doubt that among ducks at least the female is the primary focal point of defense, although she is usually not considered part of the territory ("a defended area"), as commonly defined. Territorial defense in waterfowl has therefore become greatly confused with the defense of the female, with attempted rape of other females, and with actual courtship flights."

Tinbergen (1957) distinguishes two components of territorial behavior: 1) attachment to a site, and 2) hostility; where these two components occur simultaneously they give the impression of defense of an area. It is entirely possible that defense of a mate (present or

on a nest nearby) might be misinterpreted as defense of an area. As Emlen (1957:352) has pointed out, one should avoid the "speculative assumption that the area carries special significance to the bird as an object to be defended." What appears to be territorial behavior (defense of the nesting area) by some drakes may actually be defense of the mated hen who is on a nest nearby.

Many paired Blue-winged Teal drakes at Minnedosa exhibited defensive behavior while their mates were on nests. Since the drake knows where the nest is, this hostility in the vicinity of the nest is probably due to the female's presence there and is not defense of the area per se. Some Minnedosa males never exhibited defensive behavior in the absence of their mates (particularly if the nest was some distance from the loafing site), but all males exhibited defensive behavior in the presence of their mates. Defensive behavior was never observed in unpaired drakes. Thus, it appears that in Blue-winged Teal any defensive behavior (whether the female is with the drake or on the nest) is a defense of the mated hen rather than of the nesting area. The restriction of the male's movements to a certain area is the result of this strong pair-bond with his mate who is of necessity attached to the nest site and immediate vicinity.

When one speaks of territory and territorial behavior in waterfowl one must bear in mind the modifications of this theory as applied to ducks. My study has made clear to me that waterfowl territorial

behavior is actually defense of the female and consequently of the area around her as the result of the drake's strong pair-bond attachment to his mate. The territory of a drake includes his mated hen and immediate vicinity; it has no fixed boundaries, but moves with the hen. The "territory" may thus be quite mobile before the nest site is selected or following nest predation and it may be comparatively immobile when the hen's movements are restricted during incubation.

Functions of Territorial Behavior

The biological significance of territorial behavior has long been debated (Hinde, 1956:340). Hochbaum (1944:87) suggested that the primary function of territorial behavior in ducks is to establish isolation from sexually active birds of the same species during the mating period. This may not apply entirely to Blue-winged Teal since they successfully accomplish copulation in artificially crowded situations (McKinney, 1965:104).

In Blue-winged Teal observed by me, intense aggression occurred at the time nest sites were being selected. Nest dispersion which results from aggression may have survival value as an anti-predator device (Hammond and Mann 1956). Pair-spacing may ensure an adequate food supply but this is not of primary importance for waterfowl since broods are mobile (Evans, Hawkins, and Marshall, 1952) and the food supply is generally abundant.

Aggression and Responses

Drake Blue-winged Teal aggressiveness, as observed by me, varied with the stage of the reproductive cycle and with the time of day. Drakes were most aggressive during the early stages of nest initiation and egg-laying. The presence of the female (i.e., during her periods off the nest) tended to increase the male's aggressiveness (noted also in the Blue-winged Teal by Dzubin, 1955:288). Aggressive responses varied from mild to intense.

Head pumping is an important communication signal in many dabbling ducks (Johnsgard, 1968). This rapid movement of the head up and down as performed by Blue-winged Teal was observed by me in four contexts: 1) mutual head-pumping in the greeting ceremony, 2) mutual head-pumping in courtship activities, 3) hostile head-pumping in aggressive situations, and 4) head-pumping as an alarm signal. Hostile head-pumping by Blue-winged Teal is an important signal of aggressive intent. The threat function of these displays was indicated by the observed avoidance responses of other birds. Attack behavior patterns varied greatly in intensity and duration. Five degrees of aggression were noted as follows (listed in increasing degrees of intensity): 1) hostile head-pumping threat; 2) sneak-threat with neck extended, head low, beak open; 3) momentary lunge at intruder; 4) actual encounter, pecking, wing flailing; 5) extended chase on water or in the air.

The intruder usually retreated when he was threatened or attacked but occasionally he did not retreat and actual fighting ensued. Avoidance (retreat without being involved in a hostile encounter), a phenomenon that I often observed in Blue-winged Teal, is probably an important mechanism in the spacing of pairs on the breeding grounds.

At Minnedosa a lone male was occasionally tolerated close to a pair. Hochbaum (1944:70) distinguished between two types of unmated males: (1) sexually active drakes and (2) "novice drakes" that are not sexually active. The latter are tolerated while the former are driven off by the paired males. Trios consisting of two males and one female were observed by me on several occasions. The unpaired drake usually remained with a pair for only a few days and then moved on; these unpaired birds had no obvious home range as did the breeding birds.

None of the year-old hatchery-reared drakes released on the study area were known to maintain a pair-bond and breed successfully. Several of these birds became "third members" of a trio and were tolerated by the paired drakes. In several "novice drake" specimens examined by me, there was only slight testicular development. There are two possible explanations for the "novice drake" behavior of the hatchery-reared drakes released at Minnedosa: (1) lowered aggression due to hatchery experience and inability to compete with wild drakes or (2) sexual inactivity. It may be that yearling males are less likely to breed than older birds; according to Oring (1969:48), this is apparently true in the Gadwall (Anas strepera).

Spacing and Carrying Capacity

Stoudt (1952) and Hochbaum (1944) have expressed belief that the carrying capacity of waterfowl breeding grounds is determined by two factors--drake intolerance and availability of adequate water areas. The Minnedosa area does not appear to have approached the saturation point even with the seeding program. Dzubin (1955:289), commenting on this area, states that "there appears to be more suitable habitat available than is utilized." Thirteen percent of the birds released by me remained on Section 28 to breed (the remainder scattered to nearby sections), thus raising the natural population from 42 pairs to 55 pairs, yet many potholes remained vacant, containing no territorial males. Theoretically 164 potholes could hold at least 164 territorial drakes. Probably nesting cover is a more limiting factor in the Minnedosa area than water availability. The land is intensively farmed, more so today than ever before. Only narrow strips of nesting cover are left in the fence rows and pothole peripheries. This scarcity and scattered distribution of nesting cover must have a direct effect on the spacing of breeding pairs.

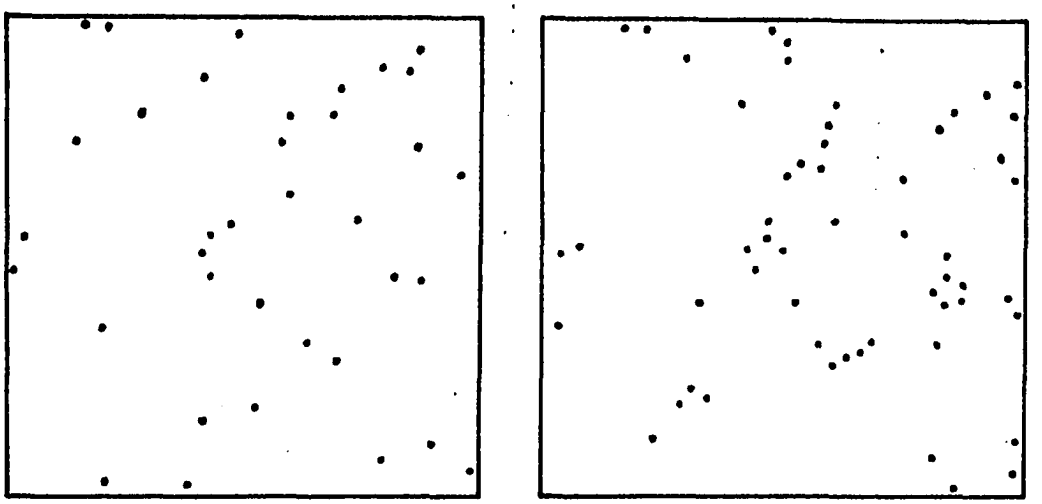
Aerial flights so common in Mallards (Anas platyrhynchos) according to Dzubin (1957) and Hori (1963), and probably responsible for spacing in that species (McKinney, 1965), were not, according to my observations, very common in Blue-winged Teal at Minnedosa.

In this species the pair-bond was so strong that the male seldom left his mate. When a male Blue-winged Teal did engage in a chase-flight (sexual or hostile) it was of short duration; the male quickly returned to his mate.

Chasing played little part in spacing of Blue-winged Teal pairs at Minnedosa. Threat-and-avoidance was probably the principal factor in spacing for this species there. Usually only a threat was sufficient to make the intruding birds move on until they finally found an unoccupied area, but occasionally an actual fight or aerial chase was necessary to dislodge a persistent intruder.

Effects of Seeding on Spacing

Figure 2 (A) shows the approximate spacing pattern of 36 pairs of Blue-winged Teal in Section 28 in 1967. The pairs were widely scattered; many of the available water areas were not utilized. Surprisingly, the release program in 1968 did not change this pattern of spacing to any great degree. Dzubin (1955:289) noted that the presence of one or two pairs in an area appeared to draw other pairs into the vicinity. This was the case at Minnedosa in 1968. Approximately the same water areas were occupied in 1968 as in 1967 even though the breeding population was larger (see Fig. 2 (B)).

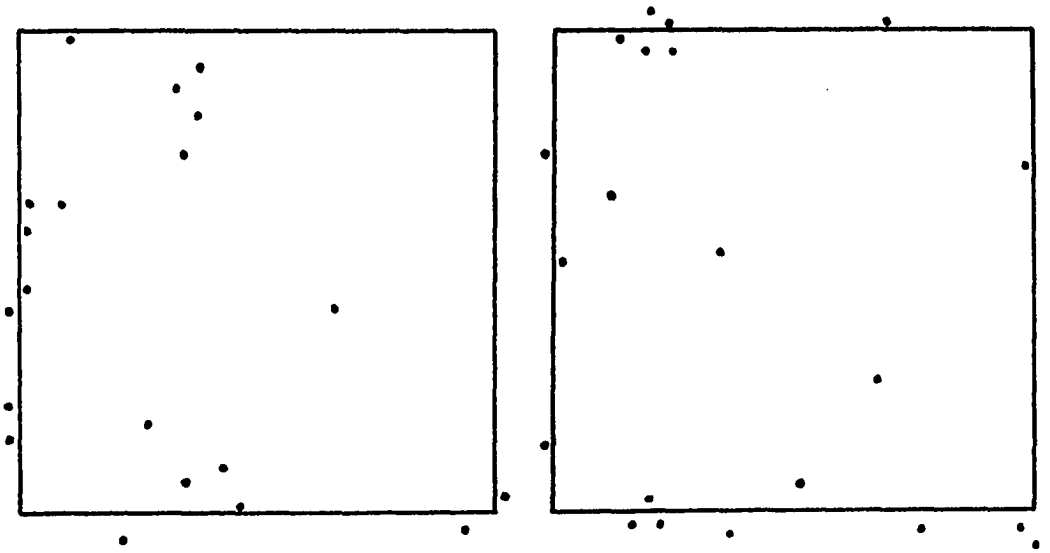


(A) (B)

Figure 2. Spacing patterns of breeding Blue-winged Teal on Section 28 near Minnedosa, Manitoba: (A) 35 pairs in 1967, (B) 55 pairs in 1968.

Home ranges were not compressed or reduced in size by an increase in the breeding population. The average size of the 1967 home range (based on 18 marked pairs out of the 35 breeding pairs) was 15.47 acres. The average size of the home range in 1968 (based on 23 marked pairs out of the 55 breeding pairs) was 18.49 acres, an increase of 3.02 acres over the previous year (see section on Home Range, p. 28).

Even though the water areas were more heavily used in 1968, nest spacing was relatively unchanged (see Fig. 3).



(A) (B)

Figure 3. Spacing patterns of Blue-winged Teal nests on Section 28 near Minnedosa, Manitoba: (A) 20 nests in 1967; (B) 21 nests in 1968.

CHAPTER IV - BREEDING BIOLOGY

Arrival

Blue-winged Teal arrived at Minnedosa on 27 April in 1967 and on 19 April in 1968. The few pairs and occasional unpaired drakes that arrived first congregated on the open water of large potholes. These large potholes I called "arrival potholes." The breeding population gradually built up during late April, but many birds arrived during the first ten days of May.

The first arrivals at Minnedosa were gregarious. The drakes showed little hostility; but as the population built up and more water areas thawed, intolerance developed and the birds dispersed over the countryside.

Blue-winged Teal arrived mated; not once in three seasons in Manitoba did I observe an unmated female during spring arrival. Glover (1956) observed that approximately sixty percent of the Blue-winged Teal were paired on arrival in Iowa. Apparently pairing begins on the wintering grounds, continues enroute north, and is completed before arrival in Manitoba.

Most sex ratio studies in waterfowl report an excess of males (Johnsgard, 1968). Glover (1956) reported two male Blue-winged Teal for each female in Iowa. Furniss (1935) reported that the "sex ratio of Blue-winged Teal in the breeding grounds of Manitoba was 1.5 males to

1 female." The sex ratio in my study at Minnedosa was 7 males to 5 females during each summer. Unpaired drakes shared water areas and hostility between drakes was exhibited only when one of the involved drakes was mated; unpaired drakes were not aggressive towards each other.

Homing

Studies by Sowls (1955:25-45) and Borden and Hochbaum (1966: 82) reveal that adult female ducks of various species tend to breed in the same area in successive years and that young females tend to breed in "natal marshes," that is, in marshes where they gained their first flight experience.

Homing may be more precise in areas such as Delta, where there is pronounced topographic feature such as the Delta marsh, than it is at Minnedosa, where there is much suitable habitat but no pronounced topographic feature. Of ten female Blue-winged Teal trapped and individually marked on Section 28 in 1967, none returned to nest on that section in 1968. None of the six wild-trapped females marked in 1968 returned in 1969. I received no report in 1969 on any of the 200 hatchery-reared birds that I had released in the Minnedosa area the previous year.

Precise homing of drakes is probably rare since there is usually an annual re-pairing (on wintering grounds or enroute on spring migration), and presumably the drake accompanies his mate as she re-

turns to her familiar home range--an area that may be entirely new to the drake. For example, a male Blue-winged Teal (at least one year old) that had been banded near Stone Mills, New York, on 19 September 1967, was collected (paired with an unbanded female) near Minnedosa, Manitoba, on 26 June 1968. This drake was in New York in 1967 and in Manitoba in 1968.

A second case of a banded drake collected on the breeding grounds indicates that homing of unpaired drakes may occur. An adult drake Blue-winged Teal banded near Shoal Lake, Manitoba, on 18 August 1966 was collected (paired with a hatchery-reared and released female) near Minnedosa, Manitoba, on 3 June 1968. This bird, in at least its third year, returned to within 90 miles of where it was banded, and did so as a single unpaired bird. Upon arrival in the Minnedosa area it paired with a hatchery-reared female who had been released only recently.

Pre-nesting Behavior

Early in the season the pair bond was exceptionally strong at Minnedosa; very seldom did a drake leave his mate in aerial pursuit of an intruding drake. Mated drakes were difficult to trap using the "live decoy walk-in trap" during the pre-nesting period since the mated drake showed no interest at all in the female decoy as long as his own mate was with him. When his mate was absent (egg laying or incubating) the drake approached the trap readily.

Dzubin (1955) and Gates (1962) suggest that pairs are more mobile during the pre-nesting period than they are after nesting has started. Prior to nest-site selection, movements of a pair at Minnedosa were somewhat random and unrestricted. Aggressive behavior was displayed by the drake only when his mate was approached too closely (15 to 20 feet) by a strange drake. Once the nest-site was selected, the pair's movements were orderly and restricted to a specific area (home range). Unpaired drakes were less restricted and moved, more or less at random, around the study area.

Nest-site Selection

Smith (1963) described "exploratory flights" of Pintails that were, presumably, investigating nesting cover. No information is available for any duck species concerning the area covered by a pair engaged in nest-site selection. At Minnedosa several individually marked Blue-winged Teal pairs were observed in nest-site selection flights. The drake followed the female in low circuitous flights over potential nesting cover. Periodically the female dropped into the grass, followed by the drake, and walked about as if searching, only to take flight and begin the circuitous flight again. A quarter of a section or more was covered thoroughly in this manner over a period of several days. The area searched was considerably larger than that finally occupied as a home range.

Nest Construction and Egg Laying

Diving ducks, according to Hochbaum (1944:47) and Low (1945: 50), construct nests two days to a week before egg laying starts. Unlike the divers, Blue-winged Teal at Minnedosa laid the first egg in a bare scrape and continued construction as egg-laying and incubation proceeded. The nest scrape was made one day before the first egg was laid. On 20 June 1968, after investigating suitable nesting cover, RW-13 spent 2 hours and 27 minutes (10:53-13:20) at the newly selected nest-site; on 21 June, during 07:00-08:50, she laid her first egg of the clutch. The nest cup was deepened and grasses added each time the female visited the nest to lay another egg. Down plucked from the female was first added with the laying of the fourth or fifth egg. As incubation neared completion, a heavy blanket of down accumulated. Once the clutch was complete, the female meticulously arranged the down over the eggs. This down undoubtedly served as an insulating and heat-retaining blanket, and perhaps it served also to hide the buffy white eggs from aerial predators.

During the egg laying period, which begins in the Minnedosa area approximately May 20th, the female visited the nest each morning between 07:00 and 10:00. After spending one or two hours on the nest, the female left the nest to join the drake on a nearby pothole and did not visit the nest again until the next morning. One egg a day was laid until the clutch was complete.

During egg laying and early incubation, while the female was at the nest, the drake occupied a specific area that is sometimes called the waiting area or loafing site. The actual loafing site at Minnedosa was a specific stretch of pothole shoreline, a muskrat lodge, a mud bar, or a rock. It is reported that if conditions are favorable the loafing sites are on the nearest piece of water (Dzubin, 1955; Stotts and Davis, 1960), but they may be up to a mile away (Evans and Black, 1956:40; Evans, Hawkins, and Marshall, 1952:40). The loafing site at Minnedosa was nearly always on the pothole to which the female flew to feed when she left the nest; this was never over one half mile away.

Little, if anything, has been written concerning how a female duck manages to fly directly to her nest. To the human eye, certain areas of suitable nesting habitat look much the same and it is often difficult for a human being to relocate a nest unless a marker is used. A series of observations on the behavior of two marked female Blue-winged Teal at Minnedosa provided some insight on duck orientation to the nest-site. It appears that the female duck learns where the nest is by association with certain topographical or vegetative features in the immediate vicinity of the nest. On June 20 I flushed a female Blue-winged Teal (RW-13) from a freshly prepared but empty scrape that was near a large clump of groundsel (Senecio sp.), a mass of bright yellow blossoms. Twenty-five yards to the east was a second and similar clump of groundsel. Early in the morning on June 21, after

the morning on June 21, after feeding, bathing and preening on pothole #55a, RW-13 flew directly over the east groundsel clump and dropped into the grass. Within two minutes she returned to the water and appeared confused, swimming in tight circles and head-bobbing. Within a few minutes she again flew from the water; this time she flew over the west groundsel clump and dropped into the grass at the site of the nest scrape. After spending two and a half hours at the scrape, she flew off. Upon checking, I found that she had laid her first egg.

One can speculate that confusion in finding this particular nest resulted from: (1) the fact that two dominant features in the vicinity of the nest--the two yellow clumps of groundsel--were nearly identical, and (2) the probability that this was the hen's second visit to the nest-site and that she had not yet learned by association the exact position of the site.

A second series of observations at Minnedosa further supports this line of thinking. A female Blue-winged Teal (R-6) had incubated a clutch of eleven eggs for at least thirteen days in a roadside stand of tall grasses when the ditch was mowed. The cutter bar passed over the nest without destroying it, leaving only two-inch stubble. The female had of course flushed. The day following the mowing, I flushed the female from the nest as I entered the observation blind. Upon returning forty-five minutes later, R-6 did not fly directly to the nest as most female teal do, but instead dropped into the stubble twenty

feet from the nest and began walking in a random pattern, stretching her neck looking in all directions as if searching for the nest. On several occasions thereafter, she (R-6) walked past the nest and retraced her steps, passing again within two feet of it. After some time she found the nest and settled to incubate. The mowing of the previous day apparently had eliminated familiar landmarks and R-6 was not yet oriented to the new surroundings.

Home Range

Female ducks involved in egg laying, incubation, and brood rearing at Minnedosa were restricted in their movements to an area quite close to the nest site. The drake occupied approximately the same region during the forepart of this period. Sowls (1955:48) has defined home range as "the area within which a bird spends its period of isolation between the break-up of spring gregariousness following spring arrival and the reformation of fall gregariousness."

The size of the home range varies considerably. Evans and Black (1956:44) stated that the mean radius of the home range for eleven pairs of Blue-winged Teal in South Dakota was 0.18 mile (an average home range, in other words, of 87.83 acres). Figure 20 of their paper plots a 256-acre home range. Basing his statement on observations of fourteen pairs, Drewien (1968) reported that home ranges of Blue-winged Teal in South Dakota averaged 160 acres; the

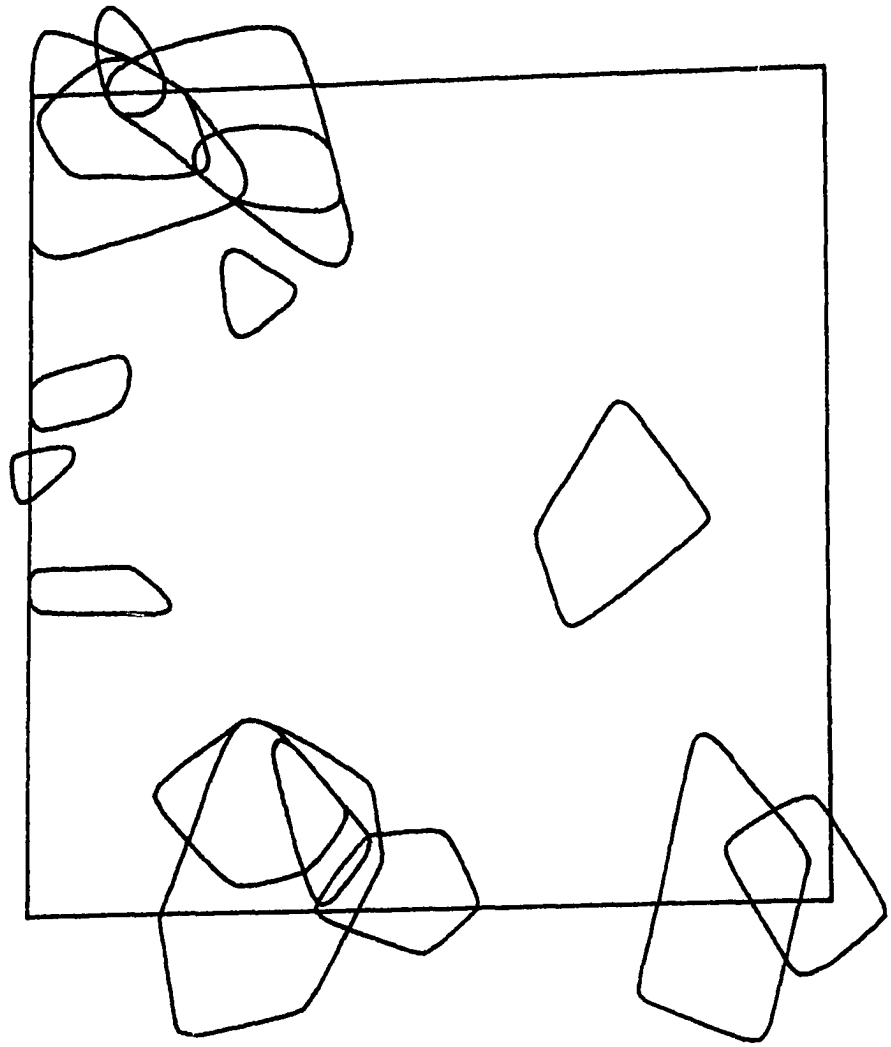


Figure 4. Blue-winged Teal home ranges on Section 28, near Minnedosa, Manitoba, in 1967.

minimum was 74 acres and the maximum was 215 acres. Dzubin (1955:287, 289), working in southwestern Manitoba, reported that Blue-winged Teal used as home range an area in excess of 250 acres; this included pre-nesting as well as nesting movements.

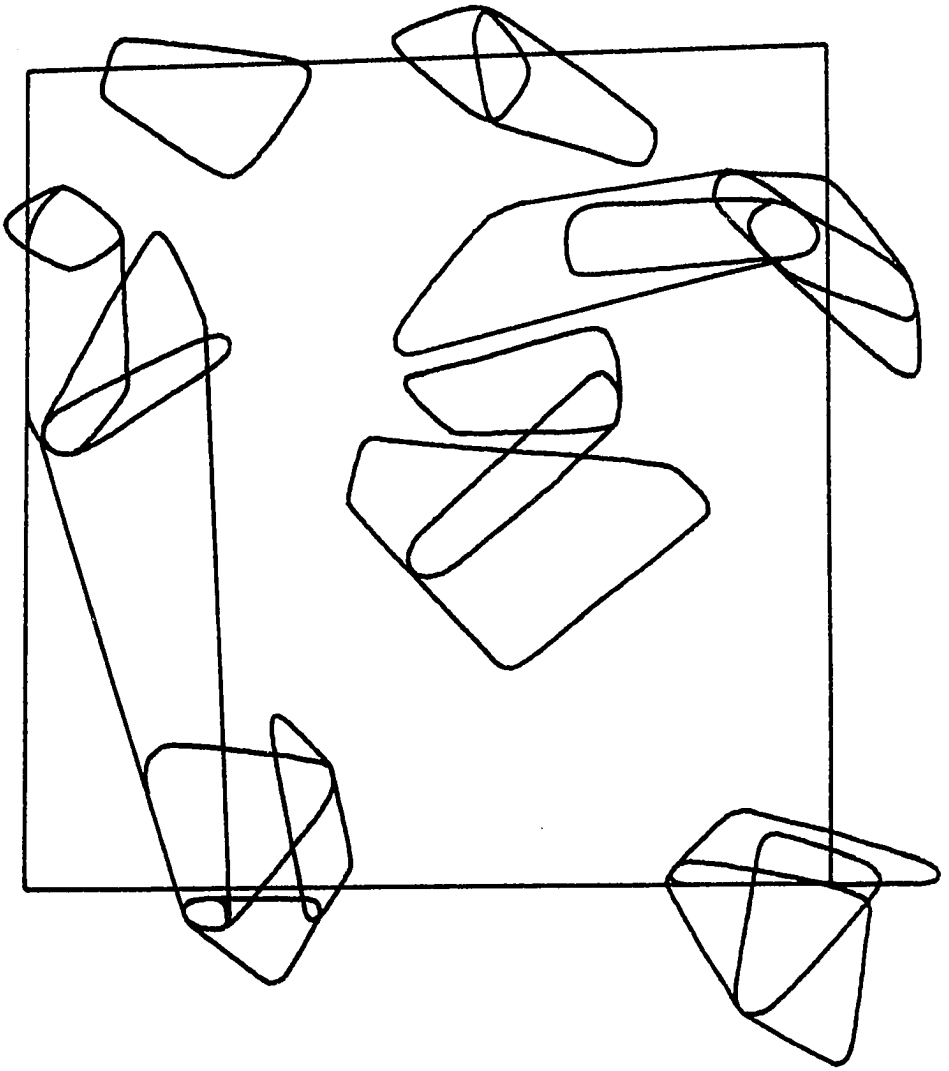


Figure 5. Blue-winged Teal home ranges on Section 28, near Minnedosa, Manitoba, in 1968.

I observed forty-one pairs of marked teal on their home ranges in Section 28 during the course of my study. The average home range was 16.98 acres; minimum was 1.42 acres and maximum was 78.59 acres (see figures 4 and 5).

Table 1. Comparison of Home Range Sizes Reported for Blue-winged Teal

	McHenry	Evans & Black (1956)	Drewien (1968)	Dzubin* (1955)
location	Manitoba	S. Dakota	S. Dakota	Manitoba
number of home ranges observed	41	11	14	--
average size in acres	16.98	87.83	160.00	250.00+
minimum size in acres	1.42	--	74.00	--
maximum size in acres	78.59	256.00	215.00	--

*This figure includes pre-nesting movements as well as home range movements after nest-site selection.

All four workers quoted in Table 1 reported approximately thirty pairs of Blue-winged Teal per square mile. The size of home range does not appear to be correlated with population density. However, the pattern of water distribution does appear to influence home range size. The South Dakota study area of Evans and Black (1956:15) contained an average of 34.7 potholes per square mile. The Minnedosa study plot (Section 28, one square mile) contained 164 potholes. Thus it appears that fewer, widely scattered potholes mean larger home ranges; many closely spaced water areas result in smaller home ranges.

In the Minnedosa area, Blue-winged Teal home ranges contained as few as one or as many as ten potholes with an average of 4.4 potholes per home range. Home ranges of neighboring pairs often overlapped; more than one pair used one small pothole but at different times during the day. Frequently two or three pairs were seen simultaneously feeding on the same larger pothole exhibiting a considerable amount of avoidance, threat and displacement. If mud bars or aquatic vegetation obstructed the view between neighboring pairs using the same pothole, peaceful sharing occurred.

Harris (1954) noted that territorial pairs of the same species mixed in feeding areas with no apparent friction between them. Two large potholes on Section 28 I classified as "neutral potholes" because four and five pairs fed there simultaneously with no signs of aggression. However, if the same pairs met on another, smaller pothole, friction invariably developed.

Incubation Behavior

Once a female teal began to incubate, the male was with her only for short periods when she left the nest to feed, bathe and preen. McKinney (1965) reports that most waterfowl species have one or two such periods a day.

Simultaneous observations of four incubating Minnedosa teals showed that there was a great deal of individual variation even though

nests were in the same stages of incubation. Females left the nest one, two, three or four times a day. Less time was spent off the nest as incubation progressed.

During the early stages of incubation, the drake maintained a "vigil", that is, he occupied a "waiting area" on a nearby pothole and it was to this pothole that the female flew when she left the nest. According to McKinney's (1965:95) review, "females seem to travel no farther than is necessary when they leave the nest." This was true in most cases on my study area, but on several occasions the females did not use water areas closest to the nest but rather used second, or third closest water areas. Evans and Black (1956:40) reported that "the nest of a pair of ducks is not generally located in or adjacent to the pothole on which the pair has been seen"; they reported that one female nested more than a mile from the pothole which the pair most often frequented. Similar observations were reported by Evans, Hawkins and Marshall (1952). The distance between nesting cover and feeding grounds varies with local conditions (Bezzel, 1959; Gates, 1962).

Each time the female came off the nest at Minnedosa, the drake flew up from the water to meet her and an elaborate greeting ceremony of excited peeping and head-pumping took place as soon as they landed on the water. Both sexes participated. Copulation occurred on the water and then the female began feeding, attended by

the drake. Many times the drake, at the waiting site, seemed to sense that the female was about to leave the nest. Even though the nest of W-27 was 250 yards away from where her mate waited, he would become alert and restless and begin the greeting ceremony just before his mate would leave the nest to join him on the water. What signaled to him her time of leaving the nest I do not know. The nest was over a ridge and no vocalization on her part was heard by me. It seems doubtful that a time interval was involved since it varied from day to day. Further investigation on this point is needed.

Each time when returning to the nest at Minnedosa the female was followed by the drake; both flew low over the nesting habitat. The female dropped into the grass at the nest and the drake continued his flight in a wide circle back to the pothole. Bennett (1938:47) records that the closest a female was observed alighting near the nest in Iowa was twenty yards. The many times this return to the nest was observed by me in the Minnedosa area the females invariably dropped into the grass directly at the nest or, at most, two or three yards away.

On 20 June 1968 my field assistant and I watched three Blue-winged Teal pairs simultaneously for sixteen hours (06:30-22:30) to determine the movements of incubating hens and corresponding movements of the drakes. Information thus gained indicated that there was quite a degree of variability among birds within the same time period.

The females left the nest one to four times a day and stayed off for as long as three hours (see Table 2).

Table 2. Periods Spent Off the Nest
by Incubating Blue-winged Teal at Minnedosa*

marked hen	W-27	R-25	Y-16
stage of incubation	10th day	7th day	10th day
1st period off nest	09:20-12:30 (190 min.)	08:15-09:10 (55 min.)	13:24-16:09 (165 min.)
2nd period off nest	13:05-13:18** (13 min.)	13:45-15:30 (105 min.)	20:41-22:12 (91 min.)
3rd period off nest	17:45-18:38 (53 min.)	18:12-19:35 (83 min.)	— —
4th period off nest	21:15-21:40 (25 min.)	— —	— —
total minutes off nest	281	243	256

*Simultaneous Observations of 3 Incubating females on 20 June 1968 from 06:30-22:30. (Heavy rain from 09:37-10:00)

**hen flushed off nest when disturbed by farming activity

All the time that W-27 was off the nest (four hours and twenty-eight minutes) she was with her mate, feeding, bathing, preening and resting. During the sixteen hour period (06:30-22:30), the drake spent twelve hours and fifty minutes on the pothole closest to the nest (120 yards) sharing it periodically with two other pairs. During the morning time off, W-27 and mate fed on the fifth closest pothole (400 yards)

from the nest; intervening water areas they did not use. Second and third breaks they spent on the closest pothole.

Cool weather or rain did not keep females on their nest. During several heavy rains, females incubating full clutches were observed off the nest, feeding or sitting in bulrush beds with their mates while it rained. According to Bruce Batts (researcher at Delta from the University of Florida) duck eggs are very cold resistant.

The responses of incubating females to me as I approached their nests were varied. Some females flushed at fifty yards; others were close sitters and flushed only if about to be stepped upon. In general, females flushed less readily as incubation progressed. One female (W-2U) pugnaciously defended her nest and would not fly away. Eggs could be removed from under her only at the risk of being pecked, clawed, and struck with the wings.

When any female teal at Minnedosa was flushed from the nest during the last few days of incubation, she fluttered off simulating broken wings and uttering plaintive quacks. If followed, such an injury-feigning female led the observer some distance from the nest.

Sowls (1955:98) found that desertion of nests by ducks was less frequent in Blue-winged Teal than in other duck species, a fact substantiated by my study. Desertion resulting from disturbance at the nest occurred most frequently from the time of nest scrape making to the laying of the fourth egg. Desertion after this point rarely occurred regardless of how often the nest was visited.

Severance of Pair-Bond

Pair-bond severance in Blue-winged Teal at Minnedosa was not abrupt. As incubation progressed, the female spent less time off the nest, members of the pair met less frequently, and the pair-bond weakened. The drake became less consistant in occupying the loafing site and ranged more and more widely. Simultaneous with severance of the pair-bond was a sharp decline in aggressive behavior of the drake toward intruding drakes.

The stage in the breeding cycle at which the male breaks off contact with his mate varies not only from species to species but also from individual to individual (McKinney, 1965:96). Pair-bond severance in Minnedosa Blue-winged Teal appeared to be a concomitant not of end-of-incubation stage but rather of lateness of season. Most Blue-winged Teal drakes at Minnedosa began abandoning females from mid- to late-June, prior to molting.

If a first nest was destroyed by a predator while the drake was still in attendance, the pair-bond remained intact and the female retained her original mate for the second nesting--if one was attempted. However, if a drake had already deserted the female when her nest was destroyed by a predator, she paired with a new drake before attempting to re-nest. Re-pairing with a new mate has also been recorded for the Gadwall (Gates, 1962) and the Pintail (Smith, 1963).

If an especially early nesting is successful the drake Blue-winged Teal may accompany the female with young. This I observed twice. Dzubin (1955) and J. H. Stoudt (per. comm.) reported instances of Mallard drakes attending young broods with their mates.

If a late Minnedosa Blue-winged Teal nesting (or re-nesting) was unsuccessful and the drake was still in attendance, the pair-bond was sometimes in force during the early part of the molting period. In 1967 and 1968 I several times observed a molting drake that had not yet lost his powers of flight and that was still strongly attached to his mate. Whether this pair-bond was maintained during migration, on the wintering ground, and into the following breeding season I do not know. Johnsgard (1968:52) believed that there is "little remating with the same individuals, owing to the break-up of pairs in late spring, the high annual mortality rate, and a general shuffling of flocks during migration."

Hatching

Little is known about the actual hatching process of ducks in the wild; few hatching nests have been observed to completion under natural conditions. Bent (1923:115) wrote that Blue-winged Teal ducklings hatch "almost simultaneously, or at least within a few hours." Bennett (1938:51) reported that "within four hours after the first egg was pipped all of the young had hatched (except dead or weak ones)."

At the Delta marsh, Sowls (1955:144) found that "all eggs of each clutch began pipping at the same time, and all young emerged within an hour of each other." Glover (1956) reported that young Blue-winged Teal pipped, hatched and vacated the nest in one day's time.

The pipping and hatching period of Blue-winged Teal in the Minnedosa area was longer than that reported by the four just-mentioned authors. According to my observations, all eggs in a clutch pipped simultaneously or nearly so and remained in this condition for a period of 20 to 24 hours before the first duckling emerged. The actual emergence from the egg shell of all ducklings in the brood required at least twelve hours. Thus the period from pipping to complete hatching for a clutch of Blue-winged Teal was 32 to 36 hours.

Once all the young of a clutch had hatched, they remained in the nest six to twelve hours before being led to water by the mother duck. The time period from pipping to nest departure was as much as 48 hours.

A female with recently hatched young might remain at the nest incubating a few remaining addled eggs. In one case at Minnedosa, a female teal (W-2U) returned to her nest after four of her nine eggs were destroyed by a predator. One day later, one duckling hatched but W-2U continued to incubate for an additional 25 hours. She then abandoned the four remaining addled eggs and took the one duckling to water.

Re-nesting

Ducks normally produce one brood a year but will often attempt a second nesting if the first nest is destroyed. Singleton (1953) reported a Mottled Duck (Anas fulvigula) that made five nesting attempts before bringing off a successful brood. Bennett (1938:58) believed that re-nesting attempts were recognizable by (1) smaller clutch size, (2) less down in the nest, (3) and lateness of season. Sowls (1955:131) believed that clutch size was not a valid criterion for distinguishing first nests from re-nests because of a wide range of individual variation. Individual marking of nesting ducks is the only way to secure accurate re-nesting information.

Re-nesting Interval

Continuous laying may occur when nests are broken up during the laying period. Sowls (1955:134-135) reported one Blue-winged Teal that laid eighteen eggs on eighteen consecutive days -- five eggs in the first nest, which was broken up, and thirteen in a second nest.

A female teal may wait a few days after the first nest has been destroyed before attempting to re-nest. This time period between destruction of the first nest and the laying of the first egg in the second nest is known as the re-nesting interval. Sowls (1955:133) found that the re-nesting interval was directly correlated with the stage of incubation at which the nest was destroyed, namely, three days plus 0.62

of a day for each day of incubation. It is doubtful whether this figure can be applied in all cases. One female Blue-winged Teal in the Minnedosa area whose first nest was destroyed on 19 June 1968, after four days of incubation, waited nineteen days before beginning egg-laying in a second nest on 8 July 1968.

Two well documented cases of Pintails re-nesting after the loss of their newly hatched broods have been reported (Sowls, 1955:136). At Minnedosa, two female Blue-winged Teal that lost their broods at the nest or enroute to water made no attempt to re-nest.

Location of "Re-nests"

Little is known about the location of "re-nests" of Blue-winged Teal. Sowls (1955:137) reported five instances of Blue-winged Teal re-nesting at Delta; the distances between first nests and "re-nests" were a maximum of 405 yards, a minimum of 135 yards, and an average of 270 yards. During the course of my study only three marked pairs were known to re-nest. The maximum distance between first nest and "re-nest" was 880 yards, the minimum distance, 200 yards.

The few large meadows surrounded by expansive wetland marsh at Delta may tend to concentrate ground-nesting ducks somewhat, whereas teal in the Minnedosa area are of necessity more scattered due to farming practices. Small concentrations of duck nests (clusters of

three to six nests) were noted at Cheyenne Bottoms in Kansas in the peripheral meadows (McHenry, 1965:22); the same phenomenon may account for closer re-nesting attempts at Delta.

Percentage of Re-nesting

Bennett (1938:58) estimated that forty percent of the Blue-winged Teal that lost their first nest attempted a second nest. Sowls (1955:139), working with marked ducks of several species, found the Pintail to be the most persistent re-nester, with 19 of 62 (30%) hens attempting second nests, whereas the Blue-winged Teal was the least persistent, with only 5 of 88 (6%) hens attempting second nests. Strohmeyer (1967) found that no first-year hen Blue-winged Teal re-nested but that 50% of the hens known to be more than a year old did so. In the Minnedosa area only three of 41 Blue-winged Teal hens (7.3%) attempted second nests.

Nest destruction with few attempts at re-nesting may result in large gatherings of paired ducks on the breeding grounds late in the nesting season. Stoudt and Davis (1948), Sowls (1955:152), and McHenry (1965:19) have commented on these late season flocks of paired birds. Environmental conditions unfavorable for nesting (or re-nesting) contribute to such flocking.

Predation

Many waterfowl production studies have shown that the majority of all nesting attempts are unsuccessful due to predation (Kalmbach, 1937, 1939; Sowls, 1948; Glover, 1956; McHenry, 1965). Predation losses suffered in the Minnedosa area were as follows: (1) 10 of 18 nests (55.5%) were destroyed by predators in 1967; (2) 17 of 21 nests (80.9%) were destroyed by predators in 1968.

Predator Species

The four principal predator species in the Minnedosa area were: (1) Red Fox (Vulpes fulva), (2) Raccoon (Procyon lotor), (3) Striped Skunk (Mephitis mephitis), and (4) Common Crow (Corvus brachyrhynchos).

In 1968, Section 28 supported two red fox litters. This species was feeding primarily on ducks and duck eggs. A local farmer reported finding duck wings and legs scattered around a fox den; there was evidence that 27 adult ducks, of several species, had been killed by this fox family. On several occasions I found evidence that a female teal had been killed while incubating. Peter Ward of the Delta Waterfowl Research Station believes that in the Delta meadows foxes selectively and methodically hunt incubating ducks (per. comm.).

The raccoon is a relatively new waterfowl predator in the Minnedosa region. This animal, traditionally a resident of the south, is gradually pushing its range northward (Lynch, 1967). This range extension into areas where winters are severe has resulted, at least in part, from availability of wintering dens. Big brush piles from land clearing and vacant farmsteads, both recent developments, are providing the raccoon with excellent wintering dens. Raccoon tracks around many destroyed duck nests indicated that this species was a serious predator in the Minnedosa region.

Partial Predation

Although complete or partial predation of a nest generally resulted in abandonment of that nesting attempt, female ducks may occasionally return to partially destroyed nests and continue to incubate; this was observed twice in my Minnedosa study. Two nests in the process of hatching were partially destroyed; the females returned to complete the incubation and brooding process and the remaining fertile eggs were hatched successfully.

Human Disturbance and Nest Predation

The relationship of human disturbance at the nest to nest predation has long been debated. Undoubtedly some predators are attracted by human intrusion and may follow human trails to nests. During this

study, it appeared that chances of nest predation were only slightly increased, if at all, by human intrusion; precautions were taken against leaving obvious trails around nests. Hammond and Forward (1956), in a study of the causes of nest predation, concluded that when reasonable care was exercised, human intrusion was usually of minor consequence. It is of interest to note that the few nests which were most disturbed during the course of extensive observations and photography work were not destroyed by predators.

Brood Predation

Newly hatched ducklings in the nest and enroute to water were extremely vulnerable to predation. I observed two cases in which the young successfully hatched but did not make it to water with the mother duck. Although I saw both females on several occasions after the hatching of their broods (1) I never saw the young with them; (2) parental behavior was never exhibited; (3) the females moved to widely scattered potholes, movements unlikely to be made with young broods. It is probable that both broods -- one of 11 young, the other of 3 young (nest had been partially destroyed earlier)-- were destroyed by a predator. Both nests were within 120 yards of water.

Eggshell Carrying

No evidence has been found that female ducks remove eggshells from nests at hatching time-- a common practice among many altricial birds. Egg caps and shell fragments from a successful hatch are left at the nest when it is abandoned by the mother duck and her brood.

However, eggshell carrying has been noted on rare occasions for the Mallard (Oates, 1905:33; Hochbaum, 1944:92), New Mexican Duck (Anas diazi) (Lindsey, 1946:491), Shoveler (Anas clypeata) (Hochbaum, 1944:92; Sowls, 1955:104-105), and Pintail (Sowls, 1955:104-105). In three such instances, Sowls (1955) found that the female duck was removing eggshells from a partially destroyed nest. This may be a nest sanitation maneuver following egg breakage in the nest.

At Delta, in 1966, I observed a female Green-winged Teal (Anas carolinensis) carrying eggshells and dropping them in a small pond. The condition of the four eggshells, later retrieved from the water, indicated that the nest had been at least partially destroyed by a predator.

In 1968 I observed an eggshell-carrying incident in the Minnedosa area. An individually-marked female Blue-winged Teal, in the fourth day of incubation returned twice to her freshly destroyed nest, each time carrying away a crushed eggshell. The nest had been completely destroyed; it is difficult to imagine what function eggshell removal would accomplish in such a situation.

Pair Reaction to Predation

I observed that if the drake was still in attendance at the time of nest predation, the pair remained on the original home range for several days. If re-nesting occurred, the pair abandoned the original home range and established a new one up to half a mile away. If re-nesting did not occur and the pair-bond remained intact, the pair wandered erratically over the breeding area for a time and went into molt.

One case of nest destruction occurred after the male had abandoned the female. Within a few days the female had paired with a new drake and had established a new home range which overlapped, in part, her original home range.

Polygamy

No anseriform bird is known to be regularly polygamous in the wild; one male mating with one female is the general rule. Polygamy does occur in Mallards in captivity (Borden and Hochbaum, 1966:81). Polygamy, in a wild population, has been reported for the Maccoa Duck (Oxyura maccoa), a stiff-tailed duck of eastern and southern Africa (Weller, 1964). Drewien (1968), in his unpublished Master's Thesis, reported observing a trio of Blue-winged Teal; both females were nesting. There are no other references to polygamy in the literature pertaining to the Blue-winged Teal; however, I observed one such instance in the Minnedosa area in 1968.

From 17 June to 29 June I observed a trio of individually-marked birds, two females and one male. Although I did not observe copulation, the behavior of the birds left no doubt in my mind that both females were mated to the same drake. Both females were nesting simultaneously near the same one-acre pothole. Pair-bonds were strong. The drake was tireless in defending both females. The trio maintained a harmonious, close-knit group. Unfortunately, both nests were destroyed by predators. A detailed account of this trio follows.

RW-13 and RW-25, both females that had been hatchery-reared at Delta, were individually-marked, banded, and released by me on pothole #45 in the Minnedosa area in early May 1968. Both were first year adults, capable of flight. In all respects they behaved as wild-reared birds do, except, perhaps, that they were less wary of human beings. Y-7, a wild-reared drake, the mate of the two females, was trapped by me on pothole #55a, individually-marked, and released on pothole #55a in mid-June 1968.

This trio I first observed as such on June 17; the group fed on pothole #55a as a compact group. No aggression within the trio was discernible. The drake was extremely active in defending both females. Noteworthy is the fact that the trio inhabited the pothole at which I had released the drake.

On June 21, I flushed RW-13 from a nest containing one egg. The nest was on the south side of the one-acre pothole (#55a), fifteen

feet from the water. On the same day, I discovered RW-25 on a nest with ten eggs. This nest was on the west side of the same pothole (#55a), ten feet from the water's edge. The nests were 200 feet apart.

As RW-25 flushed from the nest, she flopped awkwardly. I caught her easily. The right wing was missing; only one white axillar indicated where the wing had once been. A clean amputation at the shoulder was completely healed. Perhaps the wing had been lost by flying swiftly into a power line (see photo 3).

Photo 3. One-winged Blue-winged Teal hen (RW-25) captured on nest with ten eggs near Minnedosa, Manitoba, on 21 June 1968. This hen was a member of a trio: one drake mated to two hens.

In the days that followed, I made close observations of this trio. It was obvious that Y-7 had developed strong pair-bonds with both RW-13 and RW-25. All the activities of the trio were confined to pothole #55a.

Y-7 attended and defended whichever female (RW-13 or RW-25) happened to be off her nest. If both females were present, the group generally fed as a trio with no signs of conflict among them. No other drake was allowed to approach either female; both were defended with equal vigor by Y-7. This meant that if the females moved apart, which they occasionally did, Y-7 was hard pressed to defend both of them. On one occasion the females rested on opposite shores, 50 yards apart, while Y-7 frantically swam back and forth from one female to the other.

RW-25, being flightless yet incubating ten eggs, was seen by me only on pothole #55a. On two occasions RW-13 and Y-7 flew from #55a to feed on #49a; both returned to #55a within a few minutes.

Y-7 escorted his mates all the way back to their nests after each feeding, bathing, and preening session. RW-25, since she could not fly, walked to her nest followed on foot by Y-7. RW-13 flew from the water to her nest accompanied on the wing by Y-7. On one occasion both females returned to their nests at the same time. Y-7, on the west shore with RW-25, flew across to the south shore to follow RW-13 who was already in the air. He changed course, returned to RW-25, and followed her into the grass--but only momentarily. He then flew back to RW-13 who had by this time dropped onto her nest. Whereupon he circled and flew back to RW-25, who by now was settling on her nest. Unable to escort both females at the same time in opposite directions, he vacillated between the two females in a frenzy of activity.

On the morning of June 29 I discovered that the nest of flightless RW-25 had been destroyed by a predator. RW-25 herself had escaped the predator, however. She spent the day on the water of pothole #55a with Y-7. I did not see RW-25 again after June 29; since she had only one wing it is likely that she fell prey to a predator. A thorough search of the surrounding area showed no trace of her. RW-13's nest contained ten eggs on June 29; on July 13 I found that this nest, too, had been destroyed by a predator. I did not see RW-13 and Y-7 anywhere following the destruction of their nest. Subsequent searches of the area gave no clue to their disappearance.

CHAPTER V - MOLTING BIOLOGY

Johnsgard (1968:56) and Hochbaum (1944:114-119) have reported "molt migrations" in which "diver ducks" (Aythyinae) band together, leave the breeding grounds, migrate to large lakes and there pass the flightless period of their molt. Wetmore (1921), Hochbaum (1944:119-124), Sowls (1955:153-154), and Oring (1962) reported that "puddle ducks" (Anatinae) congregate on large marshes to undergo their post-nuptial molt. There seems to be no reference in the literature to drakes of either subfamily (Anatinae or Aythyinae) remaining on their breeding grounds to molt. Evans and Black (1956:43), working in the Waubay region of South Dakota, reported that "moulting ducks on the study area were a rarity, and none were seen until 1952 when three flightless hens were found in deep marshes." Blue-winged Teal in the Minnedosa pothole district did not engage in "molt migrations" but instead molted on the breeding grounds. Many drakes spent their flightless period within the confines of their original home ranges.

As the nesting season progressed and pair-bond severance occurred, radical changes in drake behavior and plumage took place. Drakes no longer frequented loafing sites with regularity, strife and sexual activity waned, and the birds once again became gregarious, banding together in small flocks. At the same time, the bright male plumage was replaced gradually by the rather nondescript female-like eclipse plumage, which gave the birds a rather mottled appearance.

This post-nuptial molt of the drakes into the eclipse plumage began in mid-June. By early July molting birds retired to the bulrush and cattail beds, became quite secretive, very quickly shed all of their flight feathers and lost their powers of flight. One suddenly became aware of the absence of flying ducks and the scarcity of birds on open water but an investigation of emergent aquatic vegetation revealed bands of flightless molters or "flappers."

Post-Nuptial Molt and the Eclipse Plumage

As the drakes molted into their eclipse plumage, the bright nuptial feathers of the breast, flanks, scapulars and upper tail coverts were replaced in a sporadic, irregular sequence. Thus during the last two weeks in June they gradually donned a female-like plumage (the eclipse plumage) but often maintained a faint white facial crescent in front of the eye. The white crescent was the last of the nuptial plumage to be molted before they lost their flight feathers (remiges) all at one time and entered the flightless or "flapper" period (see photo 4 showing molt sequence). Johnsgard (1968:67) pointed out that "the important flight feathers are not lost until the male is well into his eclipse plumage and is protectively colored."

On 15 July 1968 I flushed a male teal in molt from a cattail bed. After becoming airborne, he lost his powers of flight dramatically, and tumbled into the water, his wings flopping frantically amid a shower

of shedding flight feathers. On that same day (15 July) I observed two other male teals lose flight feathers as they flopped across the surface of the water; they never became airborne. Molting birds at Minnedosa were usually so well hidden and secretive that one seldom witnessed the loss of remiges.

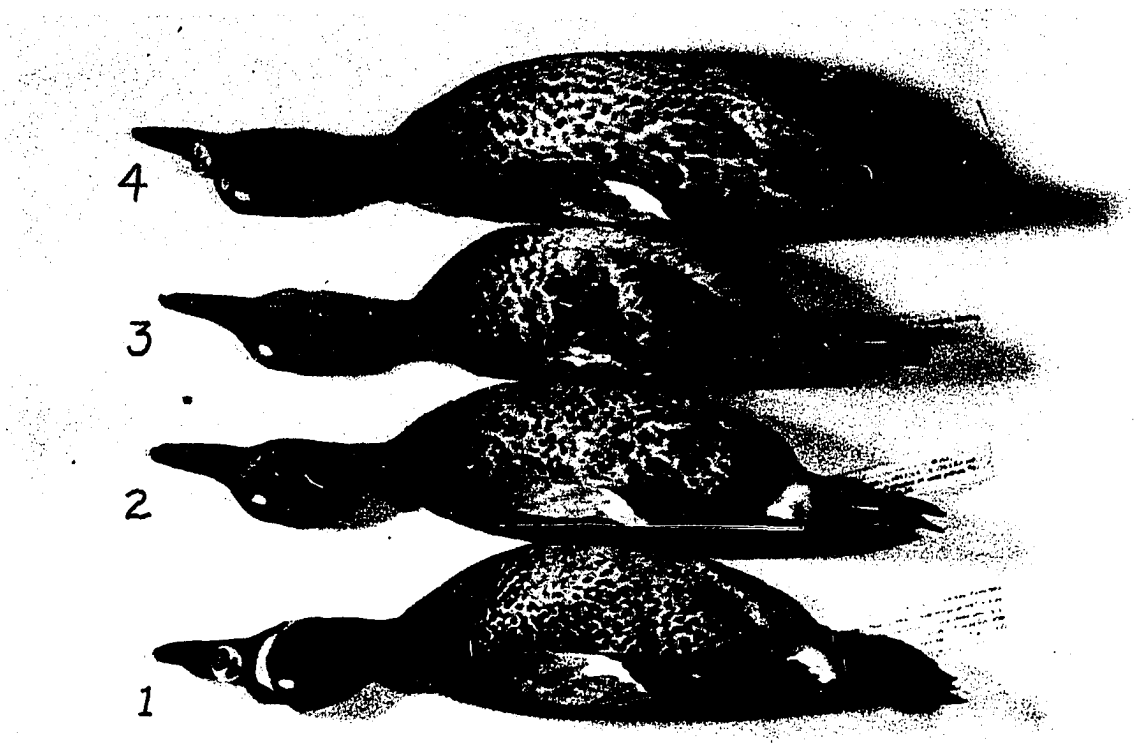


Photo 4. Four male Blue-winged Teal specimens collected in the Minnedosa area, 1968, showing sequence of molt from nuptial plumage into eclipse plumage. Drake 1 is in full nuptial plumage. Drake 2 still has powers of flight but is beginning to lose the speckled flank feathers; notice dark feathers replacing the white crescent feathers. Drake 3 is in the flightless stage and has lost the white flank patch and facial crescent; female-like eclipse plumage is nearly complete. Drake 4 is coming out of molt but is not yet able to fly.

Duration of Molt

Hochbaum (1944:121) reported the flightless period of captive Blue-winged Teal to be two and one half weeks but suggested that three or four weeks was perhaps the usual period. The flightless period for captive Pintails is close to four weeks (Sowls 1955:153). Johnsgard (1968:67) stated that "puddle ducks" have a flightless period of three to four weeks. Individually-marked Blue-winged Teal molting in the Minnedosa pothole district were flightless from 26 to 36 days. The flightless period for the population as a whole extended from approximately July 10 to August 10.

Molting Areas

Molters frequented both large and small potholes on the Minnedosa breeding grounds. The size of the pothole did not appear to determine its suitability as a molting area. All potholes used for molting supported dense beds of emergent vegetation. If the bulrush or cattail beds were stranded by a lowering water level, the molting birds abandoned the drying pothole and moved overland to a more permanent water area. If the water level was constant and the birds were not disturbed, the entire molting period was passed on the one pothole.

The number of birds in a molting flock depended somewhat on the size of the pothole. Smaller potholes, less than one-half acre in

size, harbored one to ten molting teal while larger potholes harbored as many as one hundred molting teal.

Specific potholes were not necessarily used as molting areas on consecutive years; pothole use depended on water level and vegetative growth. In 1966 only two potholes on Section 28 were used as molting areas; in 1967 the water level on Section 28 was very low, beds of emergent vegetation were exposed on mud flats, and no potholes were used for molting. However, large permanent potholes on neighboring sections did hold molting birds, indicating there was slight local movement in reaching a suitable molting habitat. In 1968 six potholes on Section 28 were used for molting.

Molting Populations

During 1966 and 1968 the molting population on Section 28 was of about the same size as the breeding population. There was no indication that the local population was augmented by birds from other areas or that local birds moved elsewhere to molt.

Individually-marked birds captured during the 1968 molting period gave evidence that resident breeders and a few non-breeders were molting on the study area. During the first part of the molting season males predominated; later, as broods hatched, the females began to molt (see photo 5).

Photo 5. Flightless molting female Blue-winged Teal (R-T3) captured with eleven other molting Blue-winged Teal (ten males, one female) on pothole #100, Section 28, near Minnedosa, Manitoba, on 22 July 1968. R-73 nested not far from pothole #100 on Section 28.

Species Composition

It is significant that only one anseriform species, the Blue-winged Teal, was found by me to be molting in the Minnedosa pothole district during the three years this project was conducted. Apparently the other waterfowl species of the area (Mallard, Pintail, Gadwall, Green-winged Teal, Anas carolinensis; Baldpate, Mareca americana; Redhead, Aythya americana; Canvasback, Aythya valisineria; Ruddy Duck, Oxyura jamaicensis) engaged in "molt-migrations," moving off the breeding grounds to molt in other areas. I found no evidence to

suggest that Blue-winged Teal engaged in "molt-migrations;" they did in fact molt on their breeding grounds. The short movements of some Blue-winged Teal to local potholes suitable for molting certainly were not noticeable.

Molting Behavior

Flightless adult Blue-winged Teal at Minnedosa seldom ventured from the cattail and bulrush beds except to feed at dawn and dusk. Even at these times they seemed reluctant to venture far out into open water and often skittered for cover at the slightest provocation, wings flailing the air. If pursued, flightless molting birds frequently dove and swam long distances under water, surfacing only their heads in the safety of a bulrush or cattail stand. Hiding birds stretched out their head and neck and sank low in the water with only the top of the head and part of the back breaking the surface. Molting birds frequently sneaked through aquatic vegetation in this semi-submerged position.

Molting birds were extremely gregarious during the flightless period. They always kept in tight groups showing no signs of aggression inter se. This flightless period was a secretive and quiet time; not once did I hear a flightless Blue-winged Teal vocalizing even when cornered or trapped.

Post-molt Movements

Once primaries and secondaries had grown back and the birds were once again capable of flight, the Minnedosa birds remained on the breeding grounds for another month (last half of August and first half of September) feeding in loose flocks of five to twenty birds. As the birds left the breeding grounds, larger flocks (20-40 birds) built up on the larger potholes. In late August and early September thousands of Blue-winged Teal, already in eclipse plumage, converged on the Delta marsh. This large and rather sudden influx of Blue-winged Teal occurred at the same time teal were moving out of the Minnedosa area. Thus it appears that, following the post-nuptial molt, Blue-winged Teal move from the pothole breeding grounds to large marshes, e. g. Delta, before finally departing on the fall migration.

The molt out of the eclipse plumage into the nuptial plumage occurs wholly on the wintering grounds. Hochbaum (1944:113) stated that "captive Blue-winged Teal drakes started to change in early December, but were not in full plumage until January." In regard to wild non-captive birds, Bennett (1938:7) reported that "males begin showing their nuptial plumage during December. By March the molt is complete and the males are in full nuptial plumage."

CHAPTER VI - SUMMARY

Despite a wealth of literature pertaining to waterfowl, little is known about the daily movements of individual ducks during the breeding and molting seasons. This study investigated the breeding and post-breeding movements of Blue-winged Teal (Anas discors) in southwestern Manitoba in 1966, 1967, and 1968 under the auspices of the Delta Waterfowl Research Station, Portage la Prairie, Manitoba.

Territoriality, aggression, and spacing of Blue-winged Teal on their breeding grounds was thoroughly investigated. Individually-marked birds, both wild-trapped and hatchery-reared, were used.

Classical territoriality has been defined as defense of an area. I believe, however, that waterfowl territoriality is actually defense of the female and consequently of the area around her, wherever she may be. Because the pair-bond is strong, the territory of a drake includes his mated hen and her immediate vicinity; it has no fixed boundaries but moves with the hen. The area per se apparently carries no special significance to the drake as a place to be defended; rather, the female is the object of defense whether she is actually with the drake or not with him but on a nest nearby.

The one square mile study plot near Minnedosa contained 164 "pothole" water areas averaging 1.49 acres in size. The plot supported 36 breeding pairs of Blue-winged Teal in 1967. A seeding program boosted the breeding population to 55 pairs in 1968. This increase in

population had no apparent effect on the size of home ranges. Based on observations of 41 marked pairs, the home range averaged 16.98 acres (an average of 15.47 acres in 1967 based on 18 pairs, of 18.49 acres in 1968 based on 23 pairs). This is considerably smaller than any previously reported Blue-winged Teal home range. Apparently home range size varies throughout the species' range. Fewer, more widely scattered water areas result in larger home ranges; many close-set water areas result in smaller home ranges. Population density does not appear to affect home range size. Considerable overlapping of home ranges and alternate sharing of water areas occurred on the Minnedosa study area. Unpaired drakes did not engage in defensive behavior. Threat and avoidance was the most common interaction between a defending drake and an intruder. This resulted in spacing that in my opinion has anti-predator survival value.

Although Sowls (1955:31) reported homing of female Blue-winged Teal on the Delta marsh, I found no evidence that any female returned to the Minnedosa study plot two years in succession.

Movements of Minnedosa pairs were random and unrestricted prior to nest-site selection. Males accompanied mates in searching suitable habitat for nest-sites. Once the nest-sites were selected, pair movements were orderly and restricted to home ranges. Home ranges included one to ten potholes with an average of 4.4 potholes per home range.

Pair-bond severance occurred in Minnedosa Blue-winged Teal from mid- to late-June regardless of the stage of incubation. At that time males flocked together and went into molt. Re-pairing for a second nest attempt occurred if the drake deserted the female prior to loss of the first nest. Predation of the second nesting attempt, with the drake still in attendance, tended to strengthen the pair-bond--a bond that continued into the molt.

One case of polygamy--a drake mated to two hens--was observed, a phenomenon seldom encountered in the Anatidae. The drake defended the two hens vigorously. Both nests were destroyed by predators.

At Minnedosa Blue-winged Teal did not engage in post-nuptial "molt migrations" in 1967 and 1968. I observed no such mass movement from the breeding grounds to a large marsh or lake as has been reported for many duck species. I repeatedly observed Blue-winged Teal undergoing the molt and flightless period on their breeding grounds, often within their original home ranges. There was no indication that the local population of molting birds (both male and female) was augmented by birds from other areas or that local birds moved elsewhere to molt. Waterfowl molting on their breeding grounds is a phenomenon heretofore unreported.

LITERATURE CITED

Altum, Bernard. 1868. Der Vogel und Leben. Münster. 240 pp.

Bartonek, James C., and Charles W. Dane. 1964. Numbered nasal discs for waterfowl. J. Wildl. Mgt. 28(4):688-692.

Bennett, Logan J. 1938. The Blue-winged Teal--Its Ecology and Management. Collegiate Press, Inc. Ames, Iowa. 144 pp.

Bent, Arthur Cleveland. 1923. Life histories of North American wild fowl, order Anseres (Part 1). U.S. Natl. Mus. Bull. 126. 244 pp.

Bezzel, E. 1959. Beitrage zur Biologie der Geschlechter bei Entenvogeln. Anz. Orn. Ges. Bayern 5:269-355.

Borden, Richard, and H. Albert Hochbaum. 1966. Gadwall seeding in New England. Trans. 31st N.A. Wildl. and Nat. Resources Conf. pp. 79-88.

Drewien, Roderick C. 1968. Ecological Relationships of Breeding Blue-winged Teal to Prairie Potholes. Unpubl. M.S. Thesis, South Dakota State University Library, Brookings, South Dakota.

Dzubin, Alex. 1955. Some evidences of home range in waterfowl. Trans. 20th N.A. Wildl. and Nat. Resources Conf. pp. 278-298.

Dzubin, Alex. 1957. Pairing display and spring and summer flights of the Mallard. Blue Jay 15:10-13.

Emlen, J. T., Jr. 1957. Defended area? -- A critique of the territory concept and of conventional thinking. Ibis 99:352.

Evans, C. D., A. S. Hawkins, and W. H. Marshall. (orig. publ. not dated; corrected to show 1952 publ. date) Movements of waterfowl broods in Manitoba. U.S. Fish and Wildlife Service, Spec. Sci. Rept.: Wildlife No. 16, 47 pp.

Evans, C. D., and K. E. Black. 1956. Duck production studies on the prairie potholes of South Dakota. U.S. Fish and Wildlife Service, Spec. Sci. Rept.: Wildlife No. 32, 59 pp.

Furniss, O. C. 1935. The sex ratio in ducks. Wilson Bull. 47:277-278.

Gates, J. M. 1962. Breeding biology of the Gadwall in northern Utah. Wilson Bull. 74:43-67.

Glover, F. A. 1956. Nesting and production of the Blue-winged Teal (Anas discors Linnaeus) in northwest Iowa. J. Wildl. Mgt. 20:28-46.

Hammond, M. C., and G. E. Mann. 1956. Waterfowl nesting islands. J. Wildl. Mgt. 20:345-352.

Hammond, M. C., and W. R. Forward. 1956. Experiments on causes of duck nest predation. J. Wildl. Mgt. 20(3):243-247.

Harris, S. W. 1954. An ecological study of the waterfowl of the Potholes Area, Grant County, Washington. Amer. Midl. Nat. 52(2):403-432.

Hinde, R. A. 1956. The biological significance of the territories of birds. Ibis 98:340-369.

Hochbaum, H. Albert. 1944. The Canvasback on a Prairie Marsh. Wildl. Mgt. Inst., Washington, D. C., 182 pp.

Hochbaum, H. Albert. 1966. Contemporary drainage within true prairie of the glacial Lake Agassiz basin. In Life, Land and Water--Proceedings of the 1966 Conference on Environmental Studies of the Glacial Lake Agassiz Region; W. J. Mayer-Oakes, ed. pp. 197-204.

Hori, J. 1963. Three-bird flights in the Mallard. Wildfowl Trust 14th Ann. Rept. pp. 124-132.

Howard, H. Eliot. 1907-1914. The British Warblers--A History with Problems of their Lives. London, 6 vols.

Howard, H. Eliot. 1920. Territory in Bird Life. Murray, London. 308 pp.

Johnsgard, P. A. 1955. Courtship activities of the Anatidae in eastern Washington. Condor 57(1):19-27.

Johnsgard, P. A. 1968. Waterfowl: Their Biology and Natural History. Univ. of Nebraska Press, Lincoln. 138 pp.

Kalmbach, E. R. 1937. Crow-waterfowl relationships based on preliminary studies on Canadian breeding grounds. U. S. Dept. Agr. Circular 433, 36 pp.

Kalmbach, E. R. 1939. Nesting success: its significance in waterfowl reproduction. Trans. 4th N. A. Wildl. and Nat. Resources Conf. pp. 591-604.

Lack, David L. 1939. The Behaviour of the Robin. Part I. The life-history, with special reference to aggressive behaviour, and territory. Part II. A partial analysis of aggressive and recognitional behaviour. Proc. Zool. Soc. London 109A: 169-219.

Lindsey, Alton A. 1946. The nesting of the New Mexican Duck. Auk 63:483-492.

Low, J. B. 1945. Ecology and management of the Redhead, Nyroca americana, in Iowa. Ecol. Mon. 15:35-69.

Lynch, Gerry M. 1967. Long-range movement of a raccoon in Manitoba. J. Mamm. 48(4):659-660.

Mayr, Ernst. 1935. Bernard Altum and the territory theory. Proc. Linnaean Soc. New York 45-46:24-38.

McHenry, Merril G. 1965. Nesting Ducks of the Cheyenne Bottoms Waterfowl Refuge, Barton County, Kansas. Unpubl. M.S. Thesis, Kansas State Teachers College, Emporia, Kansas. 94 pp.

McKinney, Frank. 1965. Spacing and chasing in breeding ducks. Wildfowl Trust 16th Ann. Rept. pp. 92-106.

Munro, David A. 1963. Ducks and the Great Plains wetlands. Canadian Audubon 25(4):105-111.

Nice, Margaret Morse. 1941. The role of territory in bird life. Amer. Midl. Nat. 26(3):441-487.

Nice, Margaret Morse. 1943. Studies in the life history of the Song Sparrow. II. Trans. Linn. Soc. New York 6:1-328.

Noble, G. K. 1939. The role of dominance in the life of birds. Auk 56:263-273.

Oates, W. Coape. 1905. Wild Ducks, How to Rear and Shoot Them. Longmans, Green and Co., London.

Oring, Lewis W. 1962. Behavior and ecology of certain ducks during the postbreeding period. J. Wildl. Mgt. 28(2):223-233.

Oring, Lewis W. 1969. Summer biology of the Gadwall at Delta, Manitoba. Wilson Bull. 81(1):44-54.

Rogers, John P. 1964. A decoy trap for male Lesser Scaups. J. Wildl. Mgt. 28(2):408-410.

Singleton, J. R. 1953. Sect. II - Mottled Duck studies. Texas Coastal Waterfowl Survey. F. A. Report Series: No. 11. Texas Game and Fish Commission, Austin, Texas. pp. 85-128.

Smith, Allen G., Jerome H. Stoudt, and J. Bernard Gollop. 1964. Prairie potholes and marshes. In Waterfowl Tomorrow. Joseph P. Linduska, ed. U.S. Dept. of Interior. pp. 39-50.

Smith, R. I. 1955. The Breeding Territory and its Relationship to Waterfowl Productivity at Ogden Bay Bird Refuge. Unpubl. M.S. Thesis, Utah State. Agric. College, Logan.

Smith, R. I. 1963. The Social Aspects of Reproductive Behavior in the Pintail (Anas acuta acuta, L.). Unpubl. Ph.D. Thesis, Utah State Univ., Logan.

Sowls, Lyle K. 1948. The Franklin ground squirrel (Citellus franklinii) and its relationship to nesting ducks. J. Mamm. 29: 113-137.

Sowls, Lyle K. 1949. A preliminary report on renesting in waterfowl. Trans. 14th N. A. Wildl. and Nat. Resources Conf. pp. 260-275.

Sowls, Lyle K. 1955. Prairie Ducks - A Study of Their Behavior, Ecology and Management. Wildl. Mgt. Inst., Washington, D. C. 193 pp.

Stotts, V. D., and D. E. Davis. 1960. The Black Duck in the Chesapeake Bay of Maryland: breeding behavior and biology. Chesapeake Science 1:127-154.

Stoudt, Jerome H., and Floyd H. Davis. 1948. 1948 Waterfowl breeding ground survey north central region. In Waterfowl populations and breeding conditions -- summer 1948. U.S. Fish and Wildlife Service, Spec. Sci. Rept.: Wildlife No. 60, pp. 123-148.

Stoudt, Jerome H. 1952. Waterfowl breeding ground survey of Redvers Area, Saskatchewan. In Waterfowl populations and breeding conditions -- summer 1952. U.S. Fish and Wildlife Service, Spec. Sci. Rept.: Wildlife No. 21, pp. 52-60.

Strohmeyer, David LaVerne. 1967. The Biology of Renesting by the Blue-winged Teal (Anas discors) in Northwest Iowa. Unpubl. Ph.D. Thesis, Univ. Minnesota 135 pp.

Tinbergen, N. 1939. On the analysis of social organization among vertebrates, with special reference to birds. Amer. Midl. Nat. 21:210-234.

Tinbergen, N. 1957. The functions of territory. Bird Study 4:14-27.

Weller, M. W. 1964. The reproductive cycle. In The Waterfowl of the World, Vol. 4, London: Country Life.

Wetmore, Alexander. 1921. Wild ducks and duck foods of the Bear River Marshes, Utah. U.S. Dept. Agric. Bull. 936. 20 pp.