Plumage studies of the Blue-winged Teal, Anas discors L

Eldon Dean Greij

Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/rtd
Part of the Zoology Commons

Recommended Citation
https://lib.dr.iastate.edu/rtd/3739

This Dissertation is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
GREIJ, Eldon Dean, 1937-
PLUMAGE STUDIES OF THE BLUE-WINGED
TEAL, ANAS DISCORS L.
Iowa State University, Ph.D., 1969
Zoology

University Microfilms, Inc., Ann Arbor, Michigan
PLUMAGE STUDIES OF THE BLUE-WINGED TEAL, ANAS DISCORS L.

by

Eldon Dean Greij

A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Major Subject: Zoology (Ecology)

Approved:

Signature was redacted for privacy.

In Charge of Major Work

Signature was redacted for privacy.

Head of Major Department

Signature was redacted for privacy.

Dean of Graduate College

Iowa State University
Of Science and Technology
Ames, Iowa
1969
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>PART I. SEQUENCE AND DESCRIPTIONS OF PLUMAGES</td>
<td>3</td>
</tr>
<tr>
<td>METHODS</td>
<td></td>
</tr>
<tr>
<td>Hand-reared Ducklings</td>
<td>4</td>
</tr>
<tr>
<td>Wild-trapped Birds</td>
<td>5</td>
</tr>
<tr>
<td>Experimental Birds</td>
<td>6</td>
</tr>
<tr>
<td>Dying of Plumages</td>
<td>7</td>
</tr>
<tr>
<td>Molt Rates</td>
<td>7</td>
</tr>
<tr>
<td>Terminology of Plumages and Molts</td>
<td>8</td>
</tr>
<tr>
<td>Terminology of Feather Patterns</td>
<td>10</td>
</tr>
<tr>
<td>NATAL PLUMAGE</td>
<td>12</td>
</tr>
<tr>
<td>Description of Natal Ducklings</td>
<td>12</td>
</tr>
<tr>
<td>Natal plumage</td>
<td>12</td>
</tr>
<tr>
<td>Color of the soft parts</td>
<td>15</td>
</tr>
<tr>
<td>JUVENAL PLUMAGE</td>
<td>20</td>
</tr>
<tr>
<td>Pre-juvenal Molt</td>
<td>20</td>
</tr>
<tr>
<td>Loss of natal down</td>
<td>20</td>
</tr>
<tr>
<td>Appearance of juvenal down</td>
<td>21</td>
</tr>
<tr>
<td>Appearance of juvenal contour feathers</td>
<td>22</td>
</tr>
<tr>
<td>Description of Juvenal Plumage</td>
<td>23</td>
</tr>
<tr>
<td>Feather Patterns of Juvenal Teal</td>
<td>25</td>
</tr>
<tr>
<td>Maturation of Primaries</td>
<td>32</td>
</tr>
<tr>
<td>FIRST BASIC PLUMAGE</td>
<td>35</td>
</tr>
<tr>
<td>First Pre-basic Molt</td>
<td>36</td>
</tr>
</tbody>
</table>
Observations of wild-trapped birds 36
Observations of captive birds 38
Descriptions of the First Basic Plumage 39
Feather Patterns of the First Basic Plumage 40
First Basic Down 45
PLUMAGES OF ADULT TEAL 47
Molts of Adult Teal 47
  Pre-alternate molt 47
  Effect of age on pre-alternate molt 51
  Pre-basic molt 53
Description of Adult Plumages 55
  Alternate plumage 55
  Basic plumage 58
Feather Patterns of Adult Teal 59
  Chest-center, chest-side, and side 59
  Belly, flank, and lower tail coverts 62
  Dorsal lower neck, interscapulars, back, and rump 65
  Upper tail coverts, tail, and scapulars 68
CHRONOLOGY OF MOLTS 72

PART II. THE INFLUENCE OF SEX HORMONES ON PLUMAGES AND MOLTS 76
INTRODUCTION 77
METHODS 79
  Feather Plucking 79
  Hormone Administration 79
  Gonadectomy 82
THE EFFECTS OF GONADECTOMY, DIETHYL STILBESTROL, AND TESTOSTERONE PROPIONATE ON FEATHER REGENERATION OF IMMATURE BLUE-WINGED TEAL 85
INTRODUCTION

The scientific study of plumages and molts of birds began with the classic works of Dwight (1900; 1902). Although many species have been studied since then, few have been examined in detail and few are based on specimens representing all plumages. These papers also are inconsistent in terminology and interpretation of the relationships between different plumages.

The purpose of this study was to describe the plumages and molts of the Blue-winged Teal and to examine, experimentally, some aspects of sexual dimorphism in this species. Plumage and molts were described from hand-reared teal, wild-trapped birds, captive birds, and museum skins. Experiments to study the hormonal influences of sexual dimorphism involved administration of sex hormones and gonadectomy. Feathers were plucked from several areas prior to the initiation of these experiments to insure feather growth during experimentally increased hormone levels.

The Blue-winged Teal was selected for this study because it is dramatically sexually dimorphic, relatively available, and easily handled in captivity. In addition, its plumages and molts have not been studied in detail and its first basic plumage, although suspected by several workers, has not been documented. Blue-winged Teal are abundant spring and fall migrants in Iowa and commonly nest in suitable areas throughout
the state but are especially abundant in northwest Iowa.

Brief descriptions of the plumages and molts of the Blue-winged Teal were given by Millais (1902), Phillips (1924), Bennett (1938), Witherby et al. (1939), Kortright (1942), and Delacour (1956). Dane (1965) gave brief plumage descriptions and made several interesting correlations between pre- and post-nuptial molts and the reproductive cycle and migration.

Migrating teal were captured by bait-trapping in northwest Iowa (Clay and Palo Alto Counties) during spring, 1967, and fall, 1967 and 1968. Observations on wild birds and nest-trapping of females continued during the summer, 1967. Eggs were collected and hatched during the summer, 1967, and the ducklings raised for the study of natal, juvenal and adult plumages. These birds also were used for experimental purposes. Additional birds were obtained from the Northern Prairie Wildlife Research Center, Jamestown, North Dakota, during late summer, 1967 and 1968.
PART I. SEQUENCE AND DESCRIPTIONS OF PLUMAGES
METHODS

Hand-reared Ducklings

The natal plumage and pre-juvenal molt were described from ducklings hatched and reared in captivity. These ducklings also were used in studying the juvenal and first basic plumages and later were used for experimental purposes.

Blue-winged Teal eggs were collected from deserted nests from 5 June to 31 July, 1967, and brought to the hatching facilities. Eggs were incubated by two White Rock hens placed in wire mesh pens containing food, water, and a nest box filled with straw. The eggs were candled at three day intervals and moistened twice daily. At the onset of pipping, eggs were placed in a box kept at 100 F and were covered with moist cotton. The heat source was a 250 watt infrared heat lamp.

After the ducklings dried, they were placed in an enclosure with a 30 inch diameter which contained commercial feed (Purina granulated non-medicated Chick-Grower) and a pie-plate filled with water and duckweed (Lemna spp.). This pen also was heated with an infrared heat lamp.

When the ducklings were 10 to 14 days old, they were placed in a circular pen about five feet in diameter. This pen contained commercial feed, water, and duckweed. An infrared heat lamp was suspended over the edge of the pen so that heat was available to the ducklings. A six foot square pen built from screen doors was placed in a fenced-in grass yard.
where older ducklings were placed during the day. The ducklings were placed in a predator-proof outdoor pen containing commercial feed and water during mid-August when they were at least one month old.

These young birds were transferred to a barn in Ames, Iowa, in September where all captive birds were held during the study.

Wild-trapped Birds

Plumage and molt information also were obtained from 304 wild-trapped birds (Table 1). The nest-trapped females included some recaptures of the same female at different times.

The bait traps were about 6 ft long, 5 ft wide, and 5 ft high and made from 1 inch mesh poultry fence. They had a 50 ft lead which was baited with cracked corn. Two kinds of nest-traps were used: a Salyer trap (Salyer, 1962) was used for laying birds and a Weller trap (Weller, 1957a) was used for incubating birds. The Salyer trap sets flat on the ground next to the nest and is camouflaged with grass. The mechanism is a spring loaded bail that can be triggered by pulling a string at some distance. The Weller trap is a wire-mesh cylinder about 30 inches high and 18 inches wide with a sliding door at the bottom that sets over the nest. The described tripping mechanism was modified; and consisted of a small stick placed under the open sliding door which projected to the center of the trap. The incubating bird was rushed by a worker who
Table 1. Date and source of wild Blue-winged Teal examined in 1967. Number in parentheses denotes immatures

<table>
<thead>
<tr>
<th>Date</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 April-13 May</td>
<td>96</td>
<td>36</td>
<td>132</td>
<td>Bait-trapping</td>
</tr>
<tr>
<td>2 June-19 July</td>
<td>-</td>
<td>60a</td>
<td>60</td>
<td>Nest-trapping</td>
</tr>
<tr>
<td>23 June-15 July</td>
<td>13</td>
<td>-</td>
<td>13</td>
<td>Spotting Scope</td>
</tr>
<tr>
<td>2 Aug.-4 Aug.</td>
<td>15 (6)</td>
<td>14 (9)</td>
<td>29 (15)</td>
<td>Night-lighting</td>
</tr>
<tr>
<td>1 Sept.</td>
<td>8 (5)</td>
<td>8 (5)</td>
<td>16 (10)</td>
<td>Bait-trapping</td>
</tr>
<tr>
<td>3 Sept.</td>
<td>6 (6)</td>
<td>6 (6)</td>
<td>12 (12)</td>
<td>Bait-trapping</td>
</tr>
<tr>
<td>14 Sept.</td>
<td>10 (10)</td>
<td>15 (15)</td>
<td>25 (25)</td>
<td>Bait-trapping</td>
</tr>
<tr>
<td>16 Sept.-23 Sept.</td>
<td>9 (8)</td>
<td>8 (7)</td>
<td>17 (15)</td>
<td>Hunter-kill</td>
</tr>
<tr>
<td>Total</td>
<td>157 (35)</td>
<td>147 (42)</td>
<td>304 (77)</td>
<td></td>
</tr>
</tbody>
</table>

aIncludes recaptures.

b1968.

frequently would reach the trap before the female flushed. In the event that the female flushed, she would hit the stick, causing the door to shut.

Night-lighting followed a method described by Leitch (1958).

Experimental Birds

A total of 146 Blue-winged Teal were kept in captivity for experimental purposes during the study. Of these, 19 were hatched in captivity and hand-reared, 41 were bait-trapped
near Ruthven in northwest Iowa, and 86 were obtained from the
Northern Prairie Wildlife Research Center, Jamestown, North
Dakota. Captive birds were housed in a renovated hog farrow­
ing barn 12 x 30 ft divided into 4 pens by 1 inch mesh poultry
fence. The concrete floor was covered with 4 to 8 inches of
wood shavings. Food and water were placed in 18 inch utility
pans located on 4 ft sq racks 8 inches high covered with % inch
hardware cloth. Cleaning was facilitated by placing 3 x 4 ft
pieces of sheet metal under the racks. The birds were fed
commercial feed (Doughboy No. 127 granulated Chick-Grower).

Dying of Plumages

To determine the completeness of the first basic plumage,
all of the feathers of the juvenal plumage were dyed. Two
dyes were used: red (Dupont Rhodamine B Extra) and green
(Dupont Victoria). Granules of the dye were saturated in 95
per cent ethanol and about 10 per cent (by volume) of detergent
(Tide) in water was added. The dye was applied with a tooth­
brush which was worked with and against the feathers.

Molt Rates

Molt rates were quantitated by using a qualitative
numerical scale to indicate the proportion of incoming feathers
for each tract or area. The following values were used: 0 =
no molt; 1 = few incoming feathers; and 2 = many incoming
feathers. Incoming feathers were observed by passing a
forceps through the feathers several times.
Terminology of Plumages and Molts

The earliest system of plumage terminology was proposed by Dwight (1900). Basing his system on the reproductive cycle, he designated the plumages as natal, juvenal, non-nuptial, and nuptial and the molts as post-juvenal, pre-nuptial, and post-nuptial. Witherby (1939) described a chronological approach and suggested these terms: nestling, juvenile, winter, and summer. Humphrey and Parkes (1959) devised a system based on evolutionary relationships of plumages. They utilized the terms natal and juvenal, but based their terminology on the assumption that the plumage resulting from the complete molt was oldest in an evolutionary sense. They called the resulting plumage "basic". Believing that the plumage worn during the breeding season was a secondary development, they called it "alternate". In addition they believed that all molts should be named after the incoming feathers instead of those being lost. They referred to the molts as pre-juvenal, pre-basic, and pre-alternate.

Stresemann (1963) criticized the system proposed by Humphrey and Parkes (1959) and advocated further use of Dwight's terminology. The main point of difference was the secondarily acquired plumage. Stresemann stated that the off-season dress (basic plumage of Humphrey and Parkes) was obviously a secondary acquisition while Humphrey and Parkes believed it to be primitive.

Amadon (1966) discussed plumages and molts in detail
agreeing somewhat with Dwight and opposing Humphrey and Parkes. Amadon stated that his system was a functional approach and he gave a distinct plumage name to all possible situations. Because of the tremendous variation within avian species, his system becomes somewhat cumbersome. His suggestions are: downy (1st, 2nd, etc.), juvenal (successive plumages of young birds are termed immature), and adult which is usually divided into breeding and nonbreeding. His terms for the molts are postjuvenal, prebreeding, and postbreeding.

I have followed Humphrey and Parkes' (1959) system because it seems well adapted to waterfowl. The family Anatidae is divided into the sub-families Anserinae, the swans and geese, and Anatinae, the ducks. The Anserinae are the more primitive of the two and are sexually monomorphic (basic plumage) with one annual molt (pre-basic). The Anatinae includes both sexually monomorphic and sexually dimorphic ducks. The dull plumage of the sexually dimorphic forms is thought to be homologous to the plumage of the Anserinae and the monomorphic Anatinae. The bright plumage (alternate) of the dimorphic ducks is secondarily acquired.

The dull plumage (basic) that is characteristic of most sexually dimorphic ducks of the northern hemisphere usually is called "eclipse" (Brooks, 1938). Its function once was thought to help conceal the male during the flightless period of wing renewal and is now thought to be a shortened version of the non-nuptial or basic plumage (Stead, 1938).
Humphrey and Parkes (1959) neither discuss nor offer terminology for the various generations of down feathers. Therefore, I have used juvenal to refer to the first generation of post-natal down. The appearance of this down precedes the juvenal contour feathers by a few days. I have used pre-juvenal to describe the molt whereby natal down is replaced by juvenal contour feathers. The terms juvenal down and pre-juvenal molt also were used by Oring (1968). I have called first basic the generation of down which follows the juvenal down. This down develops at about the onset of the pre-basic molt.

Terminology of Feather Patterns

In describing feather patterns, a number of terms are used which need explanation. A "U" or "V" shaped pattern refers to a "U" or "V" contrasting with the background color. The point of the pattern is directed toward the tip of the feather. Spotted feathers have dark spots on a light background. Barred feathers have dark cross bars on a light background or bold dark cross bars narrowly separated with a light color.

Modified "U's" refer to an intermediate condition between "U's" and spotting. The dark outer portion and dark inner portion of "U" patterned feathers become broken into spots. They are called modified "U's" if the spots are close together essentially in the pattern of the "U".
Plain feathers may or may not have light colored borders. Shaft streaks are light areas on either side of the rachis usually on the distal end of the feather.
NATAL PLUMAGE

Description of Natal Ducklings

**Natal plumage**

Newly hatched ducklings are very dark dorsally and cream to light yellow (color descriptions follow Palmer, 1962) ventrally (Fig. 1). The dorsum is darkest on the crown and rump where it approaches black. The black on the crown terminates in the center of the forehead about 3 mm from the base of the bill. The crown feathers are tipped narrowly with buffy yellow. The occiput and dorsal neck resemble the crown but are somewhat lighter. The natal down of the dorsal lower neck and inter-scapular area are somewhat lighter than the areas anterior or posterior to them and have more buffy yellow on their tips. The back, rump, and upper tail coverts are intermediate between olive and black with the intensity increasing posteriorly and also are narrowly tipped with buffy yellow. The natal rectrices are blackish gray and unmarked.

Four straw yellow spots are present on the dorsum. The most prominent pair is located on the lateral rump (dorsal to the flanks). The other pair is found on the lateral back, just posterior to the wings. Two additional yellow bands are located just anterior to the wings and lateral to the scapular area. These marks are dorsal continuations of the side and are not as prominent from dorsal view as are the other straw yellow back markings.
Figure 1. Ventral and dorsal view of a 3 day old hand-reared Blue-winged Teal duckling

Figure 2. Immature female Blue-winged Teal in juvenal plumage captured in northwest Iowa on 14 September 1967. The dark feathers visible in the chest-center are of the first basic plumage
The face is buffy yellow with a black eye-line and an auricular patch that approaches black. The buffy yellow is present in the superciliary area and is confluent above the base of the bill. The chin-throat area also is buffy yellow. Some of these buffy yellow areas, particularly around the dark auricular patch, have an orange-yellow cast. The buffy yellow continues on the lateral and ventral neck.

The chest-center, chest-side, and side feathers are medium gray broadly tipped with buffy yellow. The belly feathers are cream and buffy yellow, being brightest anteriorly. The appearance of the chest, therefore, is more dull than the belly. Down of the lower belly, flank, and crissum is gray basally and broadly tipped with a pale cream.

The wings are dark dorsally, varying from olive to black with feathers narrowly tipped buffy yellow. The feathers of the secondary area also are dark. However, they are broadly tipped with straw yellow. A straw yellow band is located on the anterior edge of the wing distal to the alula. The ventral side of the wing is straw yellow with the trailing edge varying from olive to black. The humerus is covered with straw yellow ventrally and is dark dorsally.

Color of the soft parts

Fifty-four observations of bill color were made on 27 Blue-winged Teal over a 12 week period following hatching (Table 2). The maxilla of newly hatched teal is dark gray with
Table 2. Changes in bill color of live Blue-winged Teal from hatching to 12 weeks

<table>
<thead>
<tr>
<th>Age wks.</th>
<th>No. of observ.</th>
<th>Maxilla</th>
<th>Nail</th>
<th>Mandible</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>Slate gray, pink lateral base, lateral border pink or gray</td>
<td>Pink</td>
<td>Pink, gray lateral base in some</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Distal portion with pink cast, becoming mottled with blue</td>
<td>Proximal portion becoming gray</td>
<td>Mostly pink, with gray and purple markings</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>Slate gray basally, distal 1/3 mottled with blue, pink distally</td>
<td>Gray basally, 1/3 mottled with blue, pink distally</td>
<td>Basal 1/3 with gray and purple, some with longitudinal gray streaks</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>No change</td>
<td>No change</td>
<td>Variable, blue-purple enchroaching on distal end</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>No change basally, mottling becoming less pronounced</td>
<td>No change basally, pink is decreasing</td>
<td>Variable, darker, increased purple, blue, and gray. Pink decreasing</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>No change basally, very little mottling distally</td>
<td>No change basally, pink is decreasing</td>
<td>Darker, blue and purple. Some with pink-purple, but no pink areas</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>Slate gray, mottling absent (or a trace)</td>
<td>No change</td>
<td>Mostly purple and dark gray</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>Slate gray to black, mottling absent</td>
<td>Slate gray to black</td>
<td>No change</td>
</tr>
<tr>
<td>Age (wks.)</td>
<td>No. of Observ.</td>
<td>Maxilla</td>
<td>Nail</td>
<td>Mandible</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------</td>
<td>---------</td>
<td>------</td>
<td>----------</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>No change (1 is sloughing)</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>No change (Both sloughing)</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>No change (Sloughing)</td>
<td>No change</td>
<td>No change</td>
</tr>
</tbody>
</table>
the lateral borders narrowly bordered with pink; the nail is pink. Areas near the lateral base of the maxilla are pink in most specimens but are light gray in others. The egg tooth is straw yellow. The mandible is pink; however, several ducklings have varying amounts of light to dark gray basally.

Towards the end of the second week, the distal 1/3 of the maxilla becomes lightly mottled with blue, but retains a pink cast. During the third week, the pink cast is lost and the mottling is more pronounced. The isolated "spots" are the same color as the nail and base of the bill. The mottling persists into the 5th week, is nearly gone after 6 weeks and disappears during the 7th week. The pink nail becomes gray basally during the second week. The pink persists for several weeks, decreasing at about 6 weeks and disappearing during the 8th week.

The mandible becomes darker during the 2nd week and gets progressively more ultramarine-violet and dark gray until the 7th week, after which there is no noticeable change.

The color of feet and tarsi of newly hatched ducklings is essentially ultramarine-violet. The tarsi are darkest on the posterior edge and become progressively lighter anteriorly. The anterior scutes are a combination of yellow, green and gray. The distal ends of the anterior tarsi are darker than the proximal portion. The dorsal parts of the digits are the same color as the anterior tarsi, with ultramarine-violet on the joints. The dorsal web and the entire underside of the foot
are black. The anterior tarsi become light gray with a pink cast during the second week changing to a hint of green during the third week. This is accompanied by a change in the lateral tarsi to a lighter color, resembling the anterior instead of the posterior tarsi.

At about seven weeks, the entire leg becomes lighter. The anterior tarsi become more yellow and the posterior tarsi become more violet.
Loss of natal down

Molt of the natal down began during the third week post-hatching. The loss of natal down was caused by wear and was first evident on the lower belly, crissum, and tail. Near the end of the third week, the natal down of the chest-center, chest-sides, sides, mid-belly, and upper tail coverts began dropping off the shafts of the incoming juvenal feathers. Early in the fourth week, the molt had progressed to the chin-throat, leaving the underside of the neck as the only ventral part of the body bearing natal down. The natal down of the ventral neck, that of the face anterior to the auricular region, and the down of the anterior 1/2 of the crown was lost by the end of the fourth week. The order of crown molt was from anterior to posterior and natal down persisted longest along the lateral borders of the crown.

After four weeks, natal down was present from the occiput through the lower back. On some birds natal down still persisted on the rump.

Entering the seventh week, natal down was still present on the occiput, nape, upper neck, and from the interscapular region through the lower back. These natal down feathers were attached to the tips of juvenal contour feathers. The natal down on the interscapular area and the back was not
visible when the wings were folded. After eight weeks, natal
down was found only on the occiput-nape areas of some birds.
Natal down appears to be lost earlier in wild birds, presumably
because of more abrasion.

Appearance of juvenal down

Juvenal down was visible a few days post-hatching (Table 3). Although this down had not emerged until 5 or 6 days in
most ducklings, developing feathers were usually visible as
swellings in the skin by 2 to 3 days. The venter was the first
area to develop juvenal down, presumably because this area was
in contact with water. The light gray juvenal down was com-
pleted after three weeks.

Table 3. Chronology of emergence of juvenal down

<table>
<thead>
<tr>
<th>Days</th>
<th>Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 4</td>
<td>None</td>
</tr>
<tr>
<td>5 - 9</td>
<td>Chest-center, chest-side, side, belly, flank, and lower tail coverts</td>
</tr>
<tr>
<td>10 - 12</td>
<td>Back, rump, and upper tail coverts</td>
</tr>
<tr>
<td>13 - 15</td>
<td>Interscapulars, and dorsal lower neck</td>
</tr>
<tr>
<td>16 - 18</td>
<td>Head and upper neck</td>
</tr>
</tbody>
</table>
Appearance of juvenal contour feathers

The blue sheaths of juvenal contour feathers were visible by separating natal down one week after hatching (Table 4). Auricular feathers and rectrices were the first to appear while side feathers and scapulars followed by about a day. At about two weeks, sheaths of juvenal contour feathers were visible on the entire venter. This was followed by feathers appearing on the head, chin-throat, rump, and upper tail coverts. Although rump feathers had emerged by 16-18 days, they were not visible.

Table 4. Chronology of the appearance of juvenal contour feathers

<table>
<thead>
<tr>
<th>Days</th>
<th>Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 - 9</td>
<td>Auriculars and rectrices</td>
</tr>
<tr>
<td>10 - 12</td>
<td>Sides and scapulars</td>
</tr>
<tr>
<td>13 - 15</td>
<td>Chest-center, chest-side, belly, flank, and lower tail coverts</td>
</tr>
<tr>
<td>16 - 18</td>
<td>Crown, face, chin-throat, rump, upper tail coverts, and tertials</td>
</tr>
<tr>
<td>19 - 22</td>
<td>Dorsal lower neck and secondaries</td>
</tr>
<tr>
<td>23 - 26</td>
<td>Upper neck, primaries, and alula</td>
</tr>
<tr>
<td>27 - 30</td>
<td>Posthumerals</td>
</tr>
<tr>
<td>31 - 34</td>
<td>Back, interscapulars, axillaries, and marginal coverts</td>
</tr>
</tbody>
</table>
At three weeks, juvenal feathers appeared on the dorsal lower neck. These feathers were continuous with those of the chest-side and developed much earlier than the juvenal feathers of the interscapular region and back. Feathering then proceeded anteriorly to the upper neck and posteriorly to the interscapular area. The appearance of feathers on the back proceeded posteriorly from the interscapulars and anteriorly from the rump. The interscapular and back feathers became visible during the seventh week.

Development of juvenal contour feathers on the wings began between 2 and 3 weeks after hatching. The tertials were the first feathers to appear followed by the secondaries and later by the primaries and alula. At one month, posthumeral feathers had developed followed closely by the axillaries and marginal coverts. The juvenal plumage was completed with all feathers unsheathed at about eight weeks. This compares with Oring's (1968) values of 7-8 weeks for the development of the juvenal plumage in the Gadwall (*Anas strepera*).

**Description of Juvenal Plumage**

The juvenal plumages of male and female Blue-winged Teal are very similar. Ventrally, they are streaked and mottled dull brown as illustrated by the female in Figure 2. The chest-center and chest-side are darker than the belly and have a mottled appearance. The upper belly is similar to the chest but is lighter and has smaller dark "blotches". The latter is
due to the smaller size of the belly feathers and the fact that the large pigmented areas of the chest feathers frequently are divided on the belly feathers. The lower belly tends to be more streaked than mottled because the dark central part of the feather often extends the length of the vane. The lower tail coverts are light with irregular shaped spots in both sexes.

Dorsally, both sexes are dark and plain as illustrated by the female in Figure 2. Close examination reveals a "scaly" appearance resulting from the light feather edgings. These marks are most prominent on the scapulars and dorsal lower neck and least prominent on the back.

The crown and eye-line are dark brown to black although the eye-line frequently is lighter than the crown. The face and superciliary area are mottled and the chin-throat is very light (near white) with varying amounts of brown speckling. The chin-throat region of some birds is plain.

Obvious sexual dimorphism of the juvenal plumage occurs in the wings (Carney, 1964; Dane, 1968). The tertials of males are darker than those of females and the contrast between the darker outer webs and the inner webs is more pronounced in males. The secondaries are iridescent green in males, while in females they are dark and weakly iridescent. The greater secondary coverts are white with a few scattered black spots in the male, while in the female, they are gray with irregular white lines. These lines vary from horizontal,
to weak "V's", to figure "8's". The use of the greater secondary coverts as an aging criterion is discussed by Dane (1965).

Feather Patterns of Juvenal Teal

Feather patterns of juvenal plumages of male and female teal are quite similar. Feather patterns are usually less prominent in females than males, but one could not determine sex on the basis of these differences. Examples from the chest-center, chest-side, side, belly, flank, and lower tail coverts of two birds taken in Iowa on 31 July 1932, are shown in Figure 3. Although pattern variations do occur, these are examples of patterns commonly observed. Some males have plain feathers in the chest-center and chest-side and little pattern­ing in the belly and side. An example of extreme patterning is shown by a male (R2) that died in captivity when 27 days old (Fig. 4).

Feathers from the rump, upper tail coverts, tail, scapu­

lars, dorsal lower neck, interscapulars, and back are mostly plain in both sexes (Fig. 5). Rump feathers and scapulars are slightly patterned in some individuals of both sexes while the dorsal lower neck feathers are frequently patterned in males. Feathers from three of the areas in Figure 5 were taken from different birds (B38 and B42) because the back of ISU specimen No. 229 was damaged.

Patterns of head feathers seemed identical in both sexes.
Figure 3. Patterns of chest-center, chest-side, side, belly, flank, and lower tail coverts, of male and female Blue-winged Teal in juvenal plumage. The birds were collected on 31 July 1932 in northwest Iowa.
Figure 4. An example of extreme patterning of a male Blue-winged Teal in juvenal plumage. The bird was hand-reared and died when 27 days old.
Figure 5. Patterns of rump, upper tail coverts, tail, scapulars, dorsal lower neck, interscapulars, and back feathers of male and female Blue-winged Teal in juvenal plumage. ISU Numbers 236 and 229 were collected in northwest Iowa on 31 July 1932. B38 and B42 were hand-reared.
236 M 229 F

RUMP

UPPER TAIL COVERTS

TAIL

SCAPULARS

B38 M B42 F

DORSAL LOWER NECK

INTERSCAPULARS

BACK
Crown feathers are medium gray and facial feathers are near white—each with a brown spot centered on the rachis at the tip of the feather. Worn crown feathers appear to be brown. Chin-throat feathers were plain white or white with small brown spots on the feather tips.

Maturation of Primaries

The importance of early flight to survival of juvenal waterfowl was discussed by Hochbaum (1944). The factor determining time of flight is the condition of the flight feathers. The maturation of the primaries from blue and soft to red and finally translucent and hard was described by Weller (1957b:22) for the Redhead (Aythya americana). The sequence of change proceeds from primary one through primary ten (i.e., proximal to distal).

Data on primary clearing were obtained from 15 hand-reared Blue-winged Teal (Fig. 6). The outer reduced primary (number eleven) was not recorded. About one week was required for a given primary to change from blue to clear. Primary one began changing early in the sixth week (about 43 days) and had cleared by the end of that week (about 49-50 days). Primary 10 began changing at the beginning of the eighth week and had cleared by the end of that week (63 days). One individual (R4) was observed at 43 days with all primaries blue and at 64 days with all primaries clear, indicating a maximum period for clearing of 21 days. The relationship between the clearing
Primary number:

<table>
<thead>
<tr>
<th>Primary number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.5</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
</tr>
<tr>
<td>7</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
</tr>
<tr>
<td>7.5</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
</tr>
<tr>
<td>8</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
</tr>
<tr>
<td>8.5</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
</tr>
<tr>
<td>9</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
<td>⬜️</td>
</tr>
</tbody>
</table>

- Blue
- Red
- Changing
- Clear

**Figure 6. Color changes of the shafts of juvenal Blue-winged Teal primaries**

process and time does not appear to be linear. The inner primaries (1-4) cleared much more rapidly than did the outer primaries (7-10).

Weller (1957b) determined that Redheads could fly with five cleared primaries at about 8½ weeks. If this is applied to the Blue-winged Teal, age at first flight would be about 7½ weeks. That teal would attain flight at a younger age than Redheads is not surprising, since divers require longer to reach the flying stage than do dabbling ducks (Hochbaum, 1944: 110). My data on the clearing of five primaries as an index to the attainment of flight of captive teal is higher than values taken from the literature for age of first flight. The age of attainment of flight by captive teal was given as 38-49 days (Hochbaum, 1944), 40-47 days (Dzubin, 1952), and, for wild birds,
42 days (Bennett, 1938). The data in this study are similar to that obtained by Oring (1968) for the attainment of flight of the Gadwall. He found that five primaries of early hatched birds cleared at 56 days, while seven primaries of late-hatched birds had cleared by 56 days. This suggests that late-hatched birds attain flight in a shorter time period than do early hatched birds.
FIRST BASIC PLUMAGE

A feather generation between the juvenal and first nuptial plumages has been reported by several workers. Jackson (1915) discussed the sequence of plumages in several species of Anatinae and referred to a first winter plumage. Although her notes are of interest, they are somewhat confusing and her use of terminology is questionable. Schioler (1921) described this plumage in several surface-feeding ducks and named it a second juvenile plumage. Snyder and Lumsden (1951) found this plumage in South American Cinnamon Teal (Anas cyanoptera) and termed it an archaeo-adult plumage. Although they stated that this plumage does not occur in the North American race, it is known also to occur in this form (M. W. Weller, Department of Zoology and Entomology, Iowa State University, Ames, Iowa, personal communication, 1969). Oring (1968), working with the Gadwall described a first basic plumage, following the nomenclature of Humphrey and Parkes (1959).

The difficulty of interpreting the presence and extent of the first basic plumage is reflected in Humphrey and Clark's (in Delacour 1964:178) statement, about a number of northern hemisphere anatids, that "...males in their first year undergo a complex postjuvenal feather replacement in which the first basic plumage may vary from almost (if not totally) nonexistent and of brief duration to extensive and of protracted duration."
They stated that this plumage in several species (including the Blue-winged Teal) may be lost entirely or so transitory as to have been overlooked.

First Pre-basic Molt

Observations of wild-trapped birds

The earliest date on which wild immature Blue-winged Teal were known to be in pre-basic molt was 8 August 1966, when a female was captured in northwest Iowa (I.S.U. No. 1374). The venter of this bird is in full molt and the head has completed the molt. The back, rump, and tail are juvenal and the feathers are all unsheathed. The sheathed upper tail coverts are first basic, except for one juvenal feather. The scapulars are essentially first basic while the dorsal lower neck is mostly juvenal but in molt. Another female (I.S.U. No. 1360) collected on 26 August 1966, is in full basic plumage.

On 1 September 1968, 12 immature Blue-winged Teal were bait-trapped in northwest Iowa. All birds were in juvenal plumage and in early pre-basic molt, with the males molting more extensively (Table 5). Molt was restricted to the body but did not include the interscapulars, back, and tail feathers of either sex. In addition, molt did not occur on the chin-throat, upper neck, and rump of females. Only one male had upper neck molt and there was little belly molt in either sex.

The most active molt occurred in the dorsal lower neck, scapulars, upper tail coverts, lower tail coverts, chest-
Table 5. Average amount of molt of 6 male and 6 female immature Blue-winged Teal examined on 1 September 1968

<table>
<thead>
<tr>
<th>Area</th>
<th>Male</th>
<th>Female</th>
<th>Area</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crown</td>
<td>1.0a</td>
<td>0.2</td>
<td>Rump</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td>Facial</td>
<td>1.0</td>
<td>0.2</td>
<td>Upper tail cov.</td>
<td>1.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Chin-throat</td>
<td>1.0</td>
<td>0</td>
<td>Tail</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Upper neck</td>
<td>0.3</td>
<td>0</td>
<td>Lower tail cov.</td>
<td>1.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Lower neck</td>
<td>1.3</td>
<td>1.0</td>
<td>Belly</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Interscapulars</td>
<td>0</td>
<td>0</td>
<td>Chest-center</td>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Scapulars</td>
<td>1.5</td>
<td>1.2</td>
<td>Chest-side</td>
<td>1.8</td>
<td>1.2</td>
</tr>
<tr>
<td>Back</td>
<td>0</td>
<td>0</td>
<td>Side</td>
<td>2.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

a0 = no molt; 1 = few incoming feathers; and 2 = many incoming feathers.

center, chest-sides, and sides of both sexes. Because males had more active molt and a larger number of basic feathers, it is indicated that males enter pre-basic molt earlier than do females.

The 25 immature teal captured on 14 September 1967, were not molting as extensively as were those captured on 1 September 1968, and their plumages were more juvenal. Males did not yield additional information about the areas involved with the first basic plumage but, in females, crown, facial, and chin-throat molt was extensive. Also some molt of the upper neck occurred.
Observations of captive birds

The first basic plumage of hand-reared Blue-winged Teal began to appear at about two months. Sixteen birds ranging from 53 to 73 days were examined and all but one (56 days) had basic feathers in the area between the chest-side and side. During the latter part of September, the chest-center, chest-sides, and sides took on a basic appearance. On several occasions, juvenal and basic feathers were found in the same area with no active molt, suggesting an interrupted molt.

On 9 September 1967, two male and two female immature teal were dyed to study the patterns and extensiveness of the pre-basic molt. Only a few feathers were replaced from 9 September through December, 1967. An extensive molt occurred between late December and February which seemed atypical in that differences between sexes and areas on a given bird were not as pronounced as expected. Infrared heat lamps turned on in December are thought to have triggered the molt or modified the commencing molt.

A second experiment was initiated, therefore, in which heat lamps were not used. Six males and six females were trapped in northwest Iowa on 1 September 1968 and dyed six days later. Of these, three males and two females survived the winter and developed their first alternate plumages. The following areas produced three different feather patterns representing the juvenal, first basic, and first alternate plumages: chest-center, chest-side, side, belly, flank,
lower tail coverts, dorsal lower neck, scapulars, and upper
tail coverts. Head molt could not be interpreted accurately.
I suspect that the birds had undergone much head molt before
they were captured.

On 5 March 1969, alternate feathers were developing on
the head, belly, chest, and sides of most males. Also replaced
at this time were the tertials, interscapulars, and rump
feathers. I interpret these feathers to be part of the first
alternate plumage. Based on wild trapped birds, however, a
few rump feathers were replaced with the first pre-basic molt.

Descriptions of the First Basic Plumage

The heads of birds in first basic plumage are very simi-
lar to those in juvenal plumage. The brown appears to be
darker and the mottling more sharply defined. The chin-throat
is white, rarely with dark speckling.

The chest-center and chest-side have a mottled appearance
because of the light borders of these feathers. In many,
these feathers are patterned in which case the mottling is
interrupted. The reason for the larger mottled areas of these
feathers compared to juvenal feathers is that first basic
feathers are much wider than juvenal feathers. The sides are
brown with irregular patterns. The belly appears to be mottled
with irregular and weak spots as opposed to streaked in the
juvenal plumage.

The dorsal aspect of this plumage is changed little from
that of the juvenal. The dorsal lower neck and upper tail coverts are more patterned than those of the juvenal plumage while the first basic scapulars appear to be identical to the juvenal scapulars.

Feather Patterns of the First Basic Plumage

Typical first basic feather patterns of the chest-center and chest-side are "U's" (Fig. 7). In some cases, however, they are plain and in others the patterns are modified "U's" to irregular spots. Side feathers are usually patterned with narrow cross bars or irregular "U's". The belly feathers seem always to be spotted.

Flank feathers were quite irregular varying from nearly plain to boldly spotted (Fig. 8). The lower tail coverts are very characteristic. They possessed much more pigmented area than did those of juvenal feathers. The irregular patterns consisted of spots and cross bars. I have observed first basic lower tail coverts on teal skins that had molted the juvenal rectrices and feel that the coverts can be used quite reliably as an aging criterion. Certainly it merits further consideration. Dorsal lower neck feathers are plain or weakly patterned. First basic scapulars are plain with light borders and faint shaft streaks are present in some. The plain scapulars are very similar to juvenal scapulars. Although upper tail coverts are not figured, they were replaced in all three plumages. The plain juvenal upper tail coverts were replaced by weakly
Figure 7. Chest-center, chest-side, side, and belly feathers of the juvénal, first basic, and first alternate plumages of a male (B40) Blue-winged Teal
<table>
<thead>
<tr>
<th>JUVENAL</th>
<th>1st BASIC</th>
<th>1st ALTERNATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEST-CENTER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHEST-SIDE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIDE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 8. Flank, lower coverts, dorsal lower neck, and scapular feathers of the juvenal, first basic, and first alternate plumages of a male (B40) Blue-winged Teal
patterned first basic feathers which were replaced by black alternate feathers.

First Basic Down

Five of the 15 hand-reared teal that were developing first basic feathers between 53 and 73 days of age also were growing new down on the chest-center, chest-side, side, and belly. Another reason for associating this down with the first basic plumage came from the plumage dying experiment of 1968-1969. The down on the ventral part of the body which was dyed on 7 September 1968, was retained through the development of the alternate plumage by males. Replacement of this dyed down on the venter of females began between 22 April and 4 May 1969 and clearly was associated with the pre-alternate molt.

The dyed down on the backs of males also was retained through the development of the alternate plumage. In females, there was much replacement of the dyed down. It seemed to be associated with the replacement of juvenal contour feathers.

Oring (1968) described this down for the Gadwall and interprets it to be part of the first alternate plumage because it is lost with the first alternate pennaceous feathers (i.e. second pre-basic molt). Although the timing of the loss of this down sounds correct, it seems more consistent with plumage nomenclature to associate feathers with their development and not with their loss. In addition, the complement of
down that develops in females in conjunction with their pre-
alternate molt should be called alternate down.
PLUMAGES OF ADULT TEAL

Molts of Adult Teal

Pre-alternate molt

Males Male Blue-winged Teal retain the basic (eclipse) plumage for a relatively short time before the pre-alternate molt begins. Bent (1962) and Roberts (1955) referred to this as a prolonged molt. Bent gave the time for completion of the new plumage as middle winter to March, while Roberts stated that the breeding plumage of males was not acquired until mid-winter or early spring. Bennett (1938) gave the time for the appearance of the nuptial plumage as December and for completion of this plumage as March.

Data on the completion of this molt were obtained by bait-trapping teal in northwest Iowa during spring, 1967. Of 96 different males trapped between 22 April and 13 May, only 4 showed active molt. Three of these were growing only a few feathers in one or two areas and the fourth was molting several areas. The body of this bird was essentially alternate but the head showed much basic. Its molting progress was noticeably delayed.

Females Little has been written on the pre-alternate molt of females presumably because their alternate and basic plumages are so similar that molt progress can not be determined with casual observations as is possible with males. During the 1967 spring bait-trapping, 36 females were cap-
tured on 4 successive weekends from 22 April to 13 May. In addition, nesting females were captured 60 times from 2 June to 19 July. Molt rates were recorded for 15 different feather tracts or areas and the average molt rate per bird plotted against time (Fig. 9). The peak of molt occurred on 28 April when 9 of 11 birds were in full molt. Females were not examined during the last half of May as bait-trapping declined and nesting was late. Since none of the bait-trapped birds were captured by nest-trapping, it is assumed that the bait-trapped birds were migrants. Feather replacement was very infrequent during June and July and could not be considered as part of a molt.

It would appear that the pre-alternate molt of females must terminate by the latter part of May. Feather patterns developed before 13 May were typical alternate, while those grown during June were dark with some mottling and light borders. Parts of these light borders extended closer to the rachis than others. These patterns are nearly identical to feathers grown experimentally under the influence of 18 and 24 mg diethyl stilbestrol implants (Fig. 23). Because these patterns do not occur with any degree of regularity in wild birds, it follows that teal do not normally replace feathers during June when estrogen levels appear to be very high.
Figure 9. Average intensity of molt of female Blue-winged Teal captured during spring and summer, 1967. The method of capture during April and May was bait-trapping and during June and July nest-trapping. Horizontal line indicates mean, vertical line represents range, and number in parentheses denotes number of birds.

0 = no molt; 1 = few incoming feathers; 2 = many incoming feathers.
Effect of age on pre-alternate molt

Dane (1965) discussed the correlation between age and the attainment of sexual activity and suggested that yearlings of several avian species show breeding behavior later than do older birds. He also noted that on 30 January, pre-alternate molt of captive juvenal teal was one to two weeks more advanced in early hatched birds than in late-hatched birds.

In view of this, known age captive teal were examined in late November-early December to evaluate the progress of their pre-alternate molt. Eighteen male and 17 female adult teal (about 17 months old) were examined on 26 November 1967. Of the males, 8 were in advanced pre-alternate molt with plumage in alternate aspect and the white crescent partially developed; 2 were in pre-alternate molt with plumage about 1/2 alternate and 1/2 basic, and 7 were in basic plumage of which three were beginning pre-alternate molt.

Two females were molting several areas while 15 were not replacing feathers or were growing so few that they would not be considered to be molting.

On 3 December 1967, 18 immature (about 5 months old) male teal were examined for molt activity. The plumage of one was 1/2 alternate and 1/2 basic, the crescent was not visible, and it was undergoing much pre-alternate molt. Another was in early pre-alternate molt but showed little alternate in its plumage. The remaining 16 birds varied from mostly juvenal plumage to the first basic plumage. Fourteen of these birds
were not molting while two were replacing a few feathers.

Eight immature female teal also were examined on 3 December 1967, and none were molting. Their plumage aspect was juvenal with varying amounts of first basic being present.

Information was gathered during 1967-1968 on the completion of the alternate plumage by two immature male teal and four adult male teal. The adult males assumed their second alternate plumage from early to late January, while the immature teal completed their first alternate plumage at the end of March. Hochbaum (1944) observed captive Blue-winged Teal drakes to begin the pre-alternate molt in early December and were not in full alternate plumage until January. He did not give the ages of these birds. In 1968-1969, four immature male teal completed their first alternate plumage between late March and early April. In addition, two immature females were followed during 1968-1969 and they completed their first alternate plumage in mid-May.

Therefore, captive adult male teal completed their second alternate plumage about two months before immature males completed their first alternate plumage. It also was indicated that the assumption of the first alternate plumage by immature females lagged about six weeks behind the completion date of immature males.
Pre-basic molt

Males Following the breeding season, the basic or eclipse plumage develops by a complete pre-basic molt. Bent (1962) and Roberts (1955) state that this molt begins in July and is completed in August. Bennett (1938) discusses the plumages of Blue-winged Teal, and adds that males begin to molt into eclipse plumage soon after they desert the incubating females which is usually by 20 June.

Attempts were made to determine the onset of pre-basic molt by observing males through a spotting scope. Thirteen males were observed between 23 June and 15 July 1967. A male showing no sign of molt was observed on 23 June. The first male observed in early pre-basic molt was on 6 July. The sides were 1/2 alternate and 1/2 basic and the crescent was slightly mottled. The barred alternate side feathers were still present as early pre-basic molt of the side feathers involves only the spotted feathers. A few dark feathers were observed in the flank patch. By mid-July, crescents were quite mottled and the chest and sides had a basic appearance. The flank was still mostly white.

Although this is probably the most common chronology, a couple of observations are pertinent. On 11 July, I observed a male in pre-basic molt accompany a female to her nest. The crescent was barely evident and the sides were about 1/2 alternate and 1/2 basic. On the same day, a molting male was observed copulating with his nesting female (H. J. Harris,
Department of Zoology and Entomology, Iowa State University, Ames, Iowa, personal communication, 1969). Hochbaum (1944) observed eclipse feathers on male Shovelers and Lesser Scaup before they left their females and territories.

**Females** Pre-basic molt was initiated at a later date in females than in males. Fourteen females were nest-trapped between 4 and 19 July 1967, and none of these showed active molt. On some birds, however, recently grown feathers were present which appeared to be basic. One such bird, trapped on 26 June, had two new scapulars in each tract and two new tertials on each wing flanked by badly worn tertials. Another, trapped on 12 July, also had two recently grown tertials on each wing.

Sheathed feathers first were observed on 7 July when a female (G31) was trapped on about the fourth day of incubation with a clutch of 9 eggs. Several long basally sheathed belly feathers were present in the brood patch area. This is not interpreted as part of the pre-basic molt, because the belly is not one of the first areas to molt and no other areas had sheathed feathers. These new feathers most probably resulted from a feather loss associated with the brood patch and preening. An important point about these new feathers is that they were not like the dark somewhat mottled feathers described earlier that developed in June.
Description of Adult Plumages

Alternate plumage

Males  Examples of adult male and female teal in both alternate and basic plumages are shown to permit general comparisons (Fig. 10). The alternate plumage of males is dramatically different from the basic plumage of males and both plumages of females. The heads of birds in alternate plumage are dark with a conspicuous white crescent outlined with black located anterior to the eye, beginning slightly above the eye and terminating on the lateral edges of the gular region. The face and upper neck are dark to blackish gray and the crown, chin-throat, and area anterior to the crescent are black. In some cases the white from the crescent courses posteriorly along the sides of the crown becoming confluent on the occiput. Varying amounts of violet and green iridescence are present on the head—particularly on the face, occiput and upper hind neck.

Ventrally, males vary from buffy yellow to cinnamon with prominent black spots or bars. The black lower tail coverts abruptly adjoin the lower belly. The white flank patch is immediately posterior to the side feathers and terminates sharply next to the lower tail coverts.

Dorsally, male teal have scale-like markings anteriorly and are plain dark brown or black posteriorly.

Females  The heads of female teal in alternate plumage
Figure 10. Adult male and female Blue-winged Teal in both alternate and basic plumages. The birds in alternate plumage are captive and the basic birds were wild-trapped shortly before being photographed.

A - Alternate male (F14), B - Basic male (B46), C - Alternate female (152), and D - Basic female (B47)
are mottled brown (Fig. 10). The crown feathers are dark brown
to black narrowly edged with pale cinnamon and the upper hind
neck and occiput are similar but lighter. Feathers of the face
and lateral and ventral neck are buffy yellow tipped with
brown. The chin-throat is white.

Ventrally, females are lightly streaked to mottled with
brown and are darkest on the chest. Generally, the flank is the
same as the belly and the lower tail coverts are light with
large dark spots.

The most distinctive plumage characters of female teal in
alternate plumage are the color and markings on the dorsum
where the brown is interrupted with patterns from the lower
neck through the tail. The scapulars also are patterned. The
color of these patterns is between buffy yellow and cinnamon.

**Basic plumage**

**Males** Males in basic plumage have many female charac-
teristics (Fig. 10). Their heads and necks seem identical
to females and they resemble females in alternate plumage ven-
trally. They differ markedly from females, however, in that
they have essentially plain dorsums while females in alternate
plumage are highly patterned dorsally.

**Females** The heads and necks of females in basic
plumage appear to be identical to those in alternate plumage
(Fig. 10). Although they resemble alternate birds in side
view, close examination reveals mostly plain feathers as op-
posed to the patterned appearance of the alternate. In addition, basic females are plain dorsally.

Feather Patterns of Adult Teal

Feathers from 13 different areas of adult male and female Blue-winged Teal in both alternate and basic plumage are presented in order to demonstrate some of their similarities and differences. These feathers were taken from birds that were trapped in northwest Iowa. The female in alternate plumage was trapped on 28 April 1967 and the alternate male was trapped on 30 April 1967. Both birds in basic plumage were trapped on 1 September 1968. These feathers should not be interpreted as representing all of the feather patterns of a given area because variations do occur. The feathers were selected because they seemed to show those patterns seen most frequently.

Chest-center, chest-side, and side

Alternate plumage The chest-center and chest-side feathers of male teal vary from buffy yellow to cinnamon with dark spots or bars (Fig. 11). A relationship between spotting or barring and age could not be demonstrated. The patterns of chest-center and chest-side feathers in females are highly variable but are seldom plain. In some, the large pigmented area is divided into two or three longitudinal portions, while others are spotted or with "U's"; intermediate patterns were common. In some cases, the spotted feathers were very similar
Figure 11. Patterns of chest-center, chest-side, and side feathers of adult male and female Blue-winged Teal in both alternate and basic plumage.
to some of the spotted feathers of males. Most of the side feathers of males are buffy yellow to cinnamon with prominent spots (Fig. 11). The dorsal and posterior side feathers are larger than the spotted feathers and have bold cross bars instead of spots. The side feathers of females are dark brown with buffy yellow to cinnamon patterns of "U's", "V's", cross bars, or modifications of these.

**Basic plumages**  
A decreased amount of patterning is noted in the basic or "eclipse" feathers of both sexes (Fig. 11). The chest-center and chest-side feathers of males frequently have more prominent "U's" than do those figured and these feathers of females often are plain—having only buffy yellow to cinnamon borders. The side feathers of both sexes are quite similar. They are dark brown with buffy yellow to cinnamon borders and patterns which are weak to well formed "U's", "V's", or modifications of these (Fig. 11).

**Belly, flank, and lower tail coverts**

**Alternate plumage**  
Feathers from the upper belly of males either are spotted or barred, while those from the lower belly are spotted (Fig. 12). Those of females usually are spotted when the chest-center feathers are spotted and plain when the chest-center feathers are less patterned. The flank feathers of males are white, while those of females vary from spotted to plain. Frequently, the plain female flank feathers have narrow light areas next to the shaft. The
Figure 12. Patterns of belly feathers, flank feathers and lower tail coverts of adult male and female Blue-winged Teal in both alternate and basic plumages.
alternate female flank feathers are from a different bird because the flank feathers from the female figured in this series were not available. The lower tail coverts differ dramatically between sexes. Those of males are black with occasional mottling on the basal parts of some of the anterior feathers. Lower tail coverts of females are white to very pale cinnamon with dark brown spots.

**Basic plumage** Usually the belly feathers of males are spotted, while those of females are plain (Fig. 12). In males, the spotted feathers of the basic plumage differ from the spotted feathers of the alternate plumage in that the spots are larger and the background color is white. Flank feathers of males are dark brown and usually have light central areas and dark shaft streaks. Sometimes, however, they are irregularly spotted or with "U's". Female flank feathers commonly are plain. In those birds having patterned belly feathers, the flank feathers often are weakly patterned with blotches. The lower tail coverts of males and females are white with dark spots (Fig. 12). The spots frequently are joined forming large blotches.

**Dorsal lower neck, interscapulars, back, and rump**

**Alternate plumage** The dorsal lower neck feathers of males are dark brown and highly patterned with broad "U" shaped markings which frequently are flared laterally to form "W's" (Fig. 13). Longer, more narrow "U's" usually are present
Figure 13. Patterns of dorsal lower neck, interscapular, back, and rump feathers of adult male and female Blue-winged Teal in both alternate and basic plumages.
on the central parts of the feathers. Females also have dark brown dorsal lower neck feathers that are well patterned with "U's" and "W's" but these patterns are not as prominent as are those of males. Interscapulars, back, and rump feathers of males and females are dramatically different. In males, they are plain and vary from brownish olive to near black (Fig. 13). The feather patterns of females are irregular. Interscapular and back feathers frequently have "V" shaped marks in addition to the pattern illustrated (Fig. 13). The rump feathers seem to be more patterned than are the back and interscapular feathers.

**Basic plumage** Feathers from these areas are similar in both sexes and are colored similarly to those of males in alternate plumage (Fig. 13). Most of the dorsal lower neck feathers of males possess weak "U's" or "V's", while those of females usually are plain. The interscapular and back feathers are plain in both sexes, but some females have weakly patterned "V's" (Fig. 13). Rump feathers of both sexes are weakly patterned with broad "U's" or "V's" or are plain (Fig. 13).

**Upper tail coverts, tail, and scapulatrs**

**Alternate plumage** Upper tail coverts of males are plain and nearly black, while those of females are dark brown and patterned with buffy yellow to cinnamon "U's", "V's", bars, or irregular modifications of these (Fig. 14). In female teal, patterns of upper tail coverts are similar to
Figure 14. Patterns of upper tail coverts, tail feathers, and scapulars of adult male and female Blue-winged Teal in both alternate and basic plumages.
those of the rump feathers. Tail feathers of males are dark but somewhat lighter than the upper tail coverts (Fig. 14). Tail feathers of females are patterned with cross bars or weak "V's". Females occasionally are seen with a combination of plain and patterned tail feathers, in which case patterned feathers are symmetrical. Scapular feather patterns of males are the most varied of all feather groups. The short anterior feathers are highly patterned with "U's" and a variety of markings centrally, while the long posterior feathers are dark with bold shaft streaks. The distal half of the outer vane is blue on two or three of these feathers. The scapulars of females are dark brown patterned with buffy yellow to cinnamon "U's" but plain feathers also occur.

**Basic plumage** Upper tail coverts of both sexes are dark brown with buffy yellow to cinnamon patterns of weak "U's", "V's", or irregular modifications of these (Fig. 14). Tail feathers of both sexes are plain dark brown. Basic scapulars of both sexes are buffy yellow to cinnamon bordered plain feathers with shaft streaks present in some. These streaks are more common and more prominent among males than in females.
Blue-winged Teal undergo an annual plumage cycle (Fig. 15). The natal plumage is complete at hatching. The juvenal plumage develops from early June to late August. Most young teal are flying or in the act of learning to fly by mid-August (Bennett, 1938). It is important to remember that early hatched teal can be in late first pre-basic molt when younger teal have many sheathed juvenal feathers. These plumages can be differentiated on the basis of color, patterns, and feather size. For example, chest-center feathers of the first basic plumage can be nearly twice as wide as those from juvenal plumages. In addition when the venter is producing juvenal feathers, interscapular and back feathers can not be seen. When first basic feathers are being produced on the venter, juvenal interscapular and back feathers are completed and they lack sheaths.

The first basic plumage involves the head, body (excluding the interscapular and back feathers), and tail. My data regarding first basic rump feathers are conflicting. I would guess that the rump is variable. No wing molt takes place with the first pre-basic molt. The second and successive pre-basic molts are complete and produce the basic or eclipse plumage.

The pre-alternate molts are always incomplete in both sexes. Based on captive teal, few interscapular and back feathers of males are replaced by the first pre-alternate molt. These feathers are replaced more extensively in females.
Figure 15. Chronology of plumages and molts of the Blue-winged Teal. Diagonal line represents timing and duration of molt and was estimated on the basis of data from wild-trapped birds.

------ incomplete molt  ------ complete molt
MALES
HEAD, BODY, TAIL, AND 'TERNIALS
INTERSCAPULAR AND BACK
WINGS

FEMALES
HEAD, BODY, TAIL, AND TERTIALS
INTERSCAPULAR AND BACK
WINGS

MOLTS -
PRE-JUVENAL
PRE-BASIC I
PRE-ALTERNATE I
PRE-BASIC II
PRE-ALTERNATE II

extensive feather replacement of feathers on the dorsum of females might be expected because the adaptive significance of the alternate plumage of females presumably is concealment and involves, therefore, a highly patterned dorsum. In males, the alternate plumage appears to be for sex recognition and it is doubtful that the interscapular and back areas would serve a signal function.

The second and successive pre-alternate molts of females are complete for the head, body, and tail, but included only the tertials of the wings. Males follow a similar pattern except I am not sure about the completeness of feather replacement of the interscapular and back areas. Based on wear, these feathers appear only to be partially replaced.

Males molt earlier than females for all molts beginning with the first pre-alternate molt. Limited data suggest that males also might enter the first pre-basic molt before females. Males complete the pre-alternate molt prior to spring migration. Females are in full molt during spring migration and some continue molting in May with eggs in their oviducts. I did not expect birds to be molting concomitant with other energy demanding activities. In the adult pre-basic molt, females are later than males because of brood rearing. Flight feathers of females are not shed until after brood rearing is completed (Hochbaum, 1944).
PART II. THE INFLUENCE OF SEX HORMONES ON PLUMAGES AND MOLTS
INTRODUCTION

A relationship between sex hormones and plumage characters has been established by several workers, a detailed discussion of which is given by Assenmacher (1958) and Voitkevich (1966). The dependence of the eclipse plumage of the Mallard (Anas platyrhynchos) on the testes has been shown by Goodale (1916) and Emmens and Parkes (1940), although they did not implicate a particular hormone. Hohn (1947) demonstrated a closer relationship between interstitial cell development and plumage than seminiferous tubule activity and plumage. Hohn and Cheng (1967) suggested that the testicular hormone responsible for the eclipse plumage was estrogen.

Goodale (1910) found that removal of the ovary in the Rouen Duck (A. platyrhynchos) resulted in the assumption of the male breeding plumage. Van Oordt (1931) stated that the female plumage of the domestic duck (A. platyrhynchos) was under the influence of the ovary. Emmens and Parkes (1940) and Witschi (1961) were able to feminize male plumages with estrogen administration but were not able to influence feather patterns of the male with testosterone injections.

Most knowledge about hormone and plumage relationships in ducks has been learned from studies of domestic Mallards. The molt schedule for the Mallard is different from that of the Blue-winged Teal and the influence of domestication needs to be considered.
Experiments were designed, therefore, to elucidate factors associated with sexual dimorphism in the Blue-winged Teal. Initially, regenerated feathers of gonadectomized, diethyl stilbestrol treated, and testosterone propionate-treated immature teal were observed. When it became evident that diethyl stilbestrol suppressed feather patterns of certain areas, experiments were initiated to observe the effects of different levels of diethyl stilbestrol on feather patterns of adult male teal. Finally, adult male and female teal were gonadectomized to eliminate the primary source of sex hormones. These birds were implanted with diethyl stilbestrol and testosterone to determine their effects on feather patterns.
METHODS

Feather Plucking

In order to study the effects of administered hormones on feather patterns, it is necessary to have feather growth at specified times to correspond with hormone administration. Controlling the onset of feather development is possible because feathers regenerate promptly at constant rates following plucking at any time of the year (Lillie, 1932). In the following experiments, feathers were plucked from areas that showed obvious sexual dimorphism. These areas were located on the face (included posterior part of the conspicuous crescent of the male), chin-throat, chest-center, chest-side, side, flank, lower tail coverts, and scapulars. The face and chin-throat areas were about \( \frac{1}{4} \) inch sq while the other areas were about \( \frac{1}{2} \) inch sq.

Hormone Administration

The estrogen source was diethyl stilbestrol. Three and six milligram Stimplants (Charles Pfizer and Company, Inc., Brooklyn, New York) were implanted subcutaneously in the nape with a Pfizer Automatic Implanter (Fig. 16). Control birds received the same treatment with an unloaded implanter.

Testosterone was administered by one of two methods. In the first experiment, 1 mg of testosterone propionate (The Upjohn Company, Kalamazoo, Michigan) in .2 cc cottonseed oil was injected subcutaneously in the nape daily. Control birds
received daily injections of .2 cc cottonseed oil. Birds receiving daily injections developed irregular and interrupted molt patterns and their plumages became badly worn. It was decided, therefore, to discontinue injections in subsequent experiments and use testosterone pellets. Seventy-five milligram testosterone pellets, Oreton (Schering Corporation, Bloomfield, New Jersey), were cut into five parts of approximately 15 mg each. A puncture was made in the skin of the nape and the pellets were inserted with a forceps. Control birds were subjected to the trauma of the skin puncture and forceps insertion.

Gonadectomy

The birds were taken off feed 24 hours and water 12 hours before surgery because empty viscera made the gonads more accessible. A commercial coagulant was administered to reduce hemorrhage during surgery. In the first experiment, the birds were given a synthetic vitamin K product, Clotin (Gland-O-Lac Company, Omaha, Nebraska), for three days prior to surgery. The birds gonadectomized for the final experiment were given a preparation of oxalic acid, Vetistat (Norden Laboratories, Inc., Lincoln, Nebraska). This was injected intra-muscularly about 45 minutes before operating.

Gonadectomy of the immature teal for the first experiment was facilitated by the assistance of Mr. Marc Nichols, of Decorah, Iowa, who is an experienced chick caponizer. These
birds were not anesthesized. During subsequent gonadectomies, however, the birds were anesthesized with Equithesin (Jensen-Salsbery Laboratories, Kansas City, Missouri) which is a combination of chloral hydrate, pentobarbital, and magnesium sulfate in aqueous solution of propylene glycol with 9.5 percent alcohol. This was administered by intra-muscular injections at a dosage of 2.5 cc per kilogram of body weight as recommended by Gandal (1956). Dosages of 2.0 and 2.3 cc per kilogram were tried, but these concentrations did not induce a satisfactory general anesthesia. The birds were on their backs in about 10 to 20 minutes and surgery began about one hour post-injection. They were on their feet between 3 and 4 hours following injection.

The birds were immobilized on their sides on a 27½ inch x 20 inch board. Hinged near the edge of the board was a 24 inch strip 1½ inches wide and ½ inch thick which was notched to fit over the neck and appressed wings (Fig. 17). The notches were such that a bird could be held on its left or right side. A string attached to the board was looped around the legs and through a hole where a small weight was attached to prevent leg movement.

The down dorsal to the side feathers was removed and an incision about 1¼ inches long was made through the skin (Fig. 17). A flat, blunt "probe" such as a scalpel handle was inserted between the skin and body and passed posteriorly to the last rib and raised to slide the incision of the skin over
this area. A relatively sharp spreading device was inserted between the last two ribs, leaving an opening about 5/8 x 7/8 inches.

The testes were removed with a large pair of forceps which had two small pieces (5/16 x 3/16 inches each) of 1/16 inch stainless steel silver-soldered at right angles to the ends. A home-made equature was used for removing ovaries. This consisted of a piece of 1/16 inch stainless steel soldered to the end of a ½ inch stainless steel rod 6 inches long having an inside diameter of 1/8 inch. Two small holes were drilled in the end plate and a piece of platinum wire was looped into the holes and through the handle. Tissue missed by this device was removed with a forceps.

A single suture was made through the skin although the incision usually closed when the legs were returned to their normal position.
THE EFFECTS OF GONADECTOMY, DIETHYL STILBESTROL, AND TESTOSTERONE PROPIONATE ON FEATHER REGENERATION OF IMMATURE BLUE-WINGED TEAL

Procedure

This experiment was initiated to determine the effects of gonad removal and sex hormone administration on the pattern and color of feathers regenerated from plucked areas. Twenty male and twenty female immature Blue-winged Teal essentially in juvenal plumage, but with some first basic feathers in the chest and side, were used. Five birds of each sex had been gonadectomized on 1 October 1967 when 82 days old. Of the remaining birds, 5 males and 5 females received 6 mg implants of diethyl stilbestrol and 5 males and 5 females received daily 1 mg testosterone propionate in .2 cc cottonseed oil injected subcutaneously in the nape. The birds were plucked and hormone administration was begun on 7 October 1967.

Five males and 5 females served as controls. Three of the control males received daily injections of cottonseed oil (.2 cc) and two were treated with an unloaded implanting gun on 7 October 1967. Two of the control females received daily injections of cottonseed oil and three were injected with the implanting gun.

Daily injections were anticipated until all plucked areas had regenerated feathers. However, several areas of different birds were very slow to regenerate and waiting for regeneration would have necessitated comparing feathers regenerated in
October with those grown in December or January. It was de­
cided, therefore, to examine the feathers in November. Re­
generated feathers were examined between 5 and 14 November,
28 to 37 days after plucking. Injections were continued,
however, until 17 January 1968 (102 days after plucking) when
they were terminated even though no growth of feathers had
occurred in some areas.

Results

Males

Feather patterns  Feathers were regenerated in all
plucked areas of all controls, while plucked areas of some
experimental birds were not regenerated (Table 6). Failure to
regenerate was most common in the testosterone-treated birds
and occurred in 19 of 30 plucked areas (6 areas on each of 5
birds). In the diethyl stilbestrol treatment, 6 of 30 plucked
areas failed to regenerate and 1 of 18 failed in the castrates.
The flank and lower tail coverts were the areas most frequently
failing to regenerate plucked feathers while the face and chin‐
throat regenerated most completely.

Regenerated feathers of the face and chin-throat were the
same for all treatments and resembled those originally plucked,
although the new feathers possibly were lighter than the
originals. The regenerated lower tail coverts were quite
similar in all treatments—varying from spotted to dark mottled.
Patterns of regenerated feathers of the other plucked areas of
Table 6. The effects of castration, testosterone propionate, and diethyl stilbestrol on feather regeneration of immature male Blue-winged Teal, 4 to 5 weeks following plucking and hormone administration

<table>
<thead>
<tr>
<th>Area</th>
<th>Control (5)^</th>
<th>Testosterone Propionate (5)</th>
<th>Diethyl Stilbestrol (5)</th>
<th>Castrates (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face</td>
<td>5 mottled</td>
<td>4 mottled</td>
<td>5 mottled</td>
<td>3 mottled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chin-throat</td>
<td>5 white</td>
<td>2 white</td>
<td>5 white</td>
<td>3 white</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest-center</td>
<td>2 spotted</td>
<td>1 &quot;U's&quot; and spotted</td>
<td>3 plain</td>
<td>1 &quot;U's&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 &quot;U's&quot; and spotted</td>
<td>1 modified spots</td>
<td>1 &quot;U's&quot; and spotted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 none</td>
<td>1 none</td>
<td>1 &quot;U's&quot; and modified spots</td>
</tr>
<tr>
<td>Chest-side</td>
<td>2 spotted</td>
<td>1 &quot;U's&quot; and spotted</td>
<td>3 plain</td>
<td>2 &quot;U's&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 &quot;U's&quot; and spotted</td>
<td>1 &quot;U's&quot;</td>
<td>1 &quot;U's&quot; and modified spots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 none</td>
<td>1 none</td>
<td></td>
</tr>
<tr>
<td>Side</td>
<td>2 barred and spotted</td>
<td>1 spotted</td>
<td>3 plain (hint of barring patterns)</td>
<td>2 modified spots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 spotted</td>
<td>1 &quot;U's&quot; and spotted</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 &quot;U's&quot; and spotted</td>
<td>1 modified spot</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 none</td>
<td>1 none</td>
<td></td>
</tr>
<tr>
<td>Flank</td>
<td>2 barred and spotted</td>
<td>5 none</td>
<td>2 plain</td>
<td>1 spotted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 spotted and frosted</td>
<td>3 none</td>
<td>1 none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 spotted and &quot;U's&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 &quot;U's&quot;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^Number of birds.
<table>
<thead>
<tr>
<th>Area</th>
<th>Control (5)(^a)</th>
<th>Testosterone Propionate (5)</th>
<th>Diethyl Stilbestrol (5)</th>
<th>Castrates (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower tail Coverts</td>
<td>3 dark mottled</td>
<td>1 large blotch</td>
<td>1 dark mottled</td>
<td>3 dark mottled</td>
</tr>
<tr>
<td></td>
<td>2 short quills</td>
<td>1 spotted</td>
<td>1 spotted</td>
<td>3 none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scapulars</td>
<td>2 barring</td>
<td>1 barring</td>
<td>2 &quot;U's&quot;</td>
<td>1 &quot;U&quot;</td>
</tr>
<tr>
<td></td>
<td>2 &quot;U's&quot; and &quot;V's&quot;</td>
<td>3 &quot;U's&quot; and &quot;V's&quot;</td>
<td>2 plain and &quot;V&quot;</td>
<td>1 none</td>
</tr>
<tr>
<td></td>
<td>1 plain</td>
<td>1 plain (weak pattern)</td>
<td>1 plain and frosted</td>
<td>1 none</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
these males were similar among controls, testosterone-treated birds, and castrates, but patterns were plain or female-like in the diethyl stilbestrol treatment.

Because a number of areas failed to regenerate, the birds were examined one month later on 10 December. Regeneration was more complete and the feminizing affect of diethyl stilbestrol could clearly be seen. The chest-center, chest-side, side, flank, and lower tail coverts regenerated essentially plain feathers. An example of the feminizing affect of diethyl stilbestrol is shown in the feathers of the chest-side. The regenerated chest-side feathers had "U" shaped patterns in the controls, testosterone treatment, and castrates, while in the stilbestrol treatment they were plain (Fig. 18).

**Penis size**

Notes were made on the penis condition of these birds periodically through 23 May 1968. Penises of birds following 9 days of testosterone treatment were much longer than those of the birds of other treatments (Table 7). They also were spiralled and reddish while those of all other treatments were straight and white.

The penis lengths of diethyl stilbestrol-treated birds 7 days after implantation were slightly longer than those of controls. When measured one month later (early November), penises of controls were about the same size while those of diethyl stilbestrol-treated birds were slightly smaller. Because these differences were small and the precision of measurement was probably not great, the statistical significance of
Figure 18. The effects of castration, testosterone propionate and diethyl stilbestrol on regeneration of chest-side feathers of immature male Blue-winged Teal

A - Controls, B - Castrate, C - Testosterone treatment, and D - Diethyl stilbestrol treatment
Table 7. The affect of castration, diethyl stilbestrol and testosterone propionate on the penis of immature Blue-winged Teal

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of days following treatment</th>
<th>N</th>
<th>$\bar{X}$</th>
<th>Range</th>
<th>S.E.</th>
<th>Penis condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>7 or 9</td>
<td>5</td>
<td>2.4</td>
<td>2-3</td>
<td>0.245</td>
<td>white, straight</td>
</tr>
<tr>
<td>Castrates</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0.</td>
<td>white, straight</td>
</tr>
<tr>
<td>D.S.</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>3-5</td>
<td>0.447</td>
<td>white, straight</td>
</tr>
<tr>
<td>T.P.</td>
<td>9</td>
<td>5</td>
<td>8.6</td>
<td>7-12</td>
<td>0.898</td>
<td>red, coiled</td>
</tr>
</tbody>
</table>

these data are somewhat questionable. The data do suggest, however, that diethyl stilbestrol initially caused an increase in penis size. Penises of stilbestrol treated birds reached a maximum of 7 mm in early March, while those of controls reached a maximum of at least 12 mm in February and March. Penis lengths of castrates were measured through May, 1969, 20 months after castration, and were never longer than 3 mm.

Females

**Feather patterns** Failure of areas to grow new feathers was greater among females than males. The numbers of non-regenerated areas per treatment were: testosterone propionate - 20 of 30; diethyl stilbestrol - 10 of 30; ovariectomy - 5 of 18; and controls - 3 of 30. One of the controls received daily oil injections and the other two were treated with an empty implanting gun.
The relationship between areas and the degree of regeneration was the same as for the males. The flank and lower tail coverts failed to regenerate most frequently while the face and chin-throat regenerated most completely.

Regenerated feathers of the face and chin-throat were the same for all treatments and the lower tail coverts were the same in three treatments but were not regenerated by the testosterone treatment (Table 8). The new feathers of the control and diethyl stilbestrol treatments were quite similar although the side feathers and scapulars were patterned. The testosterone-treated and ovariectomized birds regenerated more patterned feathers than did the other two treatments. However, the differences were not very dramatic.

When examined one month later in early December, additional regeneration had taken place and the effects of the treatments were more obvious. Feather patterns of control and diethyl stilbestrol-treated birds were mostly plain as was indicated by the first examination (Fig. 19).

Three of the testosterone propionate-treated birds had regenerated feathers at this time while one had regenerated only a few feathers in the face, chin-throat, and scapulars and the other had no additional regenerations. The regenerated feathers of the chest-center, chest-side, and side had "U" or "V" shaped patterns in all three birds while the flank feathers were similarly patterned in one and did not regenerate in the other two. These "U" and "V" shaped patterns were very
Table 8. The effects of ovariectomy, diethyl stilbestrol, and testosterone propionate on feather regeneration of immature female Blue-winged Teal. They were examined 4 or 5 weeks following plucking and hormone administration.

<table>
<thead>
<tr>
<th>Area</th>
<th>Control (5)⁸</th>
<th>Diethyl Stilbestrol (5)</th>
<th>Testosterone Propionate (5)</th>
<th>Ovariectomy (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face</td>
<td>5 mottled</td>
<td>5 mottled</td>
<td>4 mottled</td>
<td>3 mottled</td>
</tr>
<tr>
<td>Chin-throat</td>
<td>5 white</td>
<td>5 white</td>
<td>4 white</td>
<td>3 white</td>
</tr>
<tr>
<td>Chest-center</td>
<td>5 plain</td>
<td>3 plain</td>
<td>1 &quot;V's&quot;</td>
<td>2 plain</td>
</tr>
<tr>
<td>Chest-side</td>
<td>4 plain</td>
<td>5 plain</td>
<td>1 weak pattern</td>
<td>2 plain</td>
</tr>
<tr>
<td>Side</td>
<td>1 &quot;V's&quot; and barring</td>
<td>1 frosted</td>
<td>1 &quot;U's&quot; and &quot;V's&quot;</td>
<td>2 &quot;U's&quot; and &quot;V's&quot;</td>
</tr>
<tr>
<td>Flank</td>
<td>1 plain and spotted</td>
<td>1 plain</td>
<td>1 spotted</td>
<td>1 plain</td>
</tr>
<tr>
<td>Lower tail coverts</td>
<td>5 spotted</td>
<td>2 spotted</td>
<td>5 none</td>
<td>1 spotted</td>
</tr>
</tbody>
</table>

⁸Number of birds.
<table>
<thead>
<tr>
<th>Area</th>
<th>Control (5)(^a)</th>
<th>Diethyl Stilbestrol (5)</th>
<th>Testosterone Propionate (5)</th>
<th>Ovariectomy (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scapulars</td>
<td>2 plain and weak pattern</td>
<td>3 weak pattern</td>
<td>2 weak pattern</td>
<td>3 plain</td>
</tr>
<tr>
<td></td>
<td>1 frosted</td>
<td>1 plain</td>
<td>1 plain</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 plain</td>
<td>1 plain</td>
<td>2 none</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 none</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 19. The effects of gonadectomy, testosterone propionate, and diethyl stilbestrol on regeneration of chest-side feathers of immature female Blue-winged Teal

A - Controls, B - Ovariectomy, C - Diethyl stilbestrol treatment, and D - Testosterone treatment
bold in two and less distinct in the other. The latter (Bl2) is the individual that regenerated some plain feathers in the chest-side, chest-center, and side which were present on 7 November and are included in Table 8.

Of the two ovariectomized birds still living in December, one had essentially plain feathers and the other was quite plain in the chest-center but well patterned with narrow "U's" or "V's" in the chest-side and side with additional irregular patterns in the side feathers. Although these birds were not laparotomized, I suspect that the plain feathered bird (R11) regenerated much of her ovary while the other (Y25) was ovariectomized more completely.

Bill spots Ovariectomy and the administration of diethyl stilbestrol and testosterone propionate appeared to reduce the number of bill spots on immature females (Table 9). Control birds had many bill spots. An exception to this was R17 which only had two. Members of all three experimental treatments had relatively few bill spots, with the exception of a testosterone-treated individual (Y7) which had 32 bill spots. (This is the only bird not to regenerate any feathers.) Because of small sample size and variation in results, the reliability of these data might be questioned. However, a trend of reduced number of bill spots following ovariectomy or diethyl stilbestrol and testosterone administration is indicated.
Table 9. The effect of ovariectomy, diethyl stilbestrol, and testosterone propionate on bill spots of female immature Blue-winged Teal

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of days following treatment</th>
<th>N</th>
<th>X</th>
<th>Range</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>45 or 49</td>
<td>5</td>
<td>24.6</td>
<td>2-44</td>
<td>6.36</td>
</tr>
<tr>
<td>T.P.</td>
<td>45</td>
<td>5</td>
<td>10.4</td>
<td>3-32</td>
<td>4.96</td>
</tr>
<tr>
<td>D.S.</td>
<td>49</td>
<td>5</td>
<td>4.4</td>
<td>0-12</td>
<td>2.08</td>
</tr>
<tr>
<td>Ovariectomy</td>
<td>49</td>
<td>3</td>
<td>6.0</td>
<td>0-16</td>
<td>4.00</td>
</tr>
</tbody>
</table>

Subsequent plumages

Plumage and molt data were recorded for the castrates, male controls (in part), and diethyl stilbestrol-treated males after the regeneration experiment had been completed. The birds injected daily (testosterone treatment and injected controls) were excluded because their plumage and molt patterns were atypical. Either constant handling or large accumulations of carrier oil could have been responsible. Females are excluded because of the difficulty in relating feather patterns to plumages for all areas.

Both control birds developed two complete alternate plumages during winter and spring (Table 10). They were essentially alternate by early February and were in pre-basic molt on 30 March 1968. The resulting basic plumage was nearly complete when the birds began pre-alternate molt, and they
Table 10. Subsequent plumages of non-injected control males, diethyl stilbestrol-treated males, and castrates following completion of the feather regeneration experiment. Implanting occurred on 7 October 1967

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B28</td>
<td>Juv. p.; no molt; some basic chest, sides, and scaps</td>
<td>essent. alt. p.; no molt; penis large</td>
<td>alt. pl.; no molt; penis (2 basic scaps); p. large</td>
<td>alt. p.; little pre-alt. m.; penis large</td>
</tr>
<tr>
<td>B25</td>
<td>Juv. p.; no molt; some basic chest, sides, and scaps</td>
<td>alt. p.; no molt; penis large (12 mm)</td>
<td>essent. alt. pl.; alt. p.; much pre-basic m.; p. large</td>
<td>little pre-alt. m.; penis large</td>
</tr>
<tr>
<td>Castrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y2</td>
<td>Juv. p.</td>
<td>basic p.; no molt; penis 1 mm.</td>
<td>basic p.; no molt; penis 2 mm.</td>
<td>basic p.; no molt; penis 2 mm.</td>
</tr>
<tr>
<td>Y12</td>
<td>Juv. p.; no molt; some basic chest, lower tail cov.</td>
<td>basic p.; little pre-basic m.; penis 2 mm.</td>
<td>basic p.; little basic p.; no pre-basic m.; molt; penis 2 mm.</td>
<td>basic p.; little basic p.; molt; penis 2 mm.</td>
</tr>
<tr>
<td>R7</td>
<td>Juv. p.; no molt; some basic chest</td>
<td>basic p.; no molt; penis 2 mm.</td>
<td>basic p.; little basic p.; no pre-basic m.; molt; penis 2 mm.</td>
<td>basic p.; little basic p.; molt; penis 2 mm.</td>
</tr>
<tr>
<td>D.S.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B22</td>
<td>basic p.; no molt; penis 4 mm.</td>
<td>essent. basic p.</td>
<td>basic p.; no molt; little molt; penis 3 mm.</td>
<td></td>
</tr>
</tbody>
</table>
Table 10 (Continued)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D.S. Y20</td>
<td>basic p.; no molt; penis 3 mm.</td>
<td>basic p.; little molt</td>
<td>basic p.; little pre-basic m.</td>
<td></td>
</tr>
<tr>
<td>YL4</td>
<td>basic p.; no molt; penis 5 mm.</td>
<td>basic p.; no molt; penis 5 mm.</td>
<td>basic p.; little pre-basic m.</td>
<td></td>
</tr>
</tbody>
</table>
were in alternate plumage by 23 May 1968. The infra-red heat lamps used to heat the building undoubtedly caused this unusual molting pattern.

Diethyl stilbestrol-treated males molted into basic plumage and remained basic through 23 May, at which time two of the three remaining birds were in pre-basic molt. Three diethyl stilbestrol-treated males were undergoing tertial molt (2 on 30 March and 1 on 23 May) while in basic plumage and pre-basic molt. Tertial molt normally accompanies pre-alternate molt but probably occurred because these birds did not undergo pre-alternate molt. The omission of the first alternate plumage probably was caused by stilbestrol or the infra-red heat lamps.

The castrates molted into basic plumage and were still basic on 23 May. They remained in basic plumage throughout the summer and fall and began pre-alternate molt in February 1969. In early March, the two castrates (R7 died earlier) were about \( \frac{1}{2} \) alternate and \( \frac{1}{2} \) basic. A laparotomy on 5 March 1969 revealed an absence of testicular tissue on both sides of both birds. They assumed the alternate plumage in late March-early April at which time penis lengths were still between 2 and 3 mm.
THE EFFECTS OF DIETHYL STILBESTROL ON FEATHER PATTERNS AND MOLT OF ADULT MALE BLUE-WINGED TEAL

Procedure

6 and 12 mg implants of diethyl stilbestrol

Results of the first experiment indicated that diethyl stilbestrol would suppress patterns of regenerating feathers in males. To further test this hypothesis, an experiment was initiated using 15 adult (about 18 months old) male Blue-winged Teal. Some of the birds were in early pre-alternate molt, having a plumage that appeared to be basic, and others were in advanced pre-alternate molt, having a plumage that appeared to be alternate. The birds were divided into three groups of 5 each, such that each group contained birds with similar plumages.

Feathers were plucked on 26 December 1967. On 6 January 1968, 11 days after plucking, one group received 6 mg implants of diethyl stilbestrol, a second group received 12 mg implants of diethyl stilbestrol, and a third group, the controls, were treated with an unloaded implanting gun.

18 and 24 mg implants of diethyl stilbestrol

Because the 6 and 12 mg treatments proved to be only partially effective in modifying feather patterns, another experiment was established to compare controls with 18 and 24 mg diethyl stilbestrol treatments. Surviving birds from the 6 and 12 mg experiment also were used for this experiment. There-
fore, only 4 birds were used for each treatment and two males with histories similar to the other birds were added. Plucking and implanting occurred on 18 August 1968. Most of the birds were in basic plumage and several were in early pre-alternate molt. Three were essentially in alternate plumage.

Results

6 and 12 mg implants of diethyl stilbestrol

Regenerated feathers were examined on 20 January 1968, 14 days after implanting and 25 days after plucking. In all treatments, the face, chin-throat, and flank regenerated alternate feathers.

The chest-center and chest-side feathers of controls were spotted, while those from experimental birds were either spotted, or had "U" or modified "U" shaped patterns (Fig. 20). These patterns usually were not well defined. One bird (109) had well developed "U's". The spotted feathers from the experimental birds had the proximal spots joined—giving the feather a darker appearance. These feathers, therefore, had fewer distinct spots than those of controls. Inverted "U" patterns are common in the basic plumages of males and are frequently present in both plumages of females.

The regenerated side feathers of controls were barred or spotted, while those from the experimental birds were like the controls distally but irregularly patterned proximally (Fig. 20). Patterns were less pronounced and colors were lighter.
Figure 20. The effects of 6 and 12 mg diethyl stilbestrol implants on regenerated feather patterns of the chest-center, chest-side, and side of adult male Blue-winged Teal
Some feathers showed fairly good inverted "U's" and several had weak "U" patterns, while others showed no particular pattern.

The lower tail coverts of controls were black distally with gray mottling proximally (Fig. 21). In three of the controls, the black and mottled portions joined gradually, while in the other the demarcation was quite sharp. All of the lower tail coverts of experimental birds were black distally and mottled proximally and in most the demarcation lines were sharp. Several of the new coverts of experimental birds had a distinct horizontal line next to the black that was lighter than the more proximal mottled portions (Fig. 21, number 145). The horizontal lines did not occur on the feathers of controls and appear to indicate the area of the developing feather first affected by stilbestrol.

The scapulars of controls had blue vanes, broad shaft streaks, or irregular light-colored patterns (Fig. 21). All of the scapulars of experimental birds were like the controls distally, but with horizontal buff bands separating these portions from the brown unpatterned proximal portions. The width of these bands varied from 1/8 to 1/2 inch and the widest bands occurred in the 12 mg treatment.

**18 and 24 mg implants of diethyl stilbestrol**

Feathers regenerated during this experiment were examined on 28 September 1968, 41 days after plucking and implanting.
Figure 21. The effects of 6 and 12 mg diethyl stilbestrol implants on regenerated feather patterns of the scapulans and lower tail coverts of adult male Blue-winged Teal.
CONTROL

6 mg D.S.

12 mg D.S.

SCAPULARS

LOWER TAIL COVERTS

115 103 115 116

109 139 109

132 134

115 107 116

110 109 123

132 143
The face and chin-throat regenerated basic feathers in all treatments except one control (115) which also grew some alternate feathers.

The regenerated feathers of the other areas of controls were alternate or nearly so, while those of the experimental treatments were generally plain or lightly mottled. The regenerated chest-center and chest-side feathers were typical alternate while those of experimental treatments were plain or with weak irregular patterns (Fig. 22). The weakly patterned feathers were grown by birds that were regenerating alternate feathers when plucked.

The regenerated side feathers also were alternate, while those from experimental birds were like the feathers regenerated by the chest (Fig. 23). The regenerated flank feathers of controls were white or barred and those from diethyl stilbestrol-treated birds varied from plain to mottled or irregularly spotted (Fig. 23).

The regenerated lower tail coverts of controls were black on two birds, with basal mottling on another, and dark with irregular light patterns—resembling those of the first basic plumage—in the other. The lower tail coverts of experimental birds were very light with irregular mottling and some dark blotches (Fig. 24). The regenerated scapulars of controls were typical alternate in 115 and 144, with blue vanes and bold patterns, but with dark shaft-streaks and weak patterns in 126 and 135 (Fig. 24). The scapulars from experimental birds were
Figure 22. The effects of 18 and 24 mg diethyl stilbestrol implants on regenerated feather patterns of the chest-center and chest-side of adult male Blue-winged Teal.
Figure 23. The effects of 18 and 24 mg diethyl stilbestrol implants on regenerated feather patterns of the side and flank of adult male Blue-winged Teal
Figure 24. The effects of 18 and 24 mg diethyl stilbestrol implants on regenerated feather patterns of the lower tail coverts and scapulars of adult male Blue-winged Teal.
Effect of Diethyl Stilbestrol on Molt

The administration of diethyl stilbestrol had a pronounced inhibitory affect on molt (Table 11). In January, following the completion of the feather regeneration experiment, all of the birds were in alternate plumage. On 27 February, 52 days after stilbestrol implantation, 4 of the 5 controls were essentially in alternate plumage and in full pre-basic molt. The other control (No. 103) was badly emaciated and died a short time later. Of the birds given 6 mg of diethyl stilbestrol, 2 were in alternate plumage and not molting, 2 were essentially in alternate plumage with little pre-basic molt, and 1 died earlier. The 12 mg treated birds were in alternate plumage and were not molting. One of the 12 mg birds (No. 131) died in late January.

On 31 March, 84 days after hormone administration, 4 birds of each treatment were living. Of the control birds, 2 had plumages with basic aspect while 2 were 1/2 basic and 1/2 alternate. All were in full pre-basic molt. Of the 6 mg treated birds, 1 had a plumage with basic aspect, 2 were 1/2 basic and 1/2 alternate, and 1 was essentially alternate. These birds also were in full pre-basic molt. All of the 12 mg treated birds were essentially in alternate plumage. Two of these were in full pre-basic molt and 2 were not molting.

Although diethyl stilbestrol inhibited molt, it did not
Table 11. The effect of diethyl stilbestrol\textsuperscript{a} on molt of adult male Blue-winged Teal

<table>
<thead>
<tr>
<th>Treatment</th>
<th>27 February 1968</th>
<th>31 March 1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4 essent. alt. P. much pre-basic M.</td>
<td>1 essent. basic P. little pre-basic M.</td>
</tr>
<tr>
<td></td>
<td>1 Alt. P.; no molt badly emaciated</td>
<td>1 essent. basic P. much pre-basic M.</td>
</tr>
<tr>
<td></td>
<td>2 (\frac{1}{2}) alt. and (\frac{1}{2}) basic P. much pre-basic M.</td>
<td></td>
</tr>
<tr>
<td>6 mg D.S.</td>
<td>2 alt. P. no molt</td>
<td>1 essent. alt. P. much pre-basic M.</td>
</tr>
<tr>
<td></td>
<td>2 essent. alt. P. little pre-basic M.</td>
<td>2 (\frac{1}{2}) alt. and (\frac{1}{2}) basic P. much pre-basic M.</td>
</tr>
<tr>
<td></td>
<td>1 dead on 1 February 1968</td>
<td>1 essent. basic P. much pre-basic M.</td>
</tr>
<tr>
<td>12 mg D.S.</td>
<td>4 alt. P. no molt</td>
<td>2 essent. alt. P. no molt</td>
</tr>
<tr>
<td></td>
<td>1 dead on 29 January 1968</td>
<td>2 essent. alt. P. much pre-basic M.</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Diethyl stilbestrol was implanted on 6 January 1968.
suppress feather regeneration from plucked areas. On 20 January 1968, 25 days after plucking and 14 days after implanting, a larger number of plucked areas of controls failed to regenerate feathers than those of either experimental treatment (Table 12). The scapulars regenerated most rapidly while the flank was the slowest area to regenerate feathers.
Table 12. Regeneration status of adult male Blue-winged Teal 25 days after plucking and 14 days after implanting

<table>
<thead>
<tr>
<th>Region</th>
<th>Control</th>
<th>6 mgm. D.S.</th>
<th>12 mgm. D.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face</td>
<td>2 complete</td>
<td>4 complete</td>
<td>3 complete</td>
</tr>
<tr>
<td></td>
<td>2 little</td>
<td>1 nearly complete</td>
<td>1 much</td>
</tr>
<tr>
<td></td>
<td>1 none</td>
<td>1 little</td>
<td>1 1 little</td>
</tr>
<tr>
<td>Chin-throat</td>
<td>2 complete</td>
<td>4 complete</td>
<td>4 complete</td>
</tr>
<tr>
<td></td>
<td>1 much</td>
<td>1 nearly complete</td>
<td>1 none</td>
</tr>
<tr>
<td></td>
<td>1 none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scapulars</td>
<td>(complete or nearly complete in all)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chest-center</td>
<td>1 complete</td>
<td>2 complete</td>
<td>1 complete</td>
</tr>
<tr>
<td></td>
<td>1 nearly complete</td>
<td>1 nearly complete</td>
<td>1 nearly complete</td>
</tr>
<tr>
<td></td>
<td>1 little</td>
<td>1 some (^a)</td>
<td>1 some (^a)</td>
</tr>
<tr>
<td></td>
<td>2 none</td>
<td>1 none</td>
<td>1 none</td>
</tr>
<tr>
<td>Chest-side</td>
<td>1 complete</td>
<td>2 complete</td>
<td>1 complete</td>
</tr>
<tr>
<td></td>
<td>1 nearly complete</td>
<td>1 nearly complete</td>
<td>1 nearly complete</td>
</tr>
<tr>
<td></td>
<td>1 little</td>
<td>1 some (^a)</td>
<td>2 some (^a)</td>
</tr>
<tr>
<td></td>
<td>2 none</td>
<td>1 little</td>
<td>1 none</td>
</tr>
<tr>
<td>Side</td>
<td>1 nearly complete</td>
<td>1 nearly complete</td>
<td>1 complete</td>
</tr>
<tr>
<td></td>
<td>1 some (^a)</td>
<td>2 much</td>
<td>2 nearly complete</td>
</tr>
<tr>
<td></td>
<td>3 little</td>
<td>2 some (^a)</td>
<td>1 some (^a)</td>
</tr>
<tr>
<td></td>
<td>2 none</td>
<td></td>
<td>1 none</td>
</tr>
<tr>
<td>Flank</td>
<td>2 much</td>
<td>2 nearly complete</td>
<td>1 nearly complete</td>
</tr>
<tr>
<td></td>
<td>2 little</td>
<td>2 much</td>
<td>1 much</td>
</tr>
<tr>
<td></td>
<td>1 none</td>
<td>1 some (^a)</td>
<td>1 little</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 none</td>
</tr>
<tr>
<td>Lower tail</td>
<td>2 much</td>
<td>2 nearly complete</td>
<td>1 nearly complete</td>
</tr>
<tr>
<td>coverts</td>
<td>2 little</td>
<td>2 much</td>
<td>2 much</td>
</tr>
<tr>
<td></td>
<td>1 none</td>
<td>1 some (^a)</td>
<td>1 some (^a)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 none</td>
</tr>
</tbody>
</table>

\(^a\)Some regeneration but not certain of extent.
THE EFFECTS OF DIETHYL STILBESTROL AND TESTOSTERONE ON FEATHER REGENERATION OF GONADECTOMIZED ADULT BLUE-WINGED TEAL

Procedure

The combination of feather plucking and hormone administration can be a very effective method for studying hormonal influences on feather patterns. However, the blood hormone levels attributable to gonad secretion are not known and could be an important factor if there was significant variation in gonadal activity within treatments. It was decided, therefore, to initiate an experiment using gonadectomized adult teal.

About 70 teal were gonadectomized between 12 and 20 September 1968. Mortality was high (about 50%) for the first 30 birds, but decreased rapidly thereafter. Only two of the final 28 gonadectomized birds died. Early post-operative mortality was caused by damage to the posterior vena cava during surgery. In most cases, these birds died while on the immobilizing board.

Feathers were plucked between 1 and 2 weeks following gonadectomy, on 28 and 29 September. In addition to the areas described previously, the rump also was plucked.

On 3 October 1968, the birds were placed into 3 groups of 14 (7 males and 7 females). The controls were short one male. One group received 15 mg diethyl stilbestrol implants, a second group received 15 mg testosterone implants, and a third group, the controls, were treated with an unloaded implanting gun.

Because the birds were in various stages of their plumage
cycle, it was not possible to have all birds of each treatment in the same plumage condition. The birds were divided, therefore, such that those of each group had similar plumages. Each experimental group contained two males in alternate plumage but the controls had three; two were in basic plumage, and three had intermediate plumages.

Regenerated feathers were examined on 30 November and 1 December, 62 to 64 days after plucking. Most of the plucked areas had completed feather regeneration after one month. Five males died during the experiment from 13 November to 24 December and were dissected to check for regeneration of testes. No testicular tissue was found in four of the birds while a small nodule of tissue about 2 mm in diameter was found in one (F16) indicating incomplete castration. It seems likely, therefore, that testicular secretions were not present during the period of feather regeneration.

Results

Controls

Males All of the control males regenerated alternate feathers in most areas. Three (R/Y R/R, B10, and B28) were in alternate plumage and pre-alternate molt when plucked and regenerated alternate feathers in all areas (Fig. 25). One (F16) was in basic plumage and early pre-alternate molt when plucked and regenerated alternate feathers in all areas except the face and chin-throat, which were basic when plucked and were regrown
Figure 25. Feather patterns regenerated by a male (R/Y R/R) control castrated Blue-winged Teal that was in alternate plumage when plucked
R/Y  R/R

<table>
<thead>
<tr>
<th>R/Y</th>
<th>R/R</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLD</td>
<td>NEW</td>
</tr>
<tr>
<td>OLD</td>
<td>NEW</td>
</tr>
</tbody>
</table>

- **CHEST-CENTER**
- **FLANK**
- **CHEST-SIDE**
- **LOWER TAIL COVERTS**
- **SIDE**
- **SCAPULARS**
basic. Another (B35), wild-trapped on 1 September 1968, 27 days before plucking, was in basic plumage and not molting when plucked. This bird regenerated alternate feathers in all areas except the face and chin-throat which came in basic and the flank which was renewed with barred and dark mottled feathers (Fig. 26). The scapulars and lower tail coverts included developing alternate feathers on 5 November, thus alternate feathers were grown 46 days after castration.

**Females** The patterns of feathers regenerated by ovariectomized control females varied greatly, and had extremes of little or no change in pattern to a change to male alternate patterns (Table 13). Of the two with male alternate patterns, one (NB) regenerated face and chin-throat feathers that were like the feathers originally plucked, while the regenerated feathers of the chest-center, chest-side, side, flank, and lower tail coverts were identical to male alternate feathers (Figs. 27 and 28). The new scapulars were somewhat iridescent on the large vane, and had shaft streaks or irregular light cross patterns. The patterns of these feathers were not as pronounced as in most male alternate scapulars; however, they were definitely more male-like than female-like. Another control (133) also regenerated feathers in the face and chin-throat that were like those plucked. The new feathers of the chest-center, chest-side, and side were spotted like those of males in alternate plumage (Fig. 27). The new flank feathers
Figure 26. Feather patterns regenerated by a male (B35) control castrated Blue-winged Teal that was in basic plumage when plucked
CHEST-CENTER

FLANK

CHEST-SIDE

LOWER TAIL COVERTS

SIDE

SCAPULARS
Table 13. The effect of complete and incomplete ovariectomy on feather patterns of adult female Blue-winged Teal. The birds were ovariectomized during mid-September, plucked on 28 September, and regenerated feathers examined on 30 November 1968

<table>
<thead>
<tr>
<th>Area</th>
<th>Incomplete ovariectomy</th>
<th>Complete ovariectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Old</td>
<td>New</td>
</tr>
<tr>
<td>Chest-center</td>
<td>&quot;U's&quot;</td>
<td>&quot;U's&quot;</td>
</tr>
<tr>
<td>Chest-side</td>
<td>&quot;U's&quot;</td>
<td>&quot;U's&quot;</td>
</tr>
<tr>
<td>Side</td>
<td>&quot;U's&quot; &amp; &quot;U's&quot; irreg. patterns</td>
<td>&quot;U's&quot;, &quot;V's&quot; irreg. patterns</td>
</tr>
<tr>
<td>Flank</td>
<td>plain, &quot;U's&quot; &amp; plain &amp; &quot;U's&quot; &amp; mod. irreg. blotches</td>
<td>plain &amp; irreg. blotches</td>
</tr>
<tr>
<td>Lower tail coverts</td>
<td>spots (small)</td>
<td>spots (large)</td>
</tr>
<tr>
<td>Area</td>
<td>Incomplete ovariectomy</td>
<td>Complete ovariectomy</td>
</tr>
<tr>
<td>------</td>
<td>------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td>B7 Old New</td>
<td>R9 Old New</td>
</tr>
<tr>
<td>Scapulars</td>
<td>plain, lt.</td>
<td>plain &amp; plain &amp; plain &amp; plain &amp; irid.</td>
</tr>
<tr>
<td></td>
<td>lt. shaft</td>
<td>lt. shaft</td>
</tr>
<tr>
<td></td>
<td>shaft streaks</td>
<td>streaks</td>
</tr>
<tr>
<td></td>
<td>streaks</td>
<td>streaks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size of ovary</td>
<td>13 x 13 mm</td>
<td>15 x 4 mm</td>
</tr>
</tbody>
</table>

*aBirds were laparotomized and regenerated ovary measured on 7 December 1968.*
Figure 27. Patterns of feathers regenerated by two (133 and NB) control ovariectomized Blue-winged Teal. Laparotomy revealed very little regenerated ovarian tissue in these birds.
Figure 28. Patterns of feathers regenerated by two (133 and NB) control ovariectomized Blue-winged Teal. Laparotomy revealed very little regenerated ovarian tissue in these birds.
were spotted but with white basally. The lower tail coverts had irregular black bars on a light background giving a dark mottled appearance (Fig. 28). These feathers resembled the first basic feathers of males. The scapulars were like those of NB, being more like male alternate than any other plumage type.

Two of the controls (B7 and R9) regenerated feathers that were nearly identical to the plucked feathers (Figs. 29 and 30). The other three birds grew feathers that were somewhat intermediate between the two plumage types but were closer to B7 and R9 than 113 and NB.

On 7 December 1968, 10½ weeks after ovarietomy, the control birds were laparotomized to observe the condition of the ovaries. Of the two birds that regenerated female alternate feathers, NB had a small cluster (3 mm diameter) of follicles, while no regenerated ovarian tissue was found in 133. On some birds, regenerated ovarian tissue was found on mesenteries. Thus, it is possible to have ovarian tissue present and not see it by laparotomy. The two birds (B7 and R9) whose regenerated feathers were similar to the plucked feathers had well-developed ovaries. The other birds had regenerated ovarian tissue of a size intermediate to the above extremes. Thus it was assumed that ovarian hormone production was sufficient to prevent the developing feathers from being male alternate-like.
Figure 29. Patterns of chest-center, chest-side, and side feathers regenerated by two (R9 and B7) control ovariectomized Blue-winged Teal. Laparotomy revealed much regenerated ovarian tissue in these birds.
Figure 30. Patterns of flank, lower tail coverts, and scapular feathers regenerated by two (R9 and B7) control ovariectomized Blue-winged Teal. Laparotomy revealed much regenerated ovarian tissue in these birds.
FLANK

LOWER TAIL COVERS

SCAPULARS
Testosterone Implants

Males  The regenerated feathers of testosterone treated male castrates were quite similar to those of the control castrates in being mostly male alternate. Two of the testosterone-treated birds (R1 and B25) were in alternate plumage with pre-alternate molt when plucked and both of them regenerated alternate feathers in all areas (Fig. 31). The scapulars had faint shaft streaks, a few weak patterns, and the blue vanes were reduced and dull. Although these scapulars are not typically alternate they are more alternate than basic. Another control (B6) regenerated at least some alternate feathers in all areas except the face and chin-throat, but had scapulars similar to those just described. One testosterone-treated bird (B46) was in full basic plumage and not molting when plucked. Basic feathers were regenerated in the face and chin-throat (although a few were dark tipped), flank, and scapulars, while the chest, chest-side, and side were spotted (Fig. 32). The spots were not as distinct as those of typical alternate feathers. The lower tail coverts resemble those of the first basic plumage.

Females  Feather patterns of testosterone-treated females were difficult to interpret because the patterns obtained also were observed in non-treated ovariectomized birds. The areas that regenerated feathers noticeably different from the original plucked feathers were the chest-center, chest-side, and side. The new feathers from these areas had modified "U's"
Figure 31. Patterns of feathers regenerated by a male (R1) testosterone-treated castrated Blue-winged Teal that was in alternate plumage when plucked.
NEW CHEST-CENTER

CHEST-SIDE

FLANK

LOWER TAIL COVERTS

SIDE

SCAPULARS
Figure 32. Patterns of feathers regenerated by a male (B46) testosterone-treated castrated Blue-winged Teal that was in basic plumage when plucked.
and spots. The amount of spotting was greatest in those birds in which ovariectomy was most complete.

**Diethyl stilbestrol implants**

**Males and females** The effect of 15 mg diethyl stilbestrol implants on feather patterns of gonadectomized adult Blue-winged Teal was pattern suppression. The feathers regenerated by males were very similar to those of the 18 and 24 mg diethyl stilbestrol treatments described earlier. In this experiment, however, several birds regenerated feathers that were weakly patterned in addition to the plain feathers.

Plain feathers were regenerated by male and female teal that were physiologically capable of producing basic feathers when gonadectomized. The ability to produce basic feathers was determined by active pre-basic molt or recent completion of pre-basic molt. The regenerated chest-center, chest-side, and side feathers were dark brown with light borders and most were light centrally and with light shaft streaks (Fig. 33). The new flank feathers, lower tail coverts and scapulars were similar in both sexes (Fig. 34), but varied more than did the chest and sides.

Both plain, and irregularly and weakly patterned feathers, were regenerated by male and female teal that were physiologically capable of producing alternate feathers when gonadectomized and plucked. This was determined by active pre-alternate molt or recently completed pre-alternate molt. The new chest-
Figure 33. Patterns of chest-center, chest-side, and side feathers regenerated by male (B36) and female (B39) diethyl stilbestrol-treated gonadectomized Blue-winged Teal. These birds were in basic plumage when plucked.
Figure 34. Patterns of flank, lower tail coverts, and scapular feathers regenerated by male (B36) and female (B39) diethyl stilbestrol-treated gonadectomized Blue-winged Teal. These birds were in basic plumage when plucked.
center, chest-side and side feathers of males had the pigmented areas interrupted, while those of females were more plain (Fig. 35). In the females, the side feathers tended to be more patterned than were the chest feathers.

The new flank feathers and lower tail coverts of males had similar mottling but the tail coverts were darker (Fig. 36). In females, these areas regenerated feathers that resembled the chest and sides. The new scapulars had scattered light mottling (Fig. 36). This mottling was most pronounced in males and in some cases formed large, wide "U's", which were not found on the scapulars of wild birds in any plumage, but were similar to the "U's" found on the scapulars of many females in alternate plumage.

Females in alternate plumage have well developed patterns on rump feathers and upper tail coverts. The regenerated feathers in these areas suggest that diethyl stilbestrol suppressed feather patterns (Table 14).

The most conspicuously patterned rump feathers of the controls were from the birds with known ovarian regeneration. The control (133) that regenerated plain feathers did not regenerate ovarian tissue.
Figure 35. Patterns of chest-center, chest-side, and side feathers regenerated by male (B15) and female (B/B B/B) diethyl stilbestrol-treated gonadectomized Blue-winged Teal. These birds were in alternate plumage when plucked.
Figure 36. Patterns of flank, lower tail coverts, and scapular feathers regenerated by male (B15) and female (B/B B/B) diethyl stilbestrol-treated gonadectomized Blue-winged Teal. These birds were in alternate plumage when plucked.
FLANK

LOWER TAIL COVERTS

SCAPULARS
Table 14. The effects of ovariectomy, diethyl stilbestrol, and testosterone on the patterns of regenerated rump feathers

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Control</th>
<th>Ovariectomy &amp; (Ovariectomy)</th>
<th>Ovariectomy &amp; Testosterone</th>
<th>Diethyl Stilbestrol&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain</td>
<td>1</td>
<td>3</td>
<td>4&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Pattern</td>
<td>6</td>
<td>4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Two birds died before regeneration was complete.
<sup>b</sup>Some light mottling on the feathers of two birds.
<sup>c</sup>Pattern is very light on one bird.
DISCUSSION OF HORMONAL INFLUENCES

Feather Regeneration and Hormone Administration

**Gonadectomy**

**Male**

Patterns of regenerated feathers of castrated immature male teal were "U" shaped and identical to those regenerated by controls and testosterone-treated birds. Patterns of feathers regenerated by castrated adult teal were like male alternate, however, the face and chin-throat regenerated basic in some birds. In addition, castration of immature male teal resulted in retention of the first basic plumage for about a year longer than normal. The first alternate began to appear in February 1969, 16½ months after castration on 1 October 1967. This differs from most reports in the literature in that castration usually leads to the assumption of the alternate plumage at the next regular molt unless this molt follows closely after castration. Although few data are available on castration of immature birds, Goodale (1910) suggested that castration of young birds caused a retention of youthful characters.

**Female**

Patterns of regenerated feathers of ovariectomized immature female teal varied from plain (female-like) to "U's" (male-like). Because the birds were not laparotomized, the feather patterns can not be correlated with the completeness of ovariectomy. It seems likely, however, that the birds regenerating male-like feathers were more completely ovariecto-
mized than were the others.

The completeness of ovariectomy of adult female teal was checked by laparotomy and the results show clearly that ovaries regenerated rapidly following incomplete ovariectomy and that feather patterns were nearly identical to those originally plucked. Complete ovariectomy, however, resulted in the regeneration of male-like feathers in all areas except the face and chin-throat. This is consistent with the findings of Van Oordt (1931) that female plumages of the domestic duck were under the influence of the ovary. Response in teal varied between areas of different birds and within areas of a given bird. For example, all of the new lower tail coverts of bird NB were black, while only two of the new flank feathers were white.

**Diethyl Stilbestrol**

Male Regenerated chest-side feathers of immature male teal had inverted "U's" in controls, castrates, and testosterone treatments but were female-like in the diethyl stilbestrol treatment. This feminizing of male plumages agrees with the findings of Emmens and Parkes (1940) and Witschi (1961) on the Mallard.

The effect of 6 and 12 mg diethyl stilbestrol implants on feather patterns of adult males was more dramatic. Implanting was 11 days after plucking; therefore, the distal parts of the regrown feathers were unaffected by the hormone.
The pattern of the regenerated scapulars was particularly striking (Fig. 21). A light cross band separated the distal normal portion from the proximal plain portion. These feathers are similar to patterns induced by three days of estrogen injections on regenerating breast feathers of the Brown Leghorn fowl (Lillie, 1932). In my experiment, however, the estrogenic material was implanted and the affects of the growing feather were expected to be somewhat constant once the hormone level rose to threshold for those feathers. This light band could not be explained as the effects brought about by increasing hormone levels because 12 mg implants caused a wider band and they would be expected to reach threshold faster and thereby reduce the width of the band. A narrow light band also was present between the normal distal portion and the basal mottled portion of many of the experimentally grown lower tail coverts.

The regenerated facial and chin-throat feathers were not modified by 6 and 12 mg implants. It is possible that these feathers completed their growth before the blood estrogen level rose to threshold because they were plucked 11 days before hormone treatment and they grow rapidly. It is also possible that the estrogen threshold level was not reached. This is supported by Lillie's (1932) and Assenmacher's (1958) statements that rapidly growing feathers have a high threshold level.

In an attempt to induce higher hormone levels while the
feathers were developing, an experiment was initiated using 18 and 24 mg diethyl stilbestrol implants and feathers were plucked on the day of implanting. Only a few of the regenerated facial feathers were modified and no changes were noticed in the chin-throat. The chest-center, chest-side, and side feathers were mostly plain or female-like. There was a tendency for these feathers to be slightly patterned in those birds in which originally plucked feathers were alternate (Numbers 139 and 134 in Figs. 22 and 23).

Following completion of the feather regeneration experiment, the control birds molted into basic plumage, while the stilbestrol treated birds molted later. The 6 mg treated birds molted earlier than did the 12 mg treated birds. Because stilbestrol did not suppress feather regeneration from plucked areas (Table 12), its main action in inhibiting molt must be in preventing the loss of old feathers. This agrees with the findings of Assenmacher (1958).

**Females** Feathers regenerated by diethyl stilbestrol-treated immature female teal were less patterned than were those of controls. This lends support to the idea that feather patterns of females can vary from plain to highly patterned with all stages inbetween depending on estrogen levels.

Patterns of feathers regenerated by adult ovariectomized female teal treated with 15 mg diethyl stilbestrol implants were plain. I would expect smaller dosages to induce feathers with an intermediate amount of patterning.
Testosterone

Males Patterns of feathers regenerated by immature male teal treated with 1 mg testosterone daily did not differ from those regenerated by controls. Also, there were no noticeable differences between patterns of regenerated feathers of control castrate and testosterone-treated castrate adult males. This agrees with the findings of Emmens and Parkes (1940) that testosterone does not affect the plumage of caponized Mallards and Witschi's (1961) statement that androgens have no effect on the plumage of male Mallards.

Females Patterns of feathers regenerated by testosterone-treated immature female teal were "U" shaped while those of controls were plain. These "U's" were similar to those developed by control males. This suggests that testosterone has a masculizing affect on female plumages.

Patterns of feathers regenerated by testosterone-treated, ovariectomized adult female teal varied from those originally plucked (female-like) to the spotted and patterned male-like feathers. Because ovariectomy was shown to induce these changes, these patterns can not be attributed to testosterone administration. I would suggest, based on these studies, that testosterone administration to adult female teal will increase spotting and patterns (male-like characters).

In the experiment with immature teal, several areas of the testosterone and diethyl stilbestrol treated birds of both sexes failed to regenerate feathers after 30 days while the
gonadectomized and control birds regenerated feathers in almost all areas. This suggests that the sex hormones inhibited feather regeneration. However, this was not shown with adult birds. Three months after the treatments were initiated, however, all birds had molted into basic or alternate plumage except the daily injected controls and testosterone treated males and females. The plumages of these birds were badly worn as little feather replacement had occurred since the initial growth of plucked areas. The napes of these birds were noticeably thickened. Autopsy revealed what appeared to be a walled-off accumulation of carrier oil. This suggests that daily handling or the accumulation of oil, rather than testosterone, prevented normal molting as observed in the other treatments of this experiment.

Juvenile Plumage

No experiments were designed to study hormonal control of the juvenile plumage. Laparotomy of young birds after development of the juvenile plumage, however, revealed extremely small gonads. Hormonal secretion would not be expected under those conditions. Voitkevich's (1966) statement that the thyroid provides the hormonal stimulation for development of the juvenile plumage seems correct. He also noted that sex hormones are not formed at this time. Differences of feather patterns probably are not caused by hormones.
First Basic Plumage

Feather patterns of the first basic plumage are highly variable—at least in certain feather tracts. In many cases, chest-center, chest-side, and side feathers resemble those of the juvenal plumage and in others they are quite similar to those of the alternate plumage. Feathers grown during August seem to be less patterned than those grown later in the fall. This variation undoubtedly is caused by the time of molt and presumably is associated with gonad development. It is for this reason that I suspect late hatched teal to have more highly patterned first basic plumages.

Immature teal examined during migration frequently are in some stage of pre-basic molt but are not actively molting. This intermediate condition suggests an interrupted molt. Immature teal can be found in August, however, that have nearly finished this molt.

Alternate and Basic Plumages of Adults

Males

The alternate and basic plumages of males are dramatically different and intermediate types are not found. It would appear, therefore, that developing male plumages will be alternate until the estrogen level reaches a certain value, at which time basic patterns develop. The results of Hohn and Cheng (1967) support this idea. They found testosterone-estradiol ratios in the testes of Mallards to change from
highly in favor of testosterone in April to approximately equal amounts in late May and June. One bird had an excess of estradiol in late May. These dates correspond to peak testicular activity in the Mallard (Hohn, 1947).

The explanation of basic plumage induction and estrogen secretion during peak testicular activity lies in the closely related biosynthesis of male and female sex hormones (Voitkevich, 1966). He states that at high concentrations, part of the male sex hormone is transformed into female sex hormone.

Peak testicular activity of the Blue-winged Teal also would be expected just prior to pre-basic molt of adult males which begins between the first week and the end of June. During the summer of 1967, I observed pre-basic molt in northwest Iowa. Some parts of the birds were $\frac{1}{2}$ alternate and $\frac{1}{2}$ basic by the first week of July, indicating that basic feathers were being produced at least from the middle of June. Bennett (1938) stated that most drakes in northwest Iowa were in pre-basic molt by 20 June.

**Females**

Alternate and basic plumages of females are much more similar than those of males. It seems that female plumages are determined by estrogen and testosterone levels also, but there does not appear to be a certain threshold at which the patterns are switched. Intergradations of feather patterns are common
in females, particularly on the vent.

My data suggest that the spotted and interrupted feather patterns found on the vent and the patterned feathers of the dorsum of females reflect lower estrogen levels in relation to testosterone levels than do the plain and weakly patterned feathers. Furthermore, it seems that estrogen induces plain feathers, and that patterns of "U's", modified "U's", or spots reflect increasing levels of testosterone in relation to estrogen, or decreasing levels of estrogen. Thus, feather patterns of females suggest that ovarian secretions from December to April are low in estrogen or high in testosterone and that estrogen levels are higher from May to July.

The pre-basic molt is more complete than is the pre-alternate molt and also occurs in a shorter time period. It seems likely, therefore, that some mechanism operates to prevent pre-basic molting until reproduction is completed. Because this molt comes at about the time of gonadal collapse, it seems likely that decreasing sex hormones may help trigger the onset of molt.

It is not suggested that other factors are not involved. The role of photoperiod in the regulation of molt is discussed by Walton (1937) and Lesher and Kendeigh (1941).
1. The plumages and molts of the Blue-winged Teal (*Anas discors* L.) were described from 304 wild-trapped birds, 146 captive birds, and approximately 50 museum skins. Of the captive birds, 19 were hand-reared.

2. Birds were obtained by bait-trapping and nest-trapping in northwest Iowa during the spring and summer, 1967, and fall, 1967 and 1968. Eggs were collected and hatched during the summer, 1967, and the ducklings hand-reared. Additional birds were obtained from the Northern Prairie Wildlife Research Center, Jamestown, North Dakota during late summer and fall, 1967 and 1968.

3. The natal plumage was described from hand-reared ducklings and skins. Color changes of the tarsi and bill during the first 12 weeks after hatching were recorded.

4. Pre-juvenal molt began with the loss of natal down during the third week post-hatching. After eight weeks, natal down remained only on the occiput-nape areas of a few birds. Natal down appears to be lost earlier in the wild.

5. Juvenal down emerged at 5 to 6 days and was completed after 3 weeks. Juvenal down first developed on the venter.

6. Juvenal contour feathers first appeared at 7 to 9 days and all juvenal feathers were evident after 31-34 days. The auriculars and rectrices were earliest, followed by the scapulars and feathers of the venter. Feathers then de-
developed on the head, rump, upper tail, coverts, and tertials. The neck and wings followed and the back and inter-scapular areas were last to develop juvenal feathers. The juvenal plumage was completed at about 8 weeks.

7. The juvenal plumage was described and feather patterns were shown. Maturation of primaries was described. Primaries were clear by 8½ to 9 weeks in captive birds. The maximum time for all primaries of one bird to clear was 21 days.

8. The first pre-basic molt of wild birds began in August. Although two birds had completed this molt in August, most teal migrated before it was completed. This molt appears to be interrupted. Captive teal began this molt between 53 to 73 days.

9. The first basic plumage was described and feather patterns were shown. The following areas developed first basic feathers: crown, face, chin-throat, chest-center, chest-side, side, belly, flank, lower tail coverts, dorsal lower neck, scapulars, and upper tail coverts. The rump feathers appear to be variable and may be replaced.

10. Both males and females enter the first pre-alternate molt later than they enter the second and successive pre-alternate molts. Captive adult male teal completed the pre-alternate molt about two months before immature teal completed their first pre-alternate molt. Males complete the pre-alternate molt before spring migration, while females migrate in full molt.
11. Females did not molt during June and early July during nesting. The few feathers replaced at this time were abnormally patterned.

12. The alternate plumages were described and feather patterns were shown for both males and females.

13. Males entered the pre-basic molt during late June. Nesting females on 19 July had not begun to molt.

14. The influence of sex hormones on plumages and molts was studied by experiments with 108 immature and adult teal.

15. Treatments included the administration of 6, 12, 15, 18, and 24 mg diethyl stilbestrol, daily injections of 1 mg testosterone propionate, 15 mg testosterone implants, and gonadectomy. Prior to the experiments, feathers were plucked from the face, chin-throat, chest-center, chest-side, side, flank, lower tail coverts, and scapulars.

16. Diethyl stilbestrol suppressed feather patterns in both sexes. Six mg implants induced plain feathers in immature male teal that were identical to these regenerated by control females. Implants of 18 and 24 mg induced light and dark irregularly mottled feathers. These feathers are similar to those grown by wild birds during June, when estrogen levels are suspected of being very high.

17. Diethyl stilbestrol inhibited molt of adult birds but did not affect feather regeneration. This suggests that diethyl stilbestrol inhibits feather loss.

18. Testosterone did not modify regenerated feathers in males.
Injections of 1 mg per day induced feather patterns in females nearly identical to those of control males.

19. Castration of males resulted in male alternate-like feathers. Ovariectomy of females, if complete, induced male-like feather patterns. One ovariectomized bird (MB) regenerated the following feathers that were identical to those of male alternate feathers: spotted feathers of the chest-center and chest-side, patterned scapulars, black lower tail coverts, and white flank feathers.

20. Developing plumages of adult male teal appear to be alternate unless the estrogen level is great enough to induce basic feathers. Adult female plumages seem to depend on the ratio of testosterone to estrogen. The patterned alternate plumage of females reflects high testosterone or low estrogen levels while the less patterned basic plumage appears to be under the influence of estrogen.
LITERATURE CITED


Hochbaum, H. A. 1944 The canvasback on a prairie marsh. The American Wildlife Institute, Washington, D.C.


Humphrey, P. S. and K. C. Parkes  
1959 An approach to the study of molts and plumages.  

Jackson, A. C.  
1915 Notes on the moult and sequence of plumages in  

Kortright, F. H.  
1942 The ducks, geese, and swans of North America.  
The American Wildlife Institute, Washington, D.C.

Leitch, W. G.  
1958 Night-lighting for canvasback ducks. Ducks  
limited. Winter Quarterly.

Lesher, S. W. and S. C. Kendeigh  
1941 Effect of photoperiod on molting of feathers.  

Lillie, F. B.  
1932 The physiology of feather pattern. Wilson Bul­  
letin 44: 193-211.

Millias, J. G.  
1902 The natural history of the British surface-  

Oring, L. W.  
1968 Growth, molts, and plumages of the Gadwall.  

Palmer, R. W.  
Yale University Press, New Haven, Connecticut.

Phillips, J. C.  
1924 A natural history of the ducks. Vol. II.  
Houghton Mifflin Co., Boston, Massachusetts.

Roberts, T. S.  
1955 Manual for the identification of the birds of  
Minnesota and neighboring states. The University  
of Minnesota Press, Minneapolis, Minnesota.

Salyer, J. W.  
Management 26: 219-221.
Schioler, E. L.  

Snyder, L. L. and H. G. Lumsden  

Stead, E. F.  
1938  "Eclipse plumage", possibly a universal factor in the sequence of moult in ducks. Royal Society of New Zealand Transactions 68: 102-104.

Stresemann, E.  

Van Oordt, G. J.  

Voitkevich, A. A.  
1966  The feathers and plumage of birds. October House, Inc., New York, N.Y.

Walton, A.  

Weller, M. W.  

Weller, M. W.  


Witschi, E.  
ACKNOWLEDGMENTS

I am indebted to my major professor, Dr. M. W. Weller, for the interest he showed in my development and for advice throughout this study and in the preparation of this dissertation. The manner in which he gave of his time was most gratifying. Dr. D. R. Griffith was very helpful in arriving at initial hormone levels.

Dr. C. W. Dane of the Northern Prairie Wildlife Research Center, Jamestown, North Dakota, provided useful information and was instrumental in the acquisition of Blue-winged Teal. Dr. H. K. Nelson, Director of the center is acknowledged for providing teal for experimental purposes. Mr. Glenn Jones, Manager of the Ruthven Game Unit of the Iowa Conservation Commission, permitted me to examine trapped teal and also provided me with teal for experimental purposes.

Mr. H. J. Harris contributed greatly with suggestions, photography, by caring for birds, and in many intangible ways. Mr. D. L. Trauger contributed photographic assistance. Mr. G. C. McVey, Department of Agriculture Engineering, was most helpful in making several of the instruments used in gonadectomy.

I also want to thank Mr. Rick Schlutz for taking care of the birds during most of the study. Mr. Marc Nichols graciously took time to help with gonadectomy techniques.

Finally, I want to thank four very special persons, Maxine,
Steve, Paul, and Laura for unselfishly accepting three additional years of hectic frustration and material deprivation that are associated with graduate school.