J. Field Ornithol., 70(2):200–205

EVALUATION OF BURSAL DEPTH AS AN INDICATOR OF AGE CLASS OF HARLEQUIN DUCKS

DANIELLE D. MATHER AND DANIEL ESLER

U.S. Geological Survey, Biological Resources Division, Alaska Biological Science Center 1011 E. Tudor Road, Anchorage, Alaska 99503 USA

Abstract.—We contrasted the estimated age class of recaptured Harlequin Ducks (*Histrionicus histrionicus*) (n = 255) based on bursal depth with expected age class based on bursal depth at first capture and time since first capture. Although neither estimated nor expected ages can be assumed to be correct, rates of discrepancies between the two for within-year recaptures indicate sampling error, while between-year recaptures test assumptions about rates of bursal involution. Within-year, between-year, and overall discrepancy rates were 10%, 24%, and 18%, respectively. Most (86%) between-year discrepancies occurred for birds expected to be after-third-year (ATY) but estimated to be third-year (TY). Of these ATY-TY discrepancies, 22 of 25 (88%) birds had bursal depths of 2 or 3 mm. Further, five of six between-year recaptures that were known to be ATY but estimated to be TY had 2 mm bursas. Reclassifying birds with 2 or 3 mm bursas as ATY resulted in reduction in between-year (24% to 10%) and overall (18% to 11%) discrepancy rates. We conclude that age determination of Harlequin Ducks based on bursal depth, particularly using our modified criteria, is a relatively consistent and reliable technique.

EVALUACIÓN DE LA PROFUNDIDAD DE BURSA PARA INDICAR EDADES EN *HISTRIONICUS HISTRIONICUS*

Sinopsis.—Contrastamos las categorías de edad estimadas para individuos de *Histrionicus histrionicus* recapturados (n = 255) basándonos en la profundidad de la bursa con la categoría de edad basada en la profundidad de la bursa en su primera captura y el tiempo transcurrido desde entonces. Aunque no se puede asumir que ninguna de las dos edades sea correcta, las tasas de discrepancia entre ambas para recapturas en el mismo año indican errores de muestreo mientras que las recapturas entre años prueban aseveraciones sobre las tasas de involución de la bursa. Las tasas de discrepancias en el mismo año, entre años y total, fueron de 10%, 24%, y de 18%, respectivamente. La mayoría (86%) de las discrepancias entre años ocurrieron en aves creídas de tener más de tres años (ATY) pero estimadas en su tercer año (TY). De estas discrepancias de ATY-TY, 22 de 25 (88%) de las aves tenían profundidades de la bursa de 2 a 3 mm. Más aún, cinco de seis recapturas entre años que se sabían ser ATY pero estimadas a ser TY tuvieron bursas de 2 mm. Reclasificar las aves con bursas de 2 o 3 mm como ATY resultó en reducción de las tasas de discrepancia entre años (24% a 10%) y en general (18% a 11%). Concluímos que la determinación de edad en esta especie basándose en là profundidad de la bursa, particularmente utilizando nuestros criterios modificados, es una técnica relativamente consistente y confiable.

The bursa of Fabricius (hereafter bursa) has a long history of use for age class determination of wild waterfowl (e.g., Hochbaum 1942, Hanson 1949), although reliability estimates for the method rarely have been reported (Hohman and Cypher 1986, Esler and Grand 1994). The bursa is an immunosuppressive organ that forms as a sac on the dorsal side of the proctodeal region of the cloaca (Glick 1983). The bursa is present in juveniles, regresses as the bird matures, and eventually disappears in adults (Hochbaum 1942, Ward and Middleton 1971). Although the bursa has been used for age determination of ducks in spring (Anderson et al. 1969, LaGrange and Dinsmore 1988, Ankney and Alisauskas 1991, Young

1993), bursal involution may occur before or during an individual's first reproductive cycle, rendering it unreliable during that period (Hohman and Cypher 1986, Esler and Grand 1994). However, reliability may be higher during non-breeding seasons (Peterson and Ellarson 1978, Hohman and Cypher 1986). For birds that do not breed for two or more seasons following hatching (e.g., Canada Geese [*Branta canadensis*; Hanson 1949, Hochbaum 1942], Oldsquaws [*Clangula hymelis*; Peterson and Ellarson 1978], and other sea ducks [Goudie et al. 1994]), the degree of bursal involution may be useful for differentiating age classes.

Our objective was to assess the utility of bursal characteristics for estimating age classes of Harlequin Ducks (*Histrionicus histrionicus*) by examining rates of discrepancies in age class designations of individuals over two or more capture events. In the absence of a known age sample, discrepancy rates provide a useful measure of reliability of bursal depth as an indicator of age class. Recaptures within-year provide an estimate of sampling error and recaptures between-year test assumptions about changes in bursal depth through time.

METHODS

We captured flightless Harlequin Ducks during August and September of 1995–1997 in western Prince William Sound, Alaska using methods similar to Clarkson and Goudie (1994). We marked individuals with United States Fish and Wildlife Service leg bands. Age classes of all birds were estimated using internal bursal depth at each capture event. The bursa was exposed and a metal probe was inserted into the bursal sac to measure depth (± 1 mm). If the bursa was absent or ≤ 1 mm the birds were initially classified as after-third-year (ATY). Birds with bursal depths of >10 mm were classified as second-year (SY) and those with intermediate depths (2–10 mm) were classified as third-year (TY). Age classes are based on calendar year, thus, SY birds were approximately 14 mo old, TY birds approximately 26 mo, and ATY birds 38 mo or older. Criteria for these initial classifications followed those used in other studies of Harlequin Ducks (e.g., Goudie 1996) and were based on the assumption that bursal involution should be complete after the third year when Harlequin Ducks reach breeding age (Hohman and Cypher 1986, Esler and Grand 1994, Goudie et al. 1994). Bursal depths for SY and younger birds are consistently >10 mm (Linduska 1945, Peterson and Ellarson 1978, Hohman and Cypher 1986, Henny et al. 1991). We assumed that bursal depth of TY birds would be intermediate as involution progressed (Ward and Middleton 1971). Hatching year (HY) birds were distinguished from older birds on the basis of size, presence of down, and notched tail feathers; bursal depth of HY birds was not measured. These criteria were used to assign age classes throughout the course of the study. Exact bursal depths, in contrast to age classifications only, were recorded for birds estimated to be TY and ATY during the 1997 field season and late in 1996. Age class designations of recaptured birds were made without knowledge of age class estimates from previous captures.

TABLE 1. Age classifications of recaptured Harlequin Ducks based on bursal characteristics.

Age-class		Frequency	
Expected age	Estimated age	Between years	Within years
Discrepancies			
ATY	SY	1	1
TY	SY	0	4
ATY	TY	31	4
SY	TY	0	1
TY	ATY	4	0
SY	ATY	0	0
Consistencies			
SY	SY	0	16
TY	TY	4	47
ATY	ATY	111	31
Total recaptures		151	104

Because of the lack of known-age birds, the accuracy of using bursal depth to determine age could not be tested directly. Instead, we used records from multiple captures to determine whether individuals could be consistently classified. Consistent classification (i.e., low discrepancy rates) for within-year capture events would suggest low measurement error. Consistent classification for between-year captures (i.e., an increase of one year in age class for every year between capture events) would support the original age class criteria and assumptions about the rates and timing of bursal involution.

To document discrepancy rates, we compared *estimated* to *expected* age classifications for each individual for each recapture event. Estimated age was the age classification based on bursal depth at the time of initial capture or recapture. An expected age class designation was generated for recaptured birds, based on previous age class designations and the time elapsed between capture events. Neither estimated nor expected ages were assumed to be correct; we simply contrasted the two to determine if there was a discrepancy or consistency. Discrepancies occurred when estimated age differed from expected age (i.e., within-year recaptures with different estimated age classes or between-year recaptures that differed from a pattern of one increase in age class estimate per year). We calculated frequency of discrepancies and identified classes of discrepancies that occurred. We compared frequencies of discrepancies among groups using chi-square goodness of fit tests.

RESULTS

We recaptured 217 individuals one or more times for a total of 255 recaptures; 104 occurred within-year and 151 occurred between-years. Overall, estimated age classes of 82% (209) of recaptured ducks were consistent with expected age based on previous captures (Table 1). Of the recaptures, 176 were female, 79 were male. Proportions of consistencies and discrepancies did not differ between sexes ($\chi^2 = 0.070$, df = 1, $P = 0.79$).

Of within-year recaptures, 90% of estimated and expected ages were consistent (Table 1). This suggests that at least one of the age class estimates resulted from measurement error in 10% of cases, under the assumption that bursal depth would not change within a capture season.

Discrepancies between estimated and expected age classes occurred in 24% of between-year recaptures (Table 1), which is higher than would be expected if errors resulted only from measurement error (10%; see above). Most (86%) between-year discrepancies occurred when age class was expected to be ATY but estimated to be TY (Table 1). Bursal depths were recorded for 25 of 31 birds classified as between-year ATY-TY discrepancies. Of these ATY-TY discrepancies, 22 birds (88%) had bursal depths of 2 or 3 mm. Five ATY-TY discrepancies were known to be ATY (see below) and had bursal depths of 2 mm. These results suggest that Harlequin Ducks with bursal depths of 2 or 3 mm should be classified as ATY. By reclassifying these birds as ATY, the overall proportion of discrepancies decreased from 18% to 11% ($\chi^2 = 5.77$, df = 1, $P = 0.02$), the proportion of between-year discrepancies decreased from 24% to 10% ($\chi^2 = 10.404$, df = 1, $P < 0.01$), and the proportion of within-year discrepancies did not change ($\chi^2 = 0.203$, df = 1, $P = 0.65$). These results are consistent with the 10% measurement error predicted from within-year recaptures.

We had one instance in which a within-year discrepancy was associated with a between-year capture event. This individual was originally captured in 1995 and classified as an ATY; in 1997 the bird was captured twice and classified as an ATY once and a TY (2 mm bursa) once. As we were certain that the bird was an ATY in 1997 (see below), we classified the between-year recapture as a consistency and the within-year recapture as a discrepancy based on the original criteria. Using modified criteria, age class designations at all captures were consistent.

We had a subset of 45 individuals known to be ATY. Thirty-six birds were captured twice, first in 1995 and again in 1997, and nine were captured all three years. Because no HY birds were recaptured, all birds originally captured in 1995 and recaptured in 1997 definitely belonged in the ATY age class. Our between-year discrepancy rate for these known ATY birds was 13% using the original classification criteria. Five of the 6 discrepancies (83%) detected in this group were birds with bursa depths of 2 mm. By reclassifying these birds as ATY, our known ATY bird discrepancy rate dropped to 2% ($\chi^2 = 3.873$, df = 1, $P = 0.049$).

DISCUSSION

Based on discrepancy rates, we found that bursal depth enabled classification to relative age class, particularly after adoption of modified criteria for age class designation. Our estimate of measurement error rate (10% within-year discrepancy rate) for bursal age determination is comparable to error rates reported for some other age determination techniques. For example, age classes of 93% of female American Wigeon (*Anas americana*) (Wishart 1981) and 87.5% of Northern Pintails (*Anas acuta*) (Duncan 1985) were determined accurately using wing feather characteristics of known-age samples.

Measurement error can result from observer error; we attempted to minimize this source of error in our study by having only four trained observers measure bursas. We recommend similar cautions for other studies. Another potential source of measurement error may result from damage to the bursa while probing. Improper or prolonged probing may abrade the bursa and, as a result, bursal depth may be altered during the healing process, resulting in an inaccurate age class designation upon recapture. It may also be possible to puncture the bursa by probing too hard. Hanson (1949) found that with a small amount of added pressure a recently closed bursa may be pierced.

Our data strongly suggest that our original age class criteria, for TY and ATY birds, were inappropriate. Classifying birds with bursas ≤ 3 mm as ATY, 4–10 mm as TY, and >10 mm as SY resulted in significantly lower between-year discrepancy rates than the original criteria. After reclassification, many of the remaining discrepancies likely were due to measurement error at one or all of the captures. The results from our known ATY sample corroborate our conclusions.

The ability to determine age classes of waterfowl accurately is essential for understanding the effect of age on many aspects of population ecology (e.g., Johnson et al. 1992). Adoption of age determination methods, without indications of their accuracy or reliability, could lead to erroneous conclusions about the ecological significance of age. While our data suggest that bursal age determination of Harlequin Ducks is relatively reliable, we stress that investigators be aware that errors in age class designation are likely to occur when using this, or any other, technique.

ACKNOWLEDGMENTS

These data were collected under studies supported by the Exxon Valdez Oil Spill Trustee Council. However, the findings and conclusions presented by the authors are their own and do not necessarily reflect the views or position of the Trustee Council. Data were collected with the assistance of B. Baetsle, R. Ballas, B. Benter, T. Bowman, K. Burek, J. DeGroot, B. Jarvis, D. Monson, J. Morse, D. Mulcahy, D. Ruthrauff, D. Schaeffer, M. Stoskopf, L. Thomas, K. Trust, and the crews of the motor vessels *Auklet, Julia Breeze, Kittiwake II,* and *Waters.* We thank D. Derksen, P. Flint, I. Goudie, B. Jarvis and J. Schmutz for comments on the manuscript.

LITERATURE CITED

ANDERSON, B. W., T. E. KETOLA, AND D. W. WARNER. 1969. Spring sex and age ratios of lesser scaup and ring-necked ducks in Minnesota. J. Wildl. Manage. 33:209–212.

ANKNEY, C. D., AND R. T. ALISAUSKAS. 1991. Nutrient-reserve dynamics and diet of breeding female gadwalls. Condor 93:799–810.

CLARKSON, P., AND R. I. GOUDIE. 1994. Capture techniques and 1993 banding results for moulting harlequin ducks in the Strait of Georgia, B. C. Pp. 11–14, *in* Proc. 2nd Harlequin Duck Symp., Hornby Island, British Columbia.

DUNCAN, D. C. 1985. Differentiating yearling from adult northern pintails by wing-feather characteristics. J. Wildl. Manage. 49:576–579.

ESLER, D., AND J. B. GRAND. 1994. Comparison of age determination techniques for female northern pintails and American wigeon in spring. Wildl. Soc. Bull. 22:260–264.

GLICK, B. 1983. Bursa of Fabricius. Pp. 443–500, *in* D. S. Farner, J. R. King, and K. C. Parkes, eds. Avian biology, vol. 7. Academic Press, New York, New York.

GOUDIE, R. I. 1996. Demography of harlequin ducks in costal British Columbia. Canadian Wildlife Service Field Report. 31 pp.

———, S. BRAULT, B. CONANT, A. V. KONDRATYEV, M. R. PETERSEN, AND K. VERMEER. 1994. The status of sea ducks in the North Pacific rim: toward their conservation and management. Proc. North Am. Wildl. Nat. Res. Conf. 59:27–49.

HANSON, H. C. 1949. Methods of determining age in Canada geese and other waterfowl. J. Wildl. Manage. 13:177–183.

HENNY, C. J., L. J. BLUS, R. A. GROVE, AND S. P. THOMPSON. 1991. Accumulation of trace elements and organochlorines by Surf Scoters wintering in the Pacific Northwest. Northwestern Naturalist 72:43–60.

HOCHBAUM, H. A. 1942. Sex and age determination of waterfowl by cloacal examination. Trans. North Am. Wildl. Conf. 7:299–307.

HOHMAN, W. L., AND B. L. CYPHER. 1986. Age-class determination of ring-necked ducks. J. Wildl. Manage. 50:442–445.

JOHNSON, D. H., J. D. NICHOLS, AND M. D. SCHWARTZ. 1992. Population dynamics of breeding waterfowl. Pp. 446–485, *in* B. D. J. Batt, A. D. Afton, M. G. Anderson, C. D. Ankney, D. H. Johnson, J. A. Kadlec, and G. L. Krapu, eds. Ecology and management of breeding waterfowl. Univ. Minnesota Press, Minneapolis, Minnesota.

LAGRANGE, T. G., AND J. J. DINSMORE. 1988. Nutrient reserve dynamics of female mallards during spring migration through central Iowa. Pp. 287–297, *in* M. W. Weller, ed. Waterfowl in winter. Univ. Minnesota Press, Minneapolis, Minnesota.

LINDUSKA, J. P. 1943. A gross study of the bursa of fabricius and cock spurs as age indicators in the Ring-necked Pheasant. Auk 60:426–437.

PETERSON, S. R., AND R. S. ELLARSON. 1978. Bursae, reproductive structures, and scapular color in wintering female Oldsquaws. Auk 95:115–121.

WARD, J. G., AND A. L. A. MIDDLETON. 1971. Weight and histological studies of growth and regression in the bursa of Fabricius in the mallard, *Anas platyrhynchos*. Can. J. Zool. 49: 11–14.

WISHART, R. A. 1981. Wing-feather criteria for age separation of American wigeon. J. Wildl. Manage. 45:230–235.

YOUNG, A. D. 1993. Intraspecific variation in the use of nutrient reserves by breeding female Mallards. Condor 95:45–56.

Received 16 Feb. 1998; accepted 27 Jul. 1998.