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Discrimination of Ross's Geese and Lesser Snow Geese using rectrices in California

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Measurements of the central tail fan rectrix on geese are used to distinguish species of white geese in recreational harvest surveys. Recently, population growth and range wide population shifts warrant reexamination of current techniques used to distinguish white goose species in the Pacific Flyway. We collected 706 hunter-shot white goose tail fans at Sacramento and Delevan National Wildlife Refuges in the upper Sacramento Valley, California, from 8 November 2008 - 2 February 2009. We classified each as after-hatch year or hatch year Ross's goose (*Chen rossii*) or lesser snow goose (*Chen caerulescens caerulescens)*, and measured lengths and shaft widths of central rectrices. We used discriminant function analysis to examine if current methodologies used in harvest surveys correctly identified white goose species in the sample, and determined that total length of the central rectrix can be used to correctly identify about 92% of after-hatch year white geese. Total lengths of central rectrix measuring ≥143 mm are classified as after hatch-year snow geese. For hatch year geese, the ability to correctly identify species is reduced (80%), and central rectrix lengths of ≥127 mm are classified as snow geese. Differences among past methodologies may have been due to physiological changes among snow goose colonies or geographic differences in body size. We recommend that current methods used in the Parts Collection Survey be updated for the Pacific Flyway to account for these results.

Key words: Ross's goose, snow goose, harvest surveys, discriminant analysis, *Chen rossii, Chen caerulescens caerulescens*

Accurate estimates of population size, recruitment, survival, and harvest are necessary for the continued effective management of migratory gamebird species. For speciation of geese in harvest estimates, selected hunters annually send the United States Fish and Wildlife Service (FWS) tail fans and wings from harvested geese for the Parts Collection Survey (PCS). Wings and tail fans then are used to estimate species composition in the harvest and age-ratios for the respective species. However, geese can present a unique challenge for managers in identifying species and subspecies through harvest surveys, since many morphological measurements can overlap (Johnson et al. 1979).

Use of tail-fans has been evaluated to estimate age-ratios in Canada geese (Tacha et al. 1987, Tacha et al. 1989, Krohn and Bizeau 1989). Correct identity of subspecies or species based on morphological measurements has been investigated in Canada and cackling geese (e. g. Johnson et al. 1979, Merendino et al. 1994, Thompson et al. 1999). However, morphological measurements on intact waterfowl are not feasible in the annual PCS since only wings and tail fans are acquired through harvest surveys, and genetic sampling can be expensive and time intensive.

In the Pacific Flyway, Ross's geese (*Chen rossii*) and lesser snow geese (*Chen caerulescens caerulescens)* occur on the same wintering grounds in California. Furthermore, snow geese in California are composed of two separate breeding populations: Wrangel Island, Russia; and, western Canadian Arctic (Pacific Flyway Council 1992a, 1992b). The main wintering location of Wrangel Island snow geese has changed over time. Approximately 78-90% of the population wintered in California in the 1960s (Hines et al. 1999); however, most (60%) of the population now winters in the Fraser-Skagit Delta (Boyd and Cooke 2000). Historically, nearly all Ross's geese wintered in the Pacific Flyway, specifically California (McLandress 1979, Pacific Flyway Council 2006). The wintering range of Ross's geese has expanded into the Mississippi and Central Flyways in the last 20 years (Alisauskas et al. 2006). In addition to range-wide shifts (Alisauskas 1998), when populations of geese increase, body size has been found to decrease in snow geese (Cooch et al. 1991, Reed and Plante 1997); whether this has occurred with Wrangel Island or Western Canadian Arctic (i.e. Banks Island) snow geese remains unknown. For Ross's geese, changes in body size have been negligible over the last 20 years (Traylor 2010). Additionally, body size of goose species may range widely over large geographic regions (Alisauskas 1998, Ely et al. 2005).

When range-wide shifts in geographical wintering locations or anatomical differences arise, this may affect the ability of harvest surveys to accurately determine or estimate species composition. Thus, monitoring protocols should be reevaluated on scheduled intervals. Currently, methodology for determining species by using white goose tail fans was developed from samples collected on mid-continent snow geese (T. Moser, United State Fish and Wildlife Service, personal communication). Our objective was to evaluate the current methodology used for white geese in the Pacific Flyway by using known-species samples from hunter-harvested geese.

Methods

In the Pacific Flyway, approximately 93% and 70% of the harvest of Ross's geese and snow geese, respectively, occurs within California (Collins and Trost 2009). In California, a large majority of the wintering Ross's geese (89%) and snow geese (93%)

occur in the Sacramento Valley (Weaver 2009), one of the most productive rice growing regions in the world. From 1992-2008, the number of snow geese wintering in California has increased by about 50% (Weaver 2009). Rice fields provide geese with quality foraging areas containing seeds and other plant growth (Miller et al. 1989). Approximately 220,000 ha are available to geese for both roosting and feeding habitat in the Sacramento Valley (Fleskes et al. 2005).

We sampled geese in an area where high harvest occurs according to historical data from the PCS and Department of Fish and Game's hunter take survey. In the state, Colusa and Glenn counties are the top two for total harvest of white geese (California Department of Fish and Game 2008). We obtained hunter-shot white geese at check stations on Sacramento National Wildlife Refuge (39º 24' 15" N, 122º 10' 26" W) and Delevan National Wildlife Refuge (39º 18' 21" N, 122º 06' 35" W) in the upper Sacramento Valley of California from 8 November 2008 to 1 February 2009. Hunters voluntarily allowed tail fans of geese to be removed from each individual goose. At the time of collection, each goose was classified as either a Ross's goose or snow goose based upon characteristics of bill morphology (i.e. presence or absence of "grin patch"; Bellrose 1980). Geese were classified as after-hatch year (AHY) or hatch year (HY) based upon bill and leg coloration and feather characteristics (Bellrose 1980). Sex was determined by examination of the cloaca (Hanson 1949). During the collection of geese, a profile view of each goose head was recorded with a digital camera for species verification at a later time by an independent reviewer. The tail fan sample is usually composed of 14-18 feathers of which two are the central rectrices (Bellrose 1980). After collection of entire tail fans, we determined if either of the two central rectrices of the tail fan was present. If both were present, we measured the longer and straighter of the two. We measured total length of the rectrix (from proximal point of the calamus to the distal end of the feather) to the nearest 1 mm. We also measured the shaft diameter of the calamus at about 12 mm distance from the proximal end to the nearest 0.1 mm with dial calipers.

We calculated the mean, median, and coefficient of variation of rectrix length and shaft width for each combination of age, sex, and species. Although sex can not be determined from tail fans of geese (unless genetic techniques are used; e. g. Inman et al. 2003), accounting for sexual dimorphism may reduce error when discriminating species. We used analysis of variance (ANOVA) to test differences in central rectrix length and rectrix shaft width between species for each age and sex cohort. We used a two-group discriminant analysis (McGarigal et al. 2000) with linear common covariance and equal probabilities in JMP (SAS 2007) to determine the correct classification of white goose species from both total central rectrix length and shaft width. We used forward selection with discriminant analysis to determine the best selection criteria for AHY and HY white geese. We selected a P=0.05 for further inclusion of shaft width into the forward selection process. We separated both AHY and HY white geese into separate discriminant functions since Thompson et al. (1999) recommended this for Canada geese. After completion of the discriminant analysis, we computed prediction probabilities for separate age and species cohorts.

Results

We collected 706 central tail fans from hunter-shot white geese from 8 November 2008 to 1 February 2009 at hunter check stations on Sacramento National Wildlife Refuge (n=417) and Delevan National Wildlife Refuge (n=289). We excluded 98 tail fans from analysis because (1) no central rectrix of tail fan was present; or, (2) follicle development was still occurring in rectrix (i.e. blood quill); or, (3) missing data from original data sheets. Of the 608 tail fans used, we identified 181 Ross's geese and 357 snow geese (Table 1, Table 2). No apparent hybrids were identified in the sample. Corresponding pictures of sampled hunter-harvested geese showed 99.8% correct species identification at hunter check stations. Correlation among total rectrix length and diameter shaft width was statistically significant among HY (adj r^2=0.524, P<0.001, n=90) and AHY white geese (adj r^2=0.474, P<0.001, n=518). All sample sizes met the minimum sample sizes required for discriminant analysis (Table 1, Table 2; Williams and Titus 1988). For common variance assumptions in discriminant analysis, standard deviations of discriminating variables were approximately equal for rectrix length and shaft widths (Table 1, Table 2). Median central rectrix lengths for Ross's geese and snow geese were 12% and 11% larger in AHY than in HY geese. Within age and sex classes, rectrix length and width was shorter and narrower in Ross's geese than in snow geese (all P<0.001; Table 1).

Table 1.—Median, mean, standard deviation (*SD*), and coefficient of variation (*CV*) for the lengths of central rectrices from hunter-shot white geese in the Sacramento Valley, California, during the 2008-2009 waterfowl hunting season. ANOVA indicated significant differences (P<0.001) in length between all pairwise comparisons within age and sex categories.

	median	mean	*SD*	*CV*	*n*
Ross's geese					
HY Male	123.0	123.0	1.4	1.1	2
HY Female	118.5	119.0	10.4	8.7	18
HY	119.0	119.1	9.9	8.3	20
AHY Male	138.0	137.0	5.4	3.9	90
AHY Female	131.0	130.7	5.9	4.6	71
AHY	134.0	134.4	6.5	4.8	161
Snow geese					
HY Male	134.5	133.4	8.1	6.1	36
HY Female	136.5	135.1	8.5	6.3	34
HY	135.0	134.2	8.3	6.2	70
AHY Male	152.0	152.0	4.8	3.2	187
AHY Female	149.0	148.6	6.1	4.1	170
AHY	150.0	150.3	5.7	3.8	357

Inclusion of shaft width in analysis did not improve species discrimination of HY geese (P=0.554), but it did for AHY geese (P<0.001). We found that rectrix shaft width alone has decreased ability to correctly identify AHY Ross's geese (76.5%) and snow geese (89.6%). However, "length" and "length + width" resulted in similar numbers of

Table 2.—Median, mean, standard deviation (*SD*), and coefficient of variation (*CV*) for the shaft widths of central rectrices from hunter-shot white geese in the Sacramento Valley, California, during the 2008-2009 waterfowl hunting season. ANOVA indicated significant differences ($P<0.001$) in shaft width between all pairwise comparisons within age and sex categories.

	median	mean	*SD*	*CV*	*n*
Ross's geese					
HY Male	2.15	2.15	0.21	9.9	2
HY Female	1.95	1.94	0.19	9.9	18
HY	2.00	1.96	0.20	10.1	20
AHY Male	2.10	2.11	0.14	6.8	90
AHY Female	2.00	2.02	0.11	5.6	71
AHY	2.10	2.07	0.14	6.7	161
Snow geese					
HY Male	2.20	2.18	0.17	7.6	36
HY Female	2.10	2.15	0.14	6.5	34
HY	2.20	2.17	0.15	7.1	70
AHY Male	2.30	2.34	0.13	5.7	187
AHY Female	2.30	2.29	0.14	6.2	170
AHY	2.30	2.31	0.14	6.0	357

correct species classification for AHY Ross's geese (92.6% vs. 91.9%) and snow geese (92.7% vs. 94.1%). Use of rectrix length results in 7.3% misclassification for AHY white geese. Among AHY geese, 150 of 162 (92.6%) Ross's geese and 331 of 350 (92.7%) snow geese were correctly classified. For "length" and "length + width" models, we found similar results for Ross's geese (85.0% vs. 85.0%) and snow geese (77.1% vs. 78.6%). For HY white geese, the misclassification rate was higher at 20.0%. Among HY geese, 17 of 20 (85%) Ross's geese were classified correctly whereas 55 of 70 (78.6%) HY snow geese were correctly classified. Prediction probabilities for each age cohort suggested AHY white geese with central rectrix lengths ≥143 mm are classified as snow geese, and those with <143 mm as Ross's geese (Figure 1). For HY geese, white geese with central rectrix lengths of ≥127 mm are classified as snow geese, and those with <127 mm as Ross's geese (Figure 2).

Discussion

Although differences among sex in species were significant, differences were larger in Ross's geese when compared to snow geese (Tables 1, Table 2). Sexual dimorphism probably decreases the ability to correctly identify species in harvest surveys for geese. Cooch et al. (1996) reported that post-hatch male lesser snow geese were 2-5% larger than females. With our sample of central rectrix lengths, the median adult male snow geese were 2% larger than females. Sexual dimorphism was less prevalent in snow geese compared to Ross's geese where AHY males were significantly larger than AHY females (5%).

Currently, protocols for use of the rectrices in species classification are similar in the Pacific, Central, and Mississippi Flyways, although harvest is derived from different snow

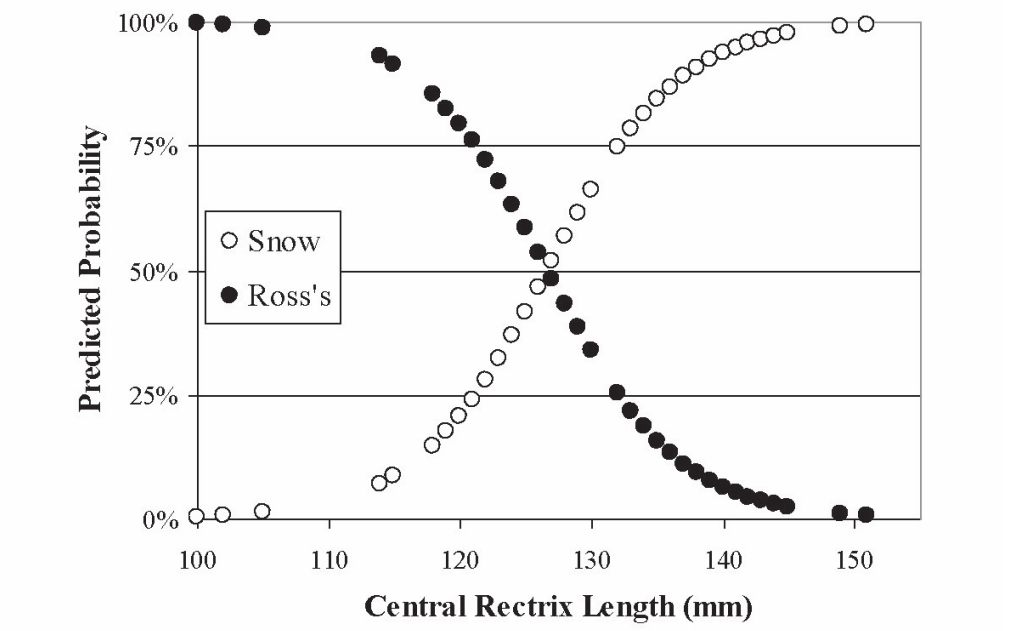

Figure 1.—Predicted probabilities for species identification in after-hatch year (AHY) white geese from central rectrix lengths based upon hunter-shot geese in the Sacramento Valley, California, during the 2008-2009 waterfowl hunting season.

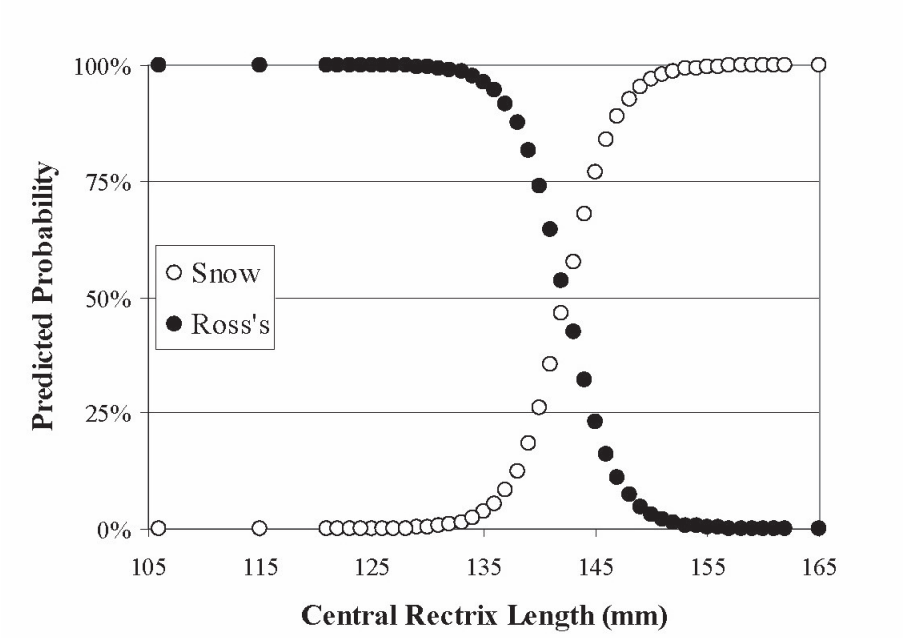

Figure 2.—Predicted probabilities for species identification in hatch year (HY) white geese from central rectrix lengths based upon hunter-shot geese in the Sacramento Valley, California, during the 2008-2009 waterfowl hunting season.

goose colonies, especially in the Pacific Flyway (Pacific Flyway Council 1992a, 1992b, Williams et al. 2008). We recommend using total length of the longest rectrix as a good species discriminator for adults and, to a lesser degree, immature birds due to the relative ease of length measurements during operational processes of the PCS. We found patterns similar to those of an analysis of white geese in the Central Flyway (T. Moser [et al.], United States Fish and Wildlife Service, unpublished data.). Those investigators reported that measurements of the central rectrix permitted correct identification of 89.7% of AHY Ross's geese and 84.4% of AHY snow geese, respectively; also, ability to distinguish species among HY geese using these measurements was poor in the Central Flyway (T. Moser [et al.], unpublished data). Currently, rectrix length of ≥134 mm is defined as an adult snow goose, although our results indicate the level to be higher ≥143 for our sample of AHY white goose tail fans. For after hatch-year white geese, A. D. Dzubin (Canadian Wildlife Service, unpublished data) reported in 1973 that central rectrix length ≥148 mm is a snow goose, and ≤139 mm is a Ross's goose. His findings also established protocol based on calamus diameter for those measurements between 140 and 147 mm. For hatch-year geese, the total length of a central rectrix ≥131 was a snow goose, and those with measurements ≤121 was classified as a Ross's goose; calamus diameter was also used to identify species for those with measurements between 120 and 130 mm. The reason for these differences is unknown at this time. However, based on our results, estimates of harvest for Ross's geese may have been underestimated while snow geese may have been overestimated in the Pacific Flyway, but the magnitude of bias remains unknown. Using the current protocols in the Pacific Flyway, misclassification rates would be 18% based on our sample of AHY rectrices.

We report different results than the current classification from the Mississippi and Central Flyways. Although body size of Ross's goose has not changed over time (Traylor 2010), body size for mid-continent snow geese had declined (Cooch et al. 1991, Alisauskas et al. 2002). Additionally, body size differences among Banks Island and Wrangel Island are unknown, and little interchange occurs between these populations (Williams et al. 2008). Investigations into geographical differences in body size among snow geese in North America and Russia may prove useful in assisting with harvest surveys in the future. The continued improvement of harvest surveys will only increase our ability to manage harvest of goose species throughout North America, especially in a time of increased population growth for most populations (United States Fish and Wildlife Service 2008).

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