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EYE COLOR OF FEMALE LESSER SCAUP IN RELATION TO AGE

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WHEN a 5-year investigation of the population ecology of the Lesser Scaup (*Aythya affinis*) was initiated, I noted considerable variation in eye color of adult females, whose irides ranged from dark brown to bright yellow. Because juveniles had brown or olive irides, I thought that variations in eye color of adults might be age-related. A marked population of known-age scaup was used to determine the relationship between eye color and age for individuals representing more than five cohorts.

R. D. Harris (MS), Canadian Wildlife Service, noted differences in eye color of female Lesser Scaups while conducting studies in the Alberta parklands during the late 1950s. Although he was not working with known-age ducks, he speculated that younger females had brown eyes and older females had yellow eyes. Phillips (1925), Kortright (1953), and Delacour (1959) described eye color in the Lesser Scaup as varying from brownish yellow to yellow in adult females and from yellow to yellowish orange in adult males. The iris of downy young scaup was termed "pale olive" by Phillips (1925).

This paper documents patterns of eye color in relation to age of female Lesser Scaups observed in the field and in the hand, including changes in eye color of individuals and variations within the population. Determination of similar relationships in males was impossible because known-age birds were never seen or recaptured on the study area, but changes and variations in eye color comparable to the patterns observed in adult females were not evident. Physiological systems governing eye color and research opportunities utilizing eye color in scaup are discussed. The occurrence of age-related patterns of eye colors in birds is also reviewed.

METHODS

Fieldwork was conducted from 1966 through 1970 in the open boreal forest near Yellowknife, Northwest Territories. Geographical and environmental characteristics

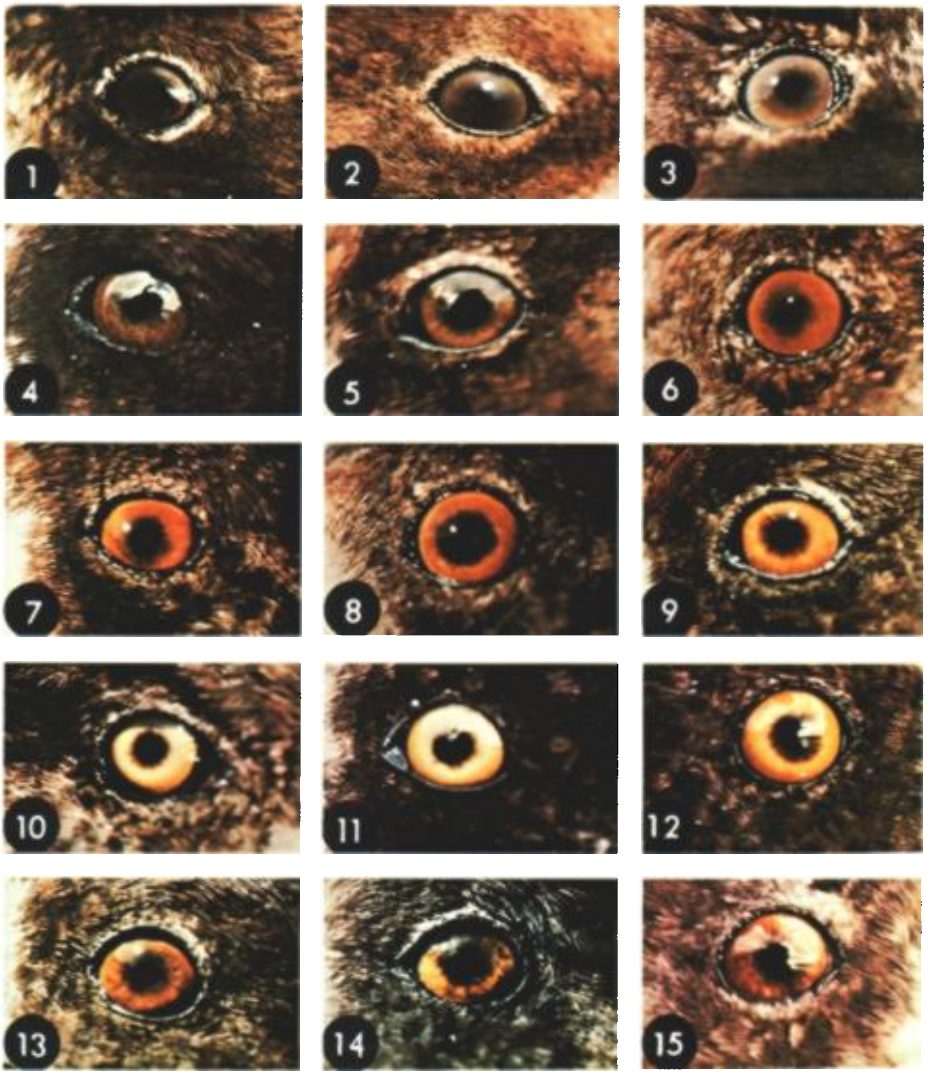

Figure 1. Eye colors of known-age female Lesser Scaups: (1–3) juveniles = Very Dark Brown (2/2 10YR), Dark Brown (3/3 10YR), Olive (4/4 5Y); (4–6) yearlings = Dark Brown (3/3 10YR), Olive Brown (4/4 2.5Y), Light Olive Brown (5/6 2.5Y); (7–9) 2-year-olds = Light Olive Brown (5/6 2.5Y), Olive Yellow (6/8 2.5Y), Olive Yellow (6/8 5Y); (10) 3-year-old = Yellow (7/8 5Y); (11) 4-year-old = Yellow (7/8 5Y); (12) 5-year-old = Yellow (7/8 5Y); (13) 4-year-old+ = Yellowish Brown (5/6 10YR); (14) 5-year-old = Olive Yellow (6/8 5Y); (15) 4-year-old = Brownish Yellow (6/8 10YR).

of the study area have been described in detail by Bartonek and Murdy (1970), Murdy et. al. (1970), and Trauger (1971).

Large numbers of flightless juveniles and molting adults were trapped annually in late summer for leg banding and color marking to identify various age classes in breeding populations of subsequent years (Trauger 1971). The general procedures described by Cowan and Hatter (1952) for drive trapping diving ducks were followed. In addition, a number of birds captured by bait trapping or collected for autopsy were studied. Sex and age were determined by cloacal examination (Hochbaum 1942) and plumage characteristics (Kortright 1953). To distinguish known-age individuals, trapped ducks were marked with colored nasal discs or saddles similar to those described by Bartonek and Dane (1964) and Sugden and Posten (1968). United States Fish and Wildlife Service aluminum leg bands were also placed on all birds trapped and released.

Each spring an attempt was made to ascertain the eye color of all marked females returning to the study area. Eye color was recorded as brown, olive brown, brownish yellow, olive yellow, or yellow whenever a positive determination was possible at close range and under good light conditions. Binoculars (7×) and telescopes (20×–30×) aided the observation of eye color in the field.

In 1967, the eye color of every adult female captured for banding was recorded. A color photograph of an eye of most females also was taken. During 1968, 1969, and 1970, eye color of adult females captured for banding or collected for autopsy was determined with Munsell Soil Color Charts (Munsell Color Company, Inc., 2441 North Calvert St., Baltimore, Maryland 21218) used as a standard. In addition, color photographs were taken of the eyes of most banded females recaptured or collected. Iris colors of know-age females captured in 1967 were converted to Munsell values by comparing photographs of these birds with photographs of birds with known eye colors. Kodachrome X film was used throughout the study.

In this paper, colors corresponding to Munsell Charts are capitalized, e.g. Very Dark Brown, and followed by a numerical specification (2/2 10YR = Value/Chroma Hue). Wood and Wood (1972) described the Munsell system of color notation and demonstrated the utility of these charts in ornithological investigation.

RESULTS

FIELD DETERMINATION OF EYE COLOR

Females of known age.—Marked females of known age were first banded as juveniles. Yearlings were observed in their first summer subsequent to hatching and ranged in age from 10 to 14 months (1 year). The 2-, 3-, and 4-year-old ducks were in their 2nd, 3rd, and 4th summers, respectively. Between 1967 and 1970, 408 records of the eye colors of 91 yearling females, 52 2-year-old females, 27 3-year-old females, and 6 4-year-old females were obtained under field conditions. The number of usable observations ranged from 1 to 11 per female and averaged 2.3 per female.

A progressive change in eye color from brown to yellow is evident between the 1st and 3rd year of life (Table 1). Although the eye color of yearling females ranged from brown to olive yellow, 79 (87%)

TABLE 1

FIELD DETERMINATION OF EYE COLOR OF KNOWN-AGE FEMALE LESSER SCAUP 1967–70

Age	Eye color					
	Brown	Olive-brown	Brownish yellow	Olive-yellow	Yellow	Total
1	79 (87)[1]	8 (9)	3 (3)	1 (1)		91
2	2 (4)	4 (8)	11 (21)	30 (58)	5 (10)	52
3				9 (33)	18 (67)	27
4				2 (33)	4 (67)	6

[1] Percentages in parentheses.

possessed brown eyes; 87 (96%) had either brown or olive brown eyes (Table 1).

Eye color of 2-year-old females varied from brown to yellow, but 41 (79%) had either brownish yellow or olive yellow eyes. Six (12%) 2-year-old females had darker eyes typical of yearling females.

All 3-year-old and 4-year-old females had either olive yellow or yellow eyes (Table 1). Two-thirds of the 2-year-olds were indistinguishable from these older females, but there was little overlap between yearling females and the 3- and 4-year-olds.

Females of unknown age.—Marked females of unknown age were first trapped as adults 1 year old and older. When observed in subsequent years, these females were 2 years old or older, i.e., known minimum age of at least 22 months. Observations of marked females and recaptures of other banded females indicated a maximum age in excess of 5 years among ducks classified as adults.

Field determinations of eye color were made for 7 adults in 1967, 29 adults in 1968, 47 adults in 1969, and 38 adults in 1970 based on 292 observations of marked birds. The number of usable records ranged from 1 to 13 per female and averaged 2.4 per female. Eye color of marked adult females ranged from olive brown to yellow (Table 2). With the exception of 10 (8%) females, the remainder had olive yellow or yellow eyes. None of the adult females had brown eyes. Most variation was found in females at least 2 years old (Table 2) as noted in known-age 2-year-olds (Table 1). Slight overlap occurred between the eye color of known yearlings (Table 1) and adults 2 years old and older (Table 2).

Eye color was more yellowish in birds marked as adults (Table 2) than in birds marked as juveniles (Table 1) because the adult group undoubtedly contained more older females. The percentage of females with yellow eyes was greatest for females at least 3 years old or older.

TABLE 2

FIELD DETERMINATION OF EYE COLOR OF ADULT FEMALE LESSER SCAUP 1967–70

Age	Eye color					Total
	Brown	Olive-brown	Brownish yellow	Olive-yellow	Yellow	
2+		1 (2)[1]	9 (14)	14 (22)	39 (62)	63
3+				4 (11)	32 (89)	36
4+				2 (10)	18 (90)	20
5+					2 (100)	2

[1] Percentages in parentheses.

HAND DETERMINATION OF EYE COLOR

Color ranges within ages.—Between 1967 and 1970, 43 female Lesser Scaups of known age were rehandled 52 times for the determination of eye color (Table 3); 25 of these were trapped during banding operations, and 18 were collected for reproductive studies. In addition, six females were recaptured both as yearlings and as 2-year-olds; one female was recaptured as a yearling and as a 4-year-old. Two females recaptured as yearlings also were collected as 4-year-olds.

The irides of 22 yearling females were predominantly Dark Brown (3/3 10YR), Olive Brown (4/4 2.5Y), and Light Olive Brown (5/6 2.5Y), but one yearling female was Olive Yellow (6/8 5Y) (Table 3). Sixteen 2-year-old females had irides ranging from Light Olive Brown (5/6 2.5Y) to Yellow (7/8 5Y). Five 3-year-old females had either Olive Yellow (6/8 5Y) or Yellow (7/8 5Y) irides. The eight 4-year-old and 5-year-old females had irides ranging from Olive Yellow (6/8 5Y) to Brownish Yellow (6/8 10YR). Iris color in juvenile females ranged from Very Dark Brown (2/2 10YR) to Olive (4/4 5Y).

Fig. 1 shows the variations found in the eye color of known-age females. Although obvious changes occur in iris color between the juvenile

TABLE 3

RANGE OF EYE COLOR OF FEMALE LESSER SCAUP OF KNOWN AGE 1967–70

Age	Munsell colors							
	Dark Brown (3/3 10YR)	Olive Brown (4/4 2.5Y)	Light Olive Brown (5/6 2.5Y)	Olive (5/6 5Y)	Olive Yellow (6/8 2.5Y)	Olive Yellow (6/8 5Y)	Yellow (7/8 5Y)	Brownish Yellow (6/8 10YR)
1	5 (3)[1]	9 (3)	8 (2)			1		
2			2	1	2	9	2	
3						2	3	
4						2	1 (1)	2 (1)
5						1	1 (1)	1 (1)

[1] Eye color determined from color photographs.

TABLE 4

CHANGES IN EYE COLOR OF FEMALE LESSER SCAUP OF VARIOUS AGES 1968–70

Band number	1968	1969	1970
716–91128[1]	Dark Brown (1)[2] (3/3 10YR)	Light Olive Brown (2) (5/6 2.5Y)	
746–13732	Olive Brown (4/4 2.5Y)	Light Olive Brown (5/6 2.5Y)	
716–91316[1]	Olive Brown (1) (4/4 2.5Y)	Olive Yellow (2) (6/8 2.5Y)	
746–13718	Olive Brown (4/4 2.5Y)	Olive Yellow (6/8 2.5Y)	
746–13546	Dark Yellowish Brown (4/4 10YR)	Yellowish Brown (5/6 10YR)	
746–13741	Light Olive Brown (5/6 2.5Y)	Olive Yellow (6/8 2.5Y)	
776–15175		Light Olive Brown (5/6 2.5Y)	Olive Yellow (6/8 5Y)
685–01151[1]		Light Olive Brown (1) (5/6 2.5Y)	Olive Yellow (2) (6/8 5Y)
716–91190	Light Olive Brown (5/6 2.5Y)	Olive Yellow (6/8 5Y)	
746–13724	Light Olive Brown (5/6 2.5Y)	Yellow (7/8 5Y)	
746–13763	Olive Yellow (6/8 5Y)	Olive Yellow (6/8 5Y)	
776–15198		Olive Yellow (6/8 5Y)	Yellow (7/8 5Y)
746–13727	Yellow (7/8 5Y)	Yellow (7/8 5Y)	
746–13507	Yellow (7/8 5Y)	Yellow (7/8 5Y)	
746–13519	Yellow (7/8 5Y)		Yellow (7/8 5Y)
776–15273	Yellow (7/8 5Y)	Yellow (7/8 5Y)	Yellow (7/8 5Y)

[1] Known-age female.
[2] Age in parentheses.

(Fig. 1.1–1.3) and yearling (Fig. 1.4–1.6) age classes, the colors represent variations of brown. Eye color in 2-year-old females (Fig. 1.7–1.9) is transitional between the eye color of yearlings (brown) and adults (Fig. 1.10–1.12) 3 years old or older (yellow). Thus, the brown eyes of yearling females become the olive yellow eyes of 2-year-olds and the yellow eyes of 3-year-olds. Further changes in eye color apparently occur after the 3rd year. A very few females 4 and 5 years old had golden

TABLE 5

VARIATIONS IN EYE COLOR OF ADULT FEMALE LESSER SCAUP 1968–70

Eye color (Munsell)	1968	1969	1970	Total
DARK GRAYISH BROWN				
3/2 2.5YR		1		1
3/2 10YR	1	1		2
DARK BROWN				
3/2 7.5YR	3	2		5
3/3 10YR	16	19	9	44
4/3 10YR		1	1	2
DARK YELLOWISH BROWN				
3/4 10YR	4	2		6
4/4 10YR	3	8	7	18
OLIVE BROWN				
4/4 2.5Y	42	42	12	96
LIGHT OLIVE BROWN				
5/6 2.5Y	26	35	21	82
YELLOWISH BROWN				
5/6 10YR	3	8	1	12
5/8 10YR	1	2	1	4
OLIVE				
5/6 5Y	1	2		3
BROWNISH YELLOW				
6/8 10YR	1	1	1	3
OLIVE YELLOW				
6/8 2.5Y	21	25	7	53
6/8 5Y	22	36	28	86
YELLOW				
7/8 2.5Y	1	1	2	4
7/8 5Y	36	28	18	82
TOTAL	181	214	108	503

or orange irides with the appearance of darker pigmentation in the iris (Fig. 1.13–1.15).

Color changes within individuals.—Sixteen female Lesser Scaups of various ages recaptured 1 or 2 years after banding provided information on changes in the eye color of individual birds (Table 4). Three of these females were known age and 13 were unknown age. Although changes in eye color were apparent in females originally banded in 1966 and 1967, the Munsell Color Charts were not used until 1968. Therefore, the information on changes in eye color of individual females was limited to the recaptures in 1968 through 1970.

Females with initial eye colors of Dark Brown (3/3 10YR), Olive Brown (4/4 2.5Y), Dark Yellowish Brown (4/4 10YR), and Light Olive Brown (5/6 2.5Y), all experienced changes (Table 4) in colora-

tion to Light Olive Brown (5/6 2.5Y), Yellowish Brown (5/6 10YR), Olive Yellow (6/8 2.5Y), Olive Yellow (6/8 5Y), and Yellow (7/8 5Y). Olive Yellow-eyed (6/8 5Y) females either remained the same color or changed to Yellow (7/8 5Y). Females with Yellow (7/8 5Y) eyes remained unchanged over a 2- or 3-year period.

These observations confirmed that changes in eye color occur from year to year. The pattern of these changes (Table 4) is consistent with the development of eye color seen in known-age females (Table 3).

Color variations within population.—During 1968, 1969, and 1970, the eye color of 503 female Lesser Scaups 1 year old and older was determined by using the Munsell Charts to show the variation (Table 5). These females were captured for banding by bait trapping and drive trapping on a few large lakes used for molting during July and August. Females captured for initial banding and recaptures of previously banded birds are included in Table 5.

In spite of marked variation in eye color (Table 5), the six major colors were Dark Brown (3/3 10YR) 9%, Olive Brown (4/4 2.5Y) 19%, Light Olive Brown (5/6 2.5Y) 16%, Olive Yellow (6/8 2.5Y) 11%, Olive Yellow (6/8 5Y) 17%, and Yellow (7/8 5Y) 16%. These were the principal eye colors observed in female Lesser Scaups of known age (Table 3).

Although this trapped sample may not be representative of the entire population, the range of eye color indicated that all age classes were represented. Annual differences in breeding productivity and seasonal phenology could influence the proportion of various age classes and the composition of eye colors in the sample. Further study may reveal additional eye color variations.

Discussion

Patterns of Eye Color in Birds

Although ornithologists have documented the eye color of birds in relation to age for only a few species, changes in eye color between juveniles and adults apparently is rather common. Thomson (1964) stated that iris color may change with age and noted that brown irides in immature birds are succeeded by yellow irides in adults of several species. A diversity of avian groups (penguins, loons, grebes, ducks, hawks, pheasants, gulls, alcids, woodpeckers, mimids, vireos, and icterids) have species exhibiting a variety of conspicuous changes in iris pigmentation in relation to age (e.g. Palmer 1962, Thomson 1964, Wood 1969). Species characterized by an extended subadult period between the juvenile and adult stages, such as the Bald Eagle (*Haliaeetus leucocephalus*) or Herring Gull (*Larus argentatus*), usually show a concomitant transition in plumage and eye color (Bent 1921, 1937).

Recently several investigators have noted specific changes in eye color in relation to age for a few bird species. Roberts (1967) found that the iris color in immature Sharp-shinned Hawks (*Accipiter striatus*) gradually changed from "lemon yellow" to "red" by the 4th or 5th year. Hamerstrom (1968) noted a progressive change from brown to yellow irides in female Marsh Hawks (*Circus cyaneus*) between 1 and 5 years old. In the Snares Islands Penguin (*Eudyptes robustus*) Stonehouse (1971) found the gray-brown eyes of yearlings differed from the reddish brown eyes of adults. The Gannet (*Morus bassana*) has a dark brown iris in the nestling, a gray-blue iris in the juvenile, and a nearly white iris in the adult (Thomson 1964).

PHYSIOLOGY OF EYE COLOR IN LESSER SCAUP

Duke-Elder (1958) described the avian iris as being richly vascularized and frequently endowed with brilliant lipochrome pigments. Unfortunately, the physiology of iris pigmentation is poorly understood, particularly in relation to pigment changes and age. Pigment deposition and vascularization of soft parts in birds is under hormonal control, especially colors closely related to the sexual cycle. Androgens are known to control the growth and color of combs and bills as well as the development of other secondary sexual characteristics (Witschi 1961). Noble and Wurm (1940) found that both sexes of the Black-crowned Night Heron (*Nycticorax nycticorax*) undergo marked changes in soft part pigmentation in response to androgen hormones.

In the Lesser Scaup changes in eye color in both the male and female probably are governed by androgens; a hypothesis yet to be verified. Although no known-age adult males were studied, there is some basis for the conjecture that androgen secretion influences their iris pigmentation. I found that young males have a rapid shift in eye color from olive-brown to bright yellow. In some individuals this change is completed within 60 days, and in most immature males the eye turns yellow within 120 days. Development of eye color in Canvasback (*Aythya valisineria*) and Redhead (*Aythya americana*) males follows a similar pattern with sexual dimorphism apparent in the irides between 10 and 16 weeks of age (Hochbaum 1944, Weller 1957). Every adult male scaup observed or recaptured during spring and summer had yellow eyes, suggesting that this color is probably maintained throughout life.

Females are known to secrete small amounts of androgens from interstitial cells of the ovary (Benoit 1950, Taber 1951, Gilbert 1971). Presumably, as the female ages, androgen production increases. Greater androgen secretion may cause a shift from brown to yellow pigmentation of irides in females as has been noted in males, but this transition

requires 2 or 3 years for females as compared with 2 or 3 months for males. Anderson and Warner (1969) presented evidence showing that yearlings averaged slightly smaller than adults in body, skeletal, and gonadal measurements, indicating that some of them did not reach full adult development during their 1st year of life. Hence it is conceivable that hormonal secretion does not attain maximum levels until the 2nd or 3rd year. Experiments designed to investigate the relationship of sexual hormones and eye color in the Lesser Scaup are now in progress.

Factors Influencing Changes in Eye Color

George (1972) cautioned that seasonal, sexual, geographic, and age variations in eye color of Hairy Woodpeckers (*Dendrocopos villosus*) and Downy Woodpeckers (*Dendrocopos pubescens*) had not been sufficiently investigated to evaluate the eye color patterns Wood (1969) reported in these species. I have not had an opportunity to evaluate seasonal and geographical influences in scaup, but the possibility exists that slight seasonal changes in eye color may take place during the breeding season, particularly in yearling and 2-year-old females. In these age classes the eye color is transitional from the brown of the juvenile to the yellow of the adult, and may at this time be subject to changes in hormone secretions associated with the breeding cycle.

For these reasons I suspect that eye color in female Lesser Scaups may be darker or more brownish in late summer, fall, and early winter, and lighter or more yellowish in late winter, spring, and early summer, particularly in females during their 1st or 2nd year. Indeed, spring and fall observations on scaup reared in captivity, killed by hunters, and trapped for banding subsequent to the field study indicate that this may be the case.

I would not anticipate any major geographic differences in patterns of eye color in relation to age. If eye color is related to hormonal secretion, it is probably under genetic control. Annual mate selection in diving ducks facilitates genetic mixing in the population.

Research Utilizing Changes in Eye Color

I used knowledge of age-related changes in eye color of Lesser Scaups to estimate annual fluctuations in the age composition of females in the breeding population (Trauger 1971). Scaup eye color also was valuable for analyzing nesting chronology and annual productivity in relation to various age classes. Behavioral studies on the species were enhanced by taking the female's age into account when watching social interactions and aggregations, because reproductive success was closely related to age (Trauger 1971).

I also found that the eye was yellow in all Greater Scaup (*Aythya*

marila) females nest trapped on islands in Great Slave Lake, Northwest Territories, but several females with brown eyes were seen in flocks near to the islands (Trauger and Bromley MS). Thus, a similar pattern of eye color and age in this species may exist, although no known-age birds were studied.

Southern (1964) employed a combination of iris colors and plumage patterns to identify various age classes in a wintering population of Bald Eagles. Linsell (1969) used differences in eye color to distinguish subadult and adult Common Goldeneyes (*Bucephala clangula*) in a study of flock composition and behavior. Undoubtedly the relationship between eye color and age in other avian species merits consideration as a useful tool in the study of population biology and social behavior.

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SUMMARY

A 5-year population study of Lesser Scaup was conducted with color-marked, known-age females in the open boreal forest near Yellowknife, Northwest Territories. During this study, variations in eye color were related to the female's age. Younger females had brownish irides and older females yellowish irides. Although males were also marked, known-age birds failed to return to the study area, but no comparable pattern of eye color was evident as all males 1 year old and older had yellow irides.

Based on 408 observations in the field and 52 observations in the hand of known-age females, eye color changed progressively between the 1st and 3rd year of life. Typically, yearlings had brown or brownish olive irides similar to eye color of juveniles. The 2-year-olds exhibited the greatest variation in eye color, overlapping slightly with both younger and older females, but generally had yellowish brown irides. Females 3 years old and older had yellowish olive or yellow irides. In addition,

292 field observations of marked females and 33 hand observations of banded females varying in age showed a similar pattern of changing eye color with increasing age. I noted 17 variations in eye color in 503 females captured for banding, but 88% of these females showed one of the six principal colors found in known-age females.

Age-related patterns of eye color occur in a diversity of avian families, but the phenomenon has been poorly documented. Although little information is available on the physiology of iris pigmentation, the process of color change is apparently related to sexual development under hormonal control. While age and sex differences are apparently important in scaup eye color, seasonal and geographic influences probably are only minor factors.

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