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SHORT COMMUNICATIONS

Molt chronology of male Mallards wintering in Missouri.—Patterns of molt vary among groups and species of waterfowl (Family Anatidae). Geese, swans, and whistling ducks have a single annual molt, generally initiated during summer; most other waterfowl have two body molts, one (the prealternate molt) initiated during summer or fall and the other (the prebasic molt) initiated at various times of the year, dependent upon species and sex specific strategies (Hohman et al. 1992). Additional molts (supplemental molts) have been reported for the Oldsquaw (*Clangula hyemalis*) (Salomonsen 1941) and may exist in other waterfowl species.

Molt chronology has been examined for a number of waterfowl species, and several factors have been shown to influence the timing of molt. Species specific differences exist even among closely related species (e.g., dabbling ducks of the tribe Anatini) and are directly related to pairing strategies; males of species that form pair bonds early in the fall or winter complete the prealternate molt earlier than those that pair later (Hohman et al. 1992). Sexual differences in molt chronology of dabbling ducks are related to role differences in the reproductive cycle. Females undergo a prolonged prebasic molt during spring and early summer to provide additional concealment during nesting, whereas males complete a short prebasic molt during mid-summer and retain their alternate plumage for a longer period (Palmer 1972). Most male dabbling ducks do not pair until the alternate plumage is in an advanced stage of development (Klint 1980; Wishart 1983; Paulus 1984; Hohman and Ankney, in press), and young males often complete the prealternate molt later than adults (Wishart 1983, Hohman et al. 1992).

Although summer molt chronology of male Mallards (*Anas platyrhynchos*) has been studied in Manitoba (Young and Boag 1981) and winter molt chronology of female Mallards has been studied in Missouri (Heitmeyer 1987), comparable information for wintering males is currently not available. This study quantifies molt of male Mallards throughout winter in southeastern Missouri and relates molt chronology to month, year, age, and pair status.

Study area and methods.—We conducted this study on Mingo National Wildlife Refuge and the adjacent Duck Creek Wildlife Management Area in southeastern Missouri. Collectively, these areas comprise the remnants of the once extensive Mingo Swamp (Korte and Fredrickson 1977), a mosaic of eight major habitat types including (1) lowland hardwood forests, (2) dead tree, (3) scrub/shrub swamp, (4) open water, (5) marshes, (6) moist-soil, (7) farmland, and (8) ditches and creeks; over 65% of the area is comprised of habitats dominated by woody vegetation (Heitmeyer 1985). Approximately 9300 ha of the Mingo Swamp flood during winters of average precipitation.

We collected male Mallards (N = 276) by shooting in the Mingo Swamp from October through March 1983–1984, 1984–1985, and 1985–1986. Pair status was determined by watching individuals for 5–30 min prior to collection and evaluating synchrony in movement between mates, isolation of pairs or single males, and stereotypic behaviors associated with pairs (e.g., copulation, mutual display, and female tolerance of males). Mallards were aged by plumage (Krapu et al. 1979), bursa, and penal characteristics.

Feathers were counted as Mallards were plucked during 1983–1984 and 1984–1985. In 1985–1986, blood quills were counted on everted skins. Titman et al. (1990) reported that molt scoring using grab samples of feathers from various regions and subregions is more reliable than using everted skins. We checked our scoring approach during 1985–1986 by sampling with grab samples on most everted skins that had visible blood quills and 30 skins with no visible blood quills. All ducks examined in this way were scored the same by both approaches.

TABLE 1

NUMBER OF INCOMING FEATHERS IN EACH OF 20 MALLARD FEATHER AREAS REQUIRED FOR ASSIGNMENT TO MOLT SCORE 0–2

	Molt score		
Feather region[a]/area	0	1	2
Capital			
Crown	<10	10–50	>50
Facial	<10	10–50	>50
Chin–throat	<10	10–50	>50
Neck	<10	10–50	>50
Scapulohumeral			
Scapulars	0	1–4	>4
Spinal			
Upper back	<5	5–10	>10
Lower back	<5	5–10	>10
Rump	<5	5–10	>10
Caudal			
Upper tail coverts	<5	5–10	>10
Tail	0	1–2	>2
Lower tail coverts	<5	5–10	>10
Ventral			
Belly	<5	5–10	>10
Chest-center	<5	5–10	>10
Chest-side	<5	5–10	>10
Side	<5	5–10	>10
Flank			
Flank	0	1–4	>4
Alar			
Primaries	0	1–2	>2
Secondaries	0	1–2	>2
Tertials	0	1–2	>2
Wing coverts	<5	5–10	>10

[a] Regions from Humphrey and Clark (1961).

Molt status was determined by methodology described by Austin and Fredrickson (1986), as modified from Billard and Humphrey (1972). Twenty feather areas were examined that corresponded to seven previously described feather regions (Humphrey and Clark 1961) (Table 1). Intensity scores (0–2) were assigned to each feather area based on the number of incoming contour feathers (Table 1). Molt-intensity scores for individual ducks were determined by summing the scores for the 20 feather areas (range = 0–40). Down molt and plumage aspect were not assessed in this study, but notes were recorded on plumage appearance of individuals that appeared unusual (e.g., the few that exhibited some basic feathers).

TABLE 2

GENERAL LINEAR MODEL USED TO DESCRIBE DIFFERENCES IN MOLT-INTENSITY OF MALE MALLARDS COLLECTED IN SOUTHEASTERN MISSOURI, WINTER 1983–1986

Source[a]	df	Sum of squares	F-value	$P > F$
Model[b]	47	3.08576337	2.55	0.0001
Error	228	5.87708902		
Corrected total	275	8.96285238		
Month	5	0.62005928	4.81	0.0003
Year	2	0.04172161	0.81	0.4464
Month × year	8	0.31241636	1.52	0.1529
Age	1	0.00477032	0.19	0.6675
Month × age	5	0.13549155	1.05	0.3884
Year × age	2	0.05933645	1.15	0.3182
Month × year × age	3	0.06455773	0.83	0.4760
Pair	1	0.00211130	0.08	0.7750
Month × pair	5	0.08087619	0.63	0.6789
Year × pair	2	0.01356378	0.26	0.7689
Month × year × pair	7	0.12670622	0.70	0.6702
Age × pair	1	0.00093448	0.04	0.8492
Month × age × pair	2	0.00352247	0.07	0.9340

[a] Year × age × pair and Month × year × age × pair were not tested because of insufficient degrees of freedom.
[b] Explained variance: $r^2 = 0.34$.

An analysis of variance model (Proc GLM) with type III sums of squares (SAS Institute Inc. 1991) was used to test if differences existed in mean molt-intensity scores among months, years, age, and pair status of individual ducks. A multiple analysis of variance model (MANOVA PROC GLM) with type III sums of squares (SAS Institute Inc. 1991) was used to test if differences existed in mean molt-intensity scores among these same variables in seven different feather regions. We only considered univariate analysis results from the MANOVA model if Wilk's Lambda tests were significant for individual variables or interaction terms. Duncan's new multiple range test was used to separate means that were determined to be significantly different. Non-normal percentage data were arcsine transformed before all analyses. A G-test (Sokal and Rohlf 1981) was used to determine if molt activity of male Mallards collected in March was independent of collection year. For this test, we categorized Mallards as those exhibiting no molt (molt-intensity score = 0), light molt (molt-intensity score = 1–9), or heavy molt (molt-intensity score >9). Significance was deemed appropriate in all tests at an alpha level of 0.05.

Results.—Mean molt-intensity scores of male Mallards varied seasonally (Table 2), with molt occurring most intensely in October and only negligibly between December and February (Fig. 1). Intermediate molt activity occurred in Mallards collected during November and March (Fig. 1). Despite the higher mean during March than during previous months, most male Mallards probably do not molt during spring, as indicated by the high percentage of nonmolting males (32%) and those with molt-intensity scores <10 (45%) collected in March.

Mean molt-intensity of male Mallards did not differ among years, age, or pair categories, nor were any interaction terms significant in the GLM ANOVA model (Table 2). Although year and month × year were not significant in the model, only 6.1% of Mallards collected

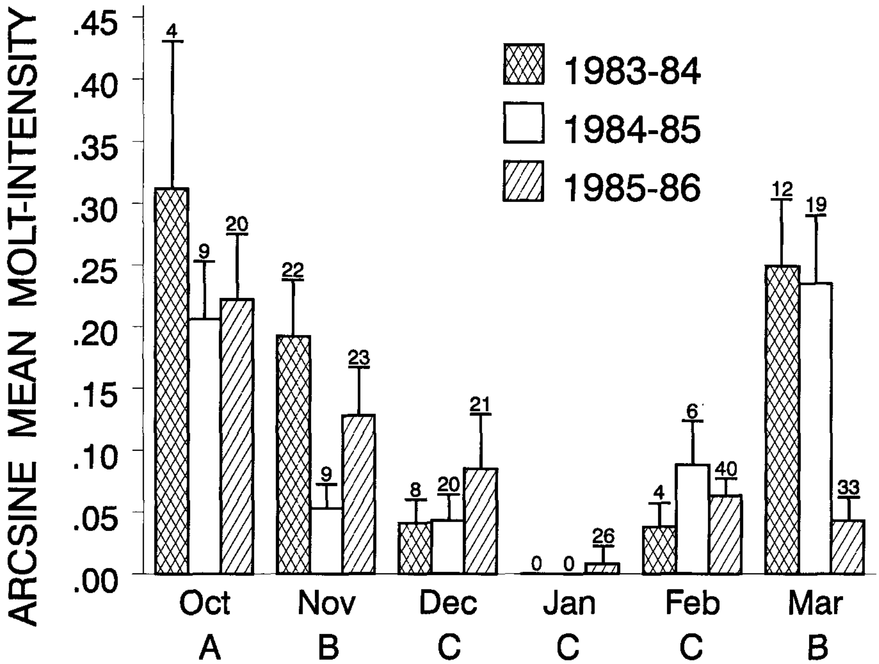

FIG. 1. Arcsine-transformed monthly molt-intensity scores (mean ± SE) of male Mallards collected in southeastern Missouri during three consecutive winters. Numbers above bars represent sample sizes. Months with the same letter below were not significantly different ($P > 0.05$) as determined by Duncan's new multiple range test.

during March 1986 had molt-intensity scores >9. A greater percentage of male Mallards were molting at this level during March of the previous two years (1984, 41.7% and 1985, 36.8%), and fewer were not molting at all (1984, 0%, 1985, 21.1%, and 1986, 54.5%, G = 21.982, df = 4, $P < 0.005$).

Month and year were the only variables or interaction terms that were significant in the MANOVA model comparing molt-intensity of various feather regions (month: Wilk's Lambda = 0.659, df = 35, P = 0.0001; and year: Wilk's Lambda = 0.879, df = 14, P = 0.0105). Monthly differences in molt activity were detected in the capital (F = 2.86, df = 5, P = 0.0158), scapulohumeral (F = 8.85, df = 5, P = 0.0001), spinal (F = 4.35, df = 5, P = 0.0008), and flank (F = 5.50, df = 5, P = 0.0001) regions; all of these regions exhibited similar patterns of declining molt activity during mid-winter, followed by an increase during early spring (Table 3). Although monthly differences were also detected in the caudal region (F = 3.78, df = 5, P = 0.0026), replacement of tail feathers was completed during November, and caudal molt was negligible after this time (Table 3). Monthly differences were not significant for the ventral and alar regions. Yearly differences were detected only in the caudal (F = 3.50, df = 2, P = 0.0320) and alar (F = 4.10, df = 2, P = 0.0179) regions, with greater molt activity occurring during 1983–1984 than during the following two winters.

Discussion.—Decline in molt-intensity of male Mallards from October through January

TABLE 3

ARCSINE MONTHLY MOLT-INTENSITY SCORES (MEAN ± SE) OF SEVEN FEATHER REGIONS OF MALE MALLARDS WINTERING IN SOUTHEASTERN MISSOURI

Feather region	Month: October (N = 33)	November (N = 54)	December (N = 49)	January (N = 26)	February (N = 50)	March (N = 64)
Capital	0.412 ±0.082	0.184 ±0.051	0.087 ±0.040	0.000 ±0.000	0.121 ±0.040	0.266 ±0.053
Scapulohumeral	1.111 ±0.118	0.776 ±0.101	0.150 ±0.051	0.060 ±0.033	0.188 ±0.068	0.376 ±0.073
Spinal	0.212 ±0.060	0.147 ±0.037	0.078 ±0.036	0.000 ±0.000	0.063 ±0.024	0.155 ±0.038
Caudal	0.230 ±0.068	0.125 ±0.032	0.050 ±0.034	0.000 ±0.000	0.025 ±0.015	0.032 ±0.011
Ventral	0.144 ±0.032	0.143 ±0.043	0.067 ±0.023	0.024 ±0.014	0.103 ±0.044	0.241 ±0.056
Flank	0.857 ±0.133	0.407 ±0.081	0.192 ±0.064	0.020 ±0.020	0.168 ±0.062	0.344 ±0.071
Alar	0.011 ±0.006	0.016 ±0.007	0.010 ±0.006	0.000 ±0.000	0.000 ±0.000	0.002 ±0.020

represented completion of the prealternate molt (Humphrey and Parkes 1959, Palmer 1976). All adult males and most juveniles in the Mingo Swamp completed or approached completion of the prealternate molt by early December. Most adults that were molting from October through December were in late molt stages, as indicated by a lack of basic plumage feathers and the general appearance of ducks that had completed the prealternate molt. Male ducks of many species can successfully pair during late stages of the molt, provided they appear in a complete alternate plumage (Wishart 1983, Paulus 1984). Most adult male Mallards wintering at the Mingo Swamp had probably completed enough of the prealternate molt prior to their arrival that they could successfully court and acquire mates, hence the reason for the lack of a relationship between pair status and molt activity in this study.

The increase in molt activity during March may represent a supplemental molt, as proposed for the Oldsquaw (Salomonsen 1941). Molt activity also increased in male Greater Scaup (*Arthya marila*) during March but was described as an interruption of the prealternate molt by Billard and Humphrey (1972). All male Mallards collected from December through March appeared to be in a full alternate plumage, suggesting that spring molt activity observed in this study was not a protraction of the prealternate molt but probably a supplemental molt. Spring molt activity has also been reported in other male dabbling ducks; e.g., Gadwalls (*Anas strepera*) (Paulus 1984) and American Wigeon (*A. americana*) (Wishart 1985), but spring molt has not been detected in Northern Pintails (*A. acuta*) (Miller 1986, Smith and Sheeley 1993). Molt-intensity of male Mallards was low on migration areas north of the Mingo Swamp (T. G. LaGrange, F. A. Reid, N. M. Gruenhagen, unpubl. data), indicating that spring molt activity probably is restricted to a portion of the population rather than being a molt initiated by all birds on wintering areas and completed during migration.

We suspect that the supplemental molt may serve to replace plumages worn during adverse conditions, primarily because of yearly differences in percentages of males molting during March. Molt-intensity during March was less during 1986 (a mild winter) than during the previous two years, following harsh winters when Mallards were forced to migrate from the Mingo Swamp because of ice cover (Combs 1987). Spring molt activity also may be related to thermoregulatory needs or possibly be an evolutionary artifact that persists because of lack of strong selection pressure.

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Habitat use by wintering and breeding bird communities in relation to edge in an irrigated forest.—About 1% of the 2000 municipal sewage systems in the United States that apply wastewater to terrestrial habitats apply it to forested landscapes (W. E. Sopper, pers. commun.; Urie 1986). This is expected to increase as small, localized sewage systems are needed in nonagricultural areas (Nutter and Red 1986). Wastewater application changes structure and species composition of forest understory plants, distribution of fruit-producing plants, and abundance of invertebrates on the forest floor (Sopper and Kardos 1973, Lewis 1977, Mastrota et al. 1989, Rollfinke and Yahner 1990). Wastewater application also has been found to affect abundance and distribution of avian species, particularly those that forage and nest near ground level (e.g., Lewis and Sampson 1981, Rollfinke and Yahner 1990, Rollfinke et al. 1990). These avian studies, however, were relatively restricted in area or were based on mist-netting data collected only during the breeding season. Furthermore, establishment and maintenance of a wastewater-application system produces a considerable amount of edge habitat because of the network of irrigation pipes and access roads. In this study, my objective was to determine use of four habitat types by wintering and breeding bird communities in relation to distance from an edge from 1987–1991 in a forest-farmland landscape, part of which was affected by wastewater irrigation in central Pennsylvania.

Study area and methods.—I conducted the study on State Game Lands 176 in Centre County, Pennsylvania, from 1987–1991 (see details in Rollfinke and Yahner 1990, Rollfinke