6 May 2003
Gary L. Ivey
PO Box 6953
Bend, OR 97708

541-929-7397; E-mail ivey@oregonvos.net



**TRACKING MOVEMENTS OF PACIFIC COAST SANDHILL CRANES THROUGH THEIR ANNUAL CYCLE.**

GARY L. IVEY,[1,2] PO Box 6953, Bend, OR 97708, USA

CAROLINE P. HERZIGER, PO Box 8123, Bend, OR 97708, USA

THOMAS J. HOFFMANN, 341 West Olympic Place, Seattle, WA 98119, USA

***Abstract:*** The subspecies composition of sandhill cranes (*Grus canadensis*) which stage and winter along the Lower Columbia River region in northwest Oregon and southwest Washington is unclear, but may include all three using the Pacific Flyway: lesser (*G. c. canadensis*), Canadian (*G. c. rowani*), and greater (*G. c. tabida*). During 2001-02, we captured and marked eight cranes using a noose line trapping technique, and attached Platform Transmitter Terminals (PTTs) to six of these birds to ascertain locations of breeding areas, migration corridors, and other winter use sites. Morphological data were collected for subspecies determination. From the measurements of these cranes, as well as their summer range, we conclude that they are the intermediate *rowani* form. Because of their unique coastal migration path and conservation issues at breeding, staging, and wintering areas, we recommend that they be managed as a unique population.

***PROCEEDINGS NORTH AMERICAN CRANE WORKSHOP 9:000-000***

[1] Present address: Oregon State University, Fisheries and Wildlife Department, 104 Nash Hall, Corvallis, OR 97331, USA

[2] E-mail: ivey@oregonvos.net

***Key words:*** British Columbia, Canadian sandhill crane, *Grus canadensis rowani*, noose line, Oregon, Ridgefield National Wildlife Refuge, Pacific Flyway, Sauvie Island Wildlife Area, Washington.

Three subspecies of sandhill cranes have been recognized in the Pacific Flyway (*tabida*, *rowani*, and *canadensis*) (Pogson and Lindstedt 1991), although the subspecific status of *rowani* has been debated (e.g., Tacha et al. 1985). The vast majority of cranes migrating between breeding grounds in Alaska and Canada and wintering areas in California use an interior route (east of the Cascade Mountains) through British Columbia (B.C.), Washington, Oregon, and northeast California (Littlefield and Ivey 2002, Petrula and Rothe In Prep.). West of the Cascades, a smaller segment stage and winter along the Lower Columbia River, using Ridgefield National Wildlife Refuge (NWR), Sauvie Island Wildlife Area (WA), and surrounding agricultural areas, however, the subspecies composition, breeding areas, migration routes, and other wintering sites of these flocks have not been previously determined. In November 2001, we initiated a pilot study in this region to determine locations of sandhill cranes throughout their annual cycle, and identify subspecies using the area.

**STUDY AREA**

Located just west of the city of Ridgefield, Clark County in southwest Washington, Ridgefield NWR lies between channels of the Columbia River and contains 2,085 ha. Just across the river in Oregon, the 4,673 ha Sauvie Island WA lies northwest of Portland in Multnomah and Columbia counties. Cranes regularly moved between these two areas, and also used private agricultural fields in the region, including Woodland Bottoms, Squaw Island, and Vancouver Bottoms in Washington, and east of Scappoose along the

Multnomah Channel in Oregon. Crane habitats consisted of foraging areas primarily in corn and barley fields, pastures, and wetlands, and roosting sites in shallow wetlands. The most consistent roost locations on and near Ridgefield NWR included Canvasback Lake (mostly private) and Wigeon Pond on Bachelor Island, and Campbell Lake on the Roth Unit, but smaller wetlands were also used, particularly on the Roth Unit. At Sauvie Island WA, Sturgeon Lake was the primary roost site.

**METHODS**

Cranes were captured using noose lines, an ancient bird-catching technique from India (Hereford et al. 2000), but little used in the U.S. We constructed our own noose lines from a template provided by Tracy Grazia of Mississippi Sandhill Crane NWR, with some modifications. We used 100-lb test monofilament fishing line to construct the nooses, and attached each noose to a .64 cm diameter, 12 cm lengths of wooden dowels (stakes). The ends of the stakes were sharpened to a point and the stakes were tied to a nylon cord, about 30 cm apart, with 25 nooses on each line. Snap swivels were tied at the ends of the nylon lines so that several lines could be linked together.

After locating fields used by foraging cranes, we returned after dark to bait potential trapping sites with corn. After observing cranes using a given bait site, we set noose lines during pre-dawn hours. The lines were set by pushing the stakes into the earth about 20 cm apart to form a wall of upright, overlapping nooses. Weights were attached to the ends of line lines to prevent entangled birds from flying away with the lines. Several lines were set at each site (75-200 nooses) in wide loop patterns, and corn was placed inside the loops of the lines. We monitored the lines from a concealed blind, using binoculars and spotting scopes. Birds feeding on the bait had to do so in close proximity to the nooses, and if they stepped into a noose, their foot became snared. Leg strain was reduced by the elastic nylon line and the few stakes which were pulled from the soil by the struggling birds.

When cranes were captured, they were hooded to limit stress while being handled. They were fitted with PTTs (30 Gram Birdborne) which were manufactured by North Star Science and Technology (Baltimore, Maryland), and glued to a blue plastic leg band; attachment was by rivets and glue and placement was on the tibia. The opposite leg was marked with a blue plastic band, engraved with a unique alpha numeric code, plus another colored plastic band and a federal band. PTTs were programmed to activate for eight hours after 60 hours of deactivation, resulting in locations being recorded from satellites about every three days so that they would last about one year. Cranes were tracked via the Argos Satellite System, with data downloaded via the Internet, and points mapped electronically. All but two cranes were outfitted with PTTs; these were in the same flock as other captured cranes and were marked with federal and color bands only.

Measurements were taken of all birds: exposed culmen (base of the upper mandible to the tip), nares to tip (anterior end of the nostril to the tip), tarsus (intertarsal joint to the distal edge of the last leg scale above the toes), weight, and wing chord (of unflattened wing from carpal joint to tip of longest primary). In addition, a blood sample was collected for genetic analyses (results to be reported in a future paper).

## RESULTS

### Trapping

Trapping efforts were conducted periodically from 21 October 2001- 4 April 2002. Eight cranes were captured: four at Ridgefield NWR and four at Sauvie Island WA. On 26 and 27 November, we captured and processed the first two cranes at Ridgefield NWR (8824 and 8726), but because most staging birds had migrated south, we decided to resume trapping during spring migration to increase our chances of capturing other subspecies (we had only seen *rowani*) and those which had migrated to California. We resumed trapping at Ridgefield NWR on 27 February 2002, and caught two additional cranes (8827 and

5621), one of which received no PTT (5621), but decided to postpone further trapping until March when more returning California migrants would be present.

We returned to Ridgefield NWR on 8 March to find that almost all of the cranes had abandoned the area, but at least 1,500 were using Sauvie Island WA where most of the unharvested corn fields had been recently mowed. On 12 March, we caught two birds in the same line at Sauvie Island WA (8725 and 3643), and placed a PTT on the smallest of the two (8725), and marked and banded the other (3643). On 13 March, we returned to the same location and caught a crane which was much smaller than the other birds we had handled (8737). Again we delayed trapping, returning on March 26 to resume trapping at Sauvie Island WA, and captured the last crane on 4 April (8746).

**Measurements**

Exposed culmen averaged 113.0 mm ($n$ = 8), nares to tip 70.4 mm ($n$ = 8), tarsus 199.9 mm ($n$ = 7), weight 4837.1 g ($n$ = 7) , and wing chord 487.8 ($n$ = 8) (Table 1). Generally, these measurements fell within the range of values reported for *rowani* (Johnson and Stewart 1973, Schmitt and Hale 1997, Johnson et al. In Prep.).

**Winter Use Areas and Spring Migration**

The two cranes that were captured in November remained in the Lower Columbia River Region all winter. Crane 8725 used Ridgefield NWR until December, then shifted to Sauvie Island WA from January until migration, while 8824 used Ridgefield NWR and the Woodland Bottoms area to the north, and then shifted to Sauvie Island WA in February. All PTT-marked birds remained at the study site until they migrated north within just a few days of each other (13 to 19 April). They followed the Columbia River northwest, moved north up the Washington coast, crossed Cape Flattery and Vancouver Island, and traveled up the coast of B.C. (Figure 1). Their final summer destinations were as far north as southern Alaska: Prince of Wales Island (8824) and Dall Island (8827). Another also reached southern Alaska, but backtracked south to near Port Edward, B.C. (8837). Three others stopped along islands further south on the B.C. coast: McCauley Island (8726), Princess Royal Island (8746), and Dowager Island (8725). All six birds stayed at these locations through the summer where we presume they nested (Figure 2).

Unfortunately, by fall migration only three PTTs were still transmitting. One crane began to move south by 6 September (8737) and another by 14 September (8824), while the third PTT continued to send data from B.C. through the winter (8725). We presume this bird either died or the PTT became detached. Since PTT data could only be collected every three days, we obtained just a few northern migration locations near the breeding grounds for 8737 (south of Prince Rupert, B.C.). For 8824, it showed a similar migration pattern as in spring, with points to the east of Prince Rupert, over central and southern Vancouver Island, and near Portland, Oregon.

The first crane to return to the study area was 8737; this bird returned to Sauvie Island WA (where it was captured) by 22 September. By 24 September, 8824 arrived along the East Fork of the Lewis River, just east of Ridgefield NWR where it had been captured. By 27 September, it was back at the Ridgefield NWR/Woodland Bottoms area where it had spent the previous winter, and it remained there until the PTT failed on 4 November.

By 14 October, 8737 began using Ridgefield NWR, and by 30 October, it moved south through southern Oregon (southwest of Klamath Falls), stopping at Meiss Lake, Siskiyou County, California. It was south of Chico in the Sacramento Valley of California by 2 November, and remained in the general area for the duration of the winter (111 days). Figure 3 illustrates the fall migration routes for 8824 and 8737.

By 24 February, 8737 returned to Sauvie Island WA, and by 16 April had moved as far north as northeast Vancouver Island, B.C. This was the same departure date from

Sauvie Island WA as the previous spring. By 19 April, it had arrived at the same summer location it used the previous year, near Port Edward, B.C.

**DISCUSSION**

**Subspecies**

Morphological and migration data indicate that the cranes in the study area appear to be *rowani*. Because of the small sample size and the unknown sexes of the birds we could not make statistical comparisons of measurement data. Therefore, we could not determine subspecies with absolute confidence; Johnson et al. (In Prep.) noted that subspecies classification by measurement was much more accurate when the sex of the bird was known due to overlaps (e.g., *rowani* males and *tabida* females). However, most of our measurements fell within the ranges reported for *rowani* in comparison with standard deviations in Johnson and Stewart (1973), Schmitt and Hale (1997), and Johnson et al. (In Prep.) (Figures 4-8). Exposed culmen, weight, and wing chord data overlapped with both sexes of *rowani* and *tabida*, but most closely corresponded to *rowani* overall for weight and wing chord. However, data for nares to tip overlapped with values for female *rowani*, and for tarsus, with female *rowani* and male and female *canadensis*. Therefore, birds in this study measured primarily as *rowani*, but with shorter nares to tip and tarsus. Disparities in some measurements may also indicate morphological differences between cranes of the Pacific Flyway and those of other Flyways where most of the historic data was obtained.

In addition, all birds captured and those carefully observed in the field had head shapes which appeared different than the large, flat head profiles of *tabida* that we had previously handled in Oregon, and lacked the round head and fine, short bill of *canadensis* we had observed in California, and eastern Oregon and Washington. We also noted that these cranes had shorter legs than *tabida*, as multiple colored leg bands placed above the metatarsal joint fit loosely below the feathers on *tabida*, but overlapped with the feathered portion of the tibia on the birds in this study.

The fact that these cranes summered along the B.C. and southern Alaska coasts also supports the conclusion that these cranes are *rowani*. Campbell et al. (1990) mention that 1,500 *rowani* have been reported nesting along the B.C. coast, and this area is within the breeding range described for *rowani* by Meine and Archibald (1996). In contrast, *canadensis* which have recently been radioed on their breeding grounds at Cook Inlet and Bristol Bay in Alaska migrated along the southern Alaska coast, then traveled through interior B.C. during both spring and fall migration (Petrula and Rothe In Prep.).

It is likely that the birds in this study are associated with the small, remnant group of cranes which breed in the Georgia Depression of southwest B.C., near Vancouver. The race of cranes from this vicinity has been confused, as museum specimens from this area have been classified as both *tabida* and *rowani* (Cooper 1996). However, live birds observed there recently appear to be *rowani* (G. Ivey and R. Drewien, personal observation). Given this information, historic accounts of cranes nesting in western Washington in the Olympic Mountains (Dawson and Bowles 1909) and near Fort Steilacoom (near Olympia) (Suckley 1860) were likely *rowani*, suggesting that historically these birds represented a coastal population which perhaps spanned from southern Alaska to central Washington.

It should be noted that recent studies of crane genetics support subspecies designations of *tabida* and *canadensis,* but not *rowani* (Rhymer et al. 2000, Glenn et al. 2002, Petersen et al. 2002). However, the cranes sampled for these studies did not include any from B.C. or the Pacific States. In contrast, studies of chick development (Baldwin 1977), and measurements of specimens and live birds, including those from coastal Alaska, indicated that *rowani* were probably distinct (Johnson and Stewart 1973, Johnson et al. In Prep.).

**Importance of study area for sandhill cranes**

The Lower Columbia River region is the only major sandhill crane stopover site between northern breeding areas and California (Littlefield and Ivey 2002). Up to 3,994 have been counted during the early fall staging period (see Littlefield and Ivey 2002), and we estimated about 1,900 using the region in March 2002. In our study, Crane 8737 arrived in the fall for a stay of 69 days, and upon returning in spring, remained for 51 days. In addition, the area serves as a wintering site for smaller number of cranes; exact numbers are unknown, but do not likely exceed a few hundred. The two captured in November 2002 (8726 and 8824) remained in the area at least 134 and 140 days after capture, respectively, before migrating north, but likely were using the area at least 30 days before.

**Trapping methods**

While the noose line method of capture is very safe, and portable, it has limitations. Cranes apparently could see the nooses, as when only a few were in the area, they carefully stepped around them to feed on the bait. They were only caught when there were crowded on the bait and distracted by each other. Waterfowl appeared much less wary of the lines and were more readily captured by this technique than cranes; we caught nine Canada geese (*Branta canadensis*) and four mallards (*Anas platyrhynchos*). We found no evidence of injuries to the birds we captured with this technique. Unfortunately, waterfowl captures hindered chances of catching cranes, as cranes were flushed when we removed waterfowl from the lines.

Regardless of the method, other factors would hinder any trapping efforts in the study area. The cranes here were exceptionally wary, so that we often had to watch the bait site with a scope from over a half mile (0.81 km) away or they would not approach the area; they were much more sensitive to our presence than *tabida* we had captured at Malheur NWR in southeast Oregon. This behavior is likely due to their remote nesting grounds and limited contact with humans. Also unlike *tabida*, they completely ignored piles of cracked corn which we placed out for bait (a popular enticement at Malheur NWR), preferring field corn cobs partially peeled to expose the kernels. At Sauvie Island WA, after much of the available corn was consumed, cranes were not very interested in our corn bait. They fed mostly by digging, and were likely searching for nut sedge (*Cyperus esculentus*) (M. Nebeker personal communication).

Trapping success was compounded by the unpredictability of these birds in their feeding and roosting habits which varied almost daily while we were trapping. This behavior may be linked to regular disruptions of feeding birds by bald eagles (*Haliaeetus leucocephalus*), coyotes (*Canis latrans*), and low-flying airplanes. Use of wetland sites was also irregular: heavy rain and high tides caused rising water levels and shifting of roost and feeding areas. Trapping was further complicated with the opening of goose season when cranes were flushed from their roost before dawn, apparently causing about 700 of the 1000 birds present to migrate out of the area on the opening day of goose season.

**CONCLUSION**

Sandhill cranes captured and observed using the Lower Columbia River region appeared to be *rowani* based on morphological measurements, general appearance in the hand and in the field, and summer locations. Perhaps some *canadensis* or *tabida* also use the region during early fall migration, but none were identified during late fall or spring. Although recent genetic evidence concludes that *rowani* and *tabida* should be considered the same subspecies, there are still morphological differences as *rowani* are smaller overall than *tabida*, and their breeding distribution does not appear to overlap, at least in the Pacific Flyway.

Currently, in Washington all crane subspecies are considered Endangered (Littlefield and Ivey 2002), and Blue-listed (Vulnerable) in British Columbia (Blood and

Backhouse 1999). The Lower Columbia River region is critical to these cranes, as it is their only major staging area between northern breeding and California wintering areas, as well as serving as a wintering site for at least several hundred. Considering that this crane use area is near the major metropolitan complex of Portland, Oregon, and Vancouver, Washington, the threat of loss of privately-owned crane habitats is significant. Such vital areas are already being lost to urbanization (e.g., plans for expansion of the Port of Vancouver), and agricultural conversions to incompatible crops such as berries, cottonwood plantations, nurseries and greenhouses. Disturbance at roost sites occurs on both public and private land (e.g., goose hunting). Similar issues of habitat loss and disturbance are occurring for cranes breeding in the Georgia Depression in B.C., and for wintering cranes in the Sacramento Valley of California which at least some of these birds utilize. Little is known about issues surrounding their remote coastal nesting areas, but human intrusions for development, recreation, or commercial purposes could reduce future numbers of these cranes. Therefore, the small size of this population of coastal-nesting cranes, coupled with threats to their habitats at wintering and breeding areas, merits elevating conservation efforts and managing them as a unique population, separate from the interior-nesting *tabida*.

## ACKNOWLEDGMENTS

This project was sponsored by the West Coast Crane Working Group, in partnership with Ridgefield NWR (U.S. Fish and Wildlife Service) and Sauvie Island WA (Oregon Department of Fish and Wildlife), with funding contributed by the Paul L. King Charitable Foundation, The Foley/Frischkorn Wildlife and Conservation Fund, Chevron Research and Technology Company, and other appreciated supporters. Tracy Grazia of the Mississippi Sandhill Crane NWR kindly demonstrated use of the noose line system, and assisted with early field work. Refuge Manager Tom Melanson facilitated our use of Ridgefield NWR and allowed us to use refuge housing. Joe Engler and Eric Anderson of Ridgefield NWR helped with logistics and early capture attempts. Mark Nebecker of Sauvie Island WA allowed our efforts there, and Mark Stern of The Nature Conservancy discussed local crane issues and donated a morning to assist with fieldwork. [redacted] provided comments on earlier drafts.

**LITERATURE CITED**

BALDWIN, J. H. 1976. A study of thermoregulatory capacities of four subspecies of sandhill crane nestlings. Pages 291-295 *in* J. C. Lewis, editor. Proceedings International Crane Workshop. Oklahoma State University Publishing Printing, Stillwater, Oklahoma, USA.

BLOOD, D. A., AND F. BACKHOUSE. 1999. Sandhill Crane: Wildlife in British Columbia at risk. Wildlife Branch, Ministry of Environment, Lands, and Parks, Victoria, British Columbia, Canada.

CAMPBELL, R. W., N. K. DAWE, E. MCTAGGART-COWAN, J. M. COOPER, G. W. KAISER, AND M. C. E. MCNALL. 1990. The birds of British Columbia. Royal British Columbia Museum, Victoria, British Columbia, Canada.

COOPER, J. M. 1996. Status of the sandhill crane in British Columbia. Ministry of Environmental Lands and Parks, Wildlife Branch, Victoria, British Columbia, Canada.

DAWSON, W. L., AND J. H. BOWLES. 1909. The birds of Washington. Occidental, Seattle, Washington, USA.

GLENN, T. C., J. E. THOMPSON, B. M. BALLARD, J. A. ROBERSON, AND J. O. FRENCH. 2002. Mitochondrial DNA variation among wintering Midcontinent Gulf Coast sandhill cranes. Journal of Wildlife Management 66:339-348.

HEREFORD, S. G., T. E. GRAZIA, M. NAGENDRAN, AND A. HUSSAIN. 2000. Use of traditional Indian trapping methods to capture sandhill cranes. Proceedings North American Crane Workshop 8:220.

JOHNSON, D. H., J. E. AUSTIN, AND J. A. SHAFFER. In Prep. A fresh look at the taxonomy of midcontinental sandhill cranes. Proceedings North American Crane Workshop 9.

_____, AND R. E. STEWART. 1973. Racial composition of migrant populations of Sandhill Cranes in the northern plain states. Wilson Bulletin 85:148-162.

LITTLEFIELD, C. D, AND G. L. IVEY. 2002. Washington State Recovery Plan for the Sandhill Crane. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

MEINE, C. D., AND G. W. ARCHIBALD, EDITORS. 1996. The cranes: status survey and conservation action plan. IUCN, Gland, Switzerland.

PETERSEN, J. L., R. BISCHOF, G. L. KRAPU, AND A. L. SZALANSKI. 2003. Genetic variation in the midcontinental population of sandhill cranes, *Grus canadensis*. Biochemical Genetics 41:1-12.

PETRULA, M.. J., AND ROTHE, T. C. In Prep. Migration chronology, routes, and winter and summer range of Pacific Flyway Population of lesser sandhill cranes. Proceedings North American Crane Workshop 9.

POGSON, T. H., AND S. M. LINDSTEDT. 1991. Distribution and abundance of large sandhill cranes, *Grus canadensis*, wintering in California's Central Valley. Condor 93:266-278.

RHYMER, J. M., M. G. FAIN, J. E. AUSTIN, D. H. JOHNSON, AND C. KRAJEWSKI. 2000. Mitochondrial phylogeography, subspecific taxonomy, and conservation genetics of sandhill cranes (*Grus canadensis*; Aves: Gruidae). Conservation Genetics 2:203-218.

SCHMITT, G. C., AND B. P. HALE. 1997. Sandhill Crane hunts in the Rio Grande Valley and southwest New Mexico. Proceedings North American Crane Workshop 7:219-231.

SUCKLEY, G. 1860. Water birds. *In* Vol. 12, Book 2, Report upon the birds collected on the survey, Zoology Report No. 3. Reports of explorations and surveys for a railroad from the Mississippi River to the Pacific Ocean. Bailliere Bros., New York, New York, USA.

TACHA, T.C., S. A. NESBITT, AND P. A. VOHS. 1994. Sandhill crane. Pages 77-94 *in* T. C. Tacha and C. E. Braun, editors. Migratory shore and upland game bird management in North America. International Association of Fish and Wildlife Agencies. Washington, D.C., USA.

Table 1. Measurements of sandhill cranes captured at Ridgefield NWR, Washington, and Sauvie Island WA, Oregon, 2001-02.

| Crane | Exposed culmen (mm) | Nares to tip (mm) | Tarsus (mm) | Weight (g) | Wing chord (mm) |
|---|---|---|---|---|---|
| 5621 | 112.0 | 61.7 | 194.0 | 4960.0 | 495.0 |
| 6343 | 113.2 | 72.0 | 207.0 | 4450.0 | 465.0 |
| 8725 | 109.7 | 72.7 | 215.0 | N/A | 492.0 |
| 8726 | 119.0 | 74.0 | 200.0 | 5610.0 | 545.0 |
| 8737 | 103.3 | 67.8 | 172.0 | 4100.0 | 435.0 |
| 8746 | 105.9 | 71.6 | 203.0 | 5500.0 | 495.0 |
| 8824 | 118.0 | 71.0 | N/A | 4960.0 | 515.0 |
| 8827 | 122.5 | 72.6 | 208.0 | 4280.0 | 460.0 |
| Mean | 113.0 | 70.4 | 199.9 | 4837.1 | 487.8 |
| SD | 6.6 | 4.0 | 14.0 | 587.4 | 34.3 |
| SE | 2.3 | 1.4 | 5.3 | 207.7 | 12.1 |
| Min | 103.3 | 61.7 | 172.0 | 4100.0 | 435.0 |
| Max | 122.5 | 74.0 | 215.0 | 5610.0 | 545.0 |

Figure legends:

Fig. 1. Spring migration route of PTT-marked sandhill cranes, 2002.
Fig. 2. Final summer destinations of PTT-marked sandhill cranes, 2002.
Fig. 3. Fall migration route and winter destination of PTT-marked sandhill cranes, 2003.
Fig. 4. Comparison of measurements of exposed culmen of sandhill cranes (n = 8) to Johnson and Stewart (1973) and Johnson et al. (In Prep) (n = 389).
Fig. 5. Comparisons of measurements of nares to tip of sandhill cranes (n = 8) to Schmitt and Hale (1977) (n = 1475).
Fig. 6. Comparisons of tarsus measurements of sandhill cranes (n = 7) to studies summarized in Schmitt and Hale (1977) and Johnson et al. (In Prep) (n = 2804).
Fig. 7. Comparisons of weights of sandhill cranes (n = 7) to studies summarized in Schmitt and Hale (1977) (n = 1811).
Fig. 8. Comparisons of wing chord measurements of sandhill cranes (n = 8) to studies summarized in Schmitt and Hale (1977) and Johnson et al. (In Prep) (n = 2812).

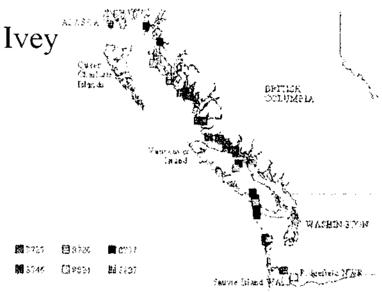

Fig. 1

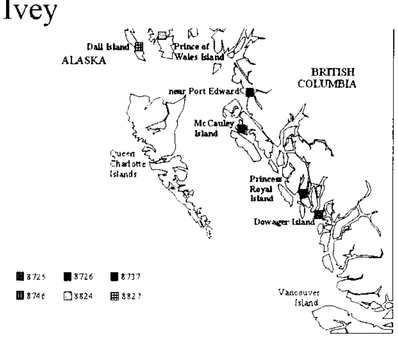
Dall Island
ALASKA
Prince of Wales Island
BRITISH COLUMBIA
near Port Edward
McCauley Island
Queen Charlotte Islands
Princess Royal Island
Dowager Island
Vancouver Island
8725
8726
8737
8746
8824
8827

Fig. 2

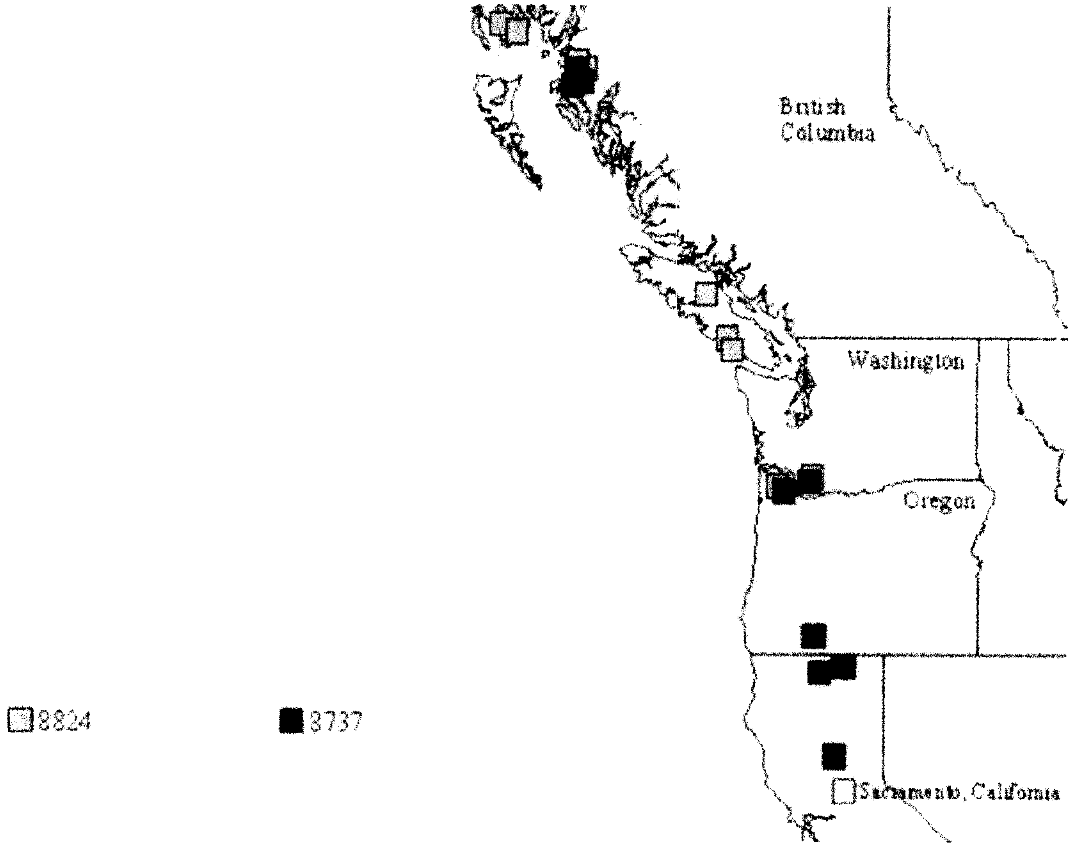
8824
8737
British Columbia
Washington
Oregon
Sacramento, California

Fig. 3

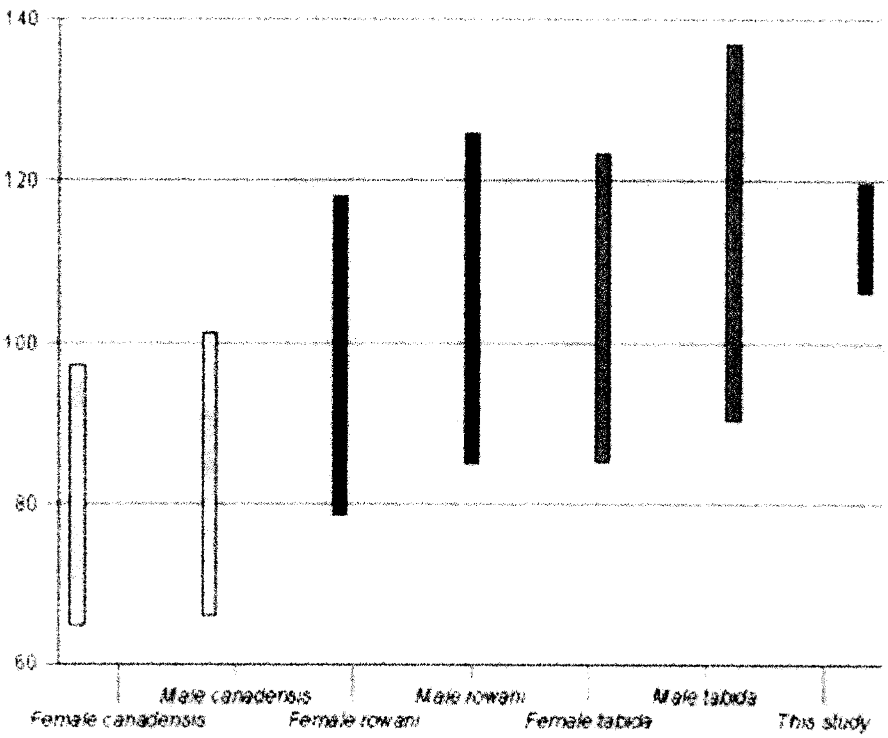
140
120
100
80
60
Female canadensis
Male canadensis
Female rowani
Male rowani
Female tabida
Male tabida
This study

Fig 4

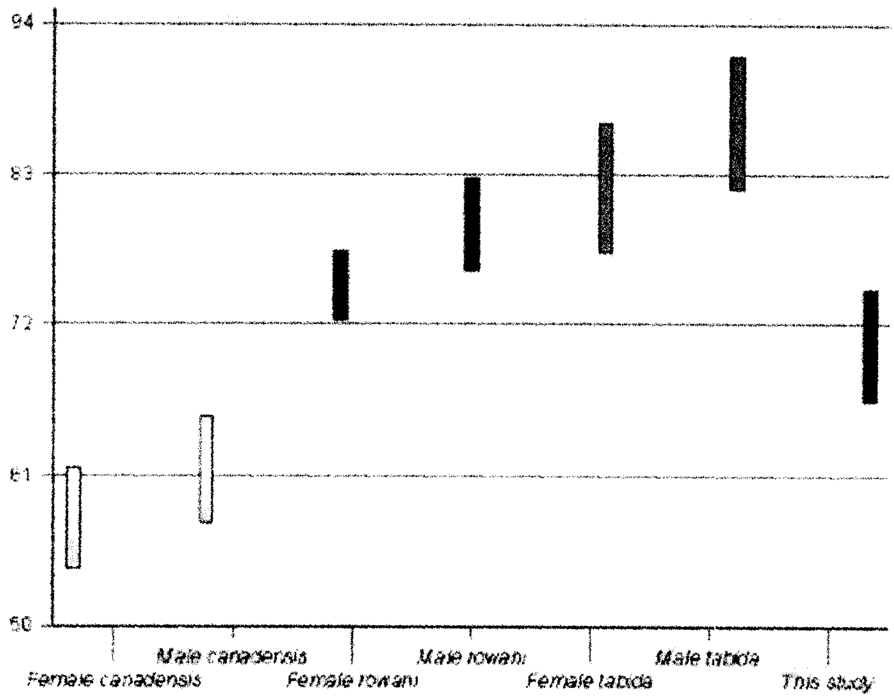
94
83
72
61
50
Male canadensis
Female canadensis
Female rowani
Male rowani
Female tabida
Male tabida
This study

Fig. 5

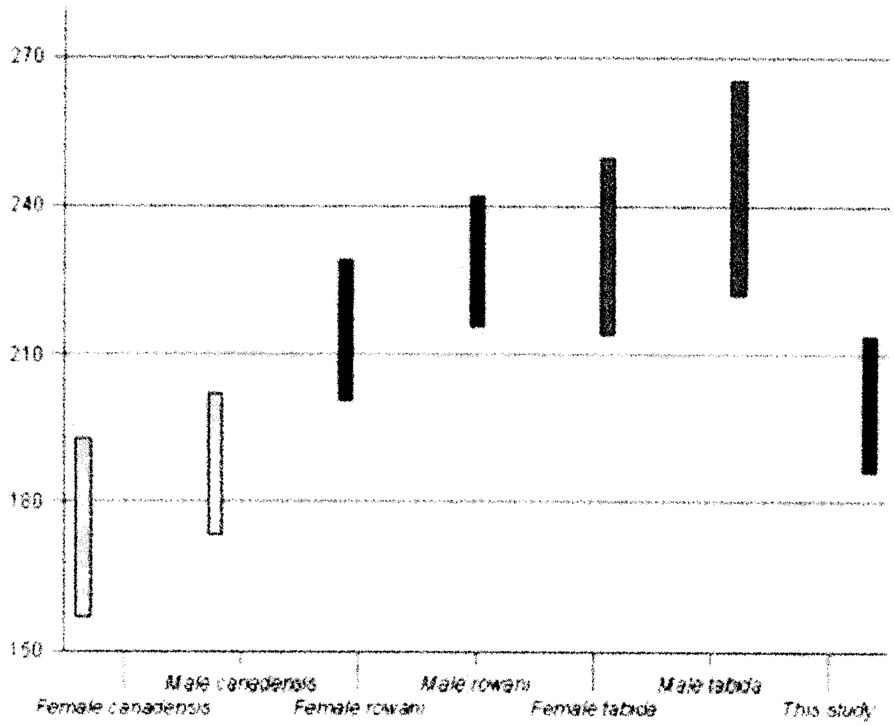
270
240
210
180
150
Male canadensis
Male rowani
Male tabida
Female canadensis
Female rowani
Female tabida
This study

Fig. 6

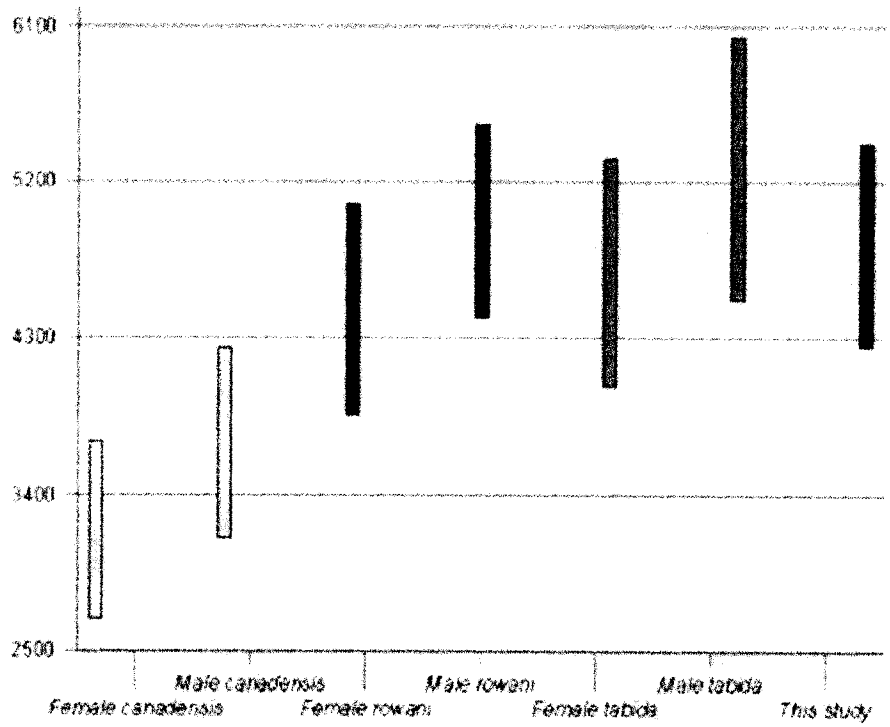
6100
5200
4300
3400
2500
Male canadensis
Female canadensis
Male rowani
Female rowani
Male tabida
Female tabida
This study

Fig. 7

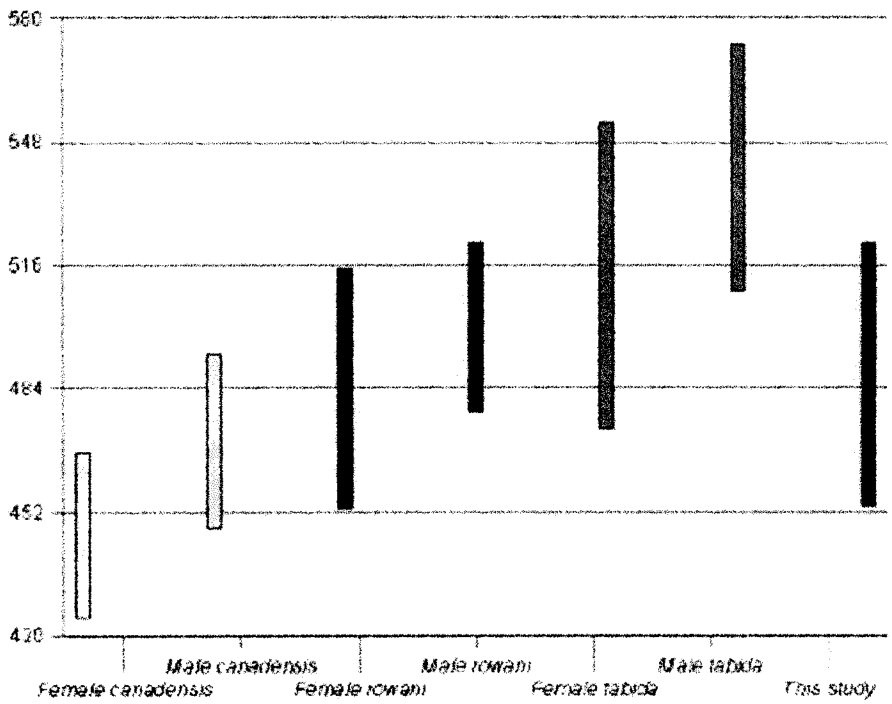
580
548
516
484
452
420
Male canadensis
Female canadensis
Male rowani
Female rowani
Male tabida
Female tabida
This study

Fig. 8