Effects of Backpack Radio-Transmitters on Female Barrow's Goldeneyes

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Abstract.—We compared time-budgets and return rates of breeding female Barrow's Goldeneyes (*Bucephala islandica*) fitted, or not, with transmitters attached with backpack harnesses in 2001-2004 in southern Québec. We compared the mean proportion of time devoted to feeding, locomotion, alert, resting, preening, and maintenance (i.e., resting plus preening) by females observed ≥200 min. Females with backpacks (N = 5) spent significantly less time feeding (x ± SE: 25 ± 5% versus 43 ± 3%) and more time in maintenance activities (51 ± 6% versus 31 ± 4%) than females without transmitters (N = 6). Mean time devoted to other behavior did not differ significantly. Upon release, females appeared disturbed with the backpack, actively bathing, preening and/or flapping wings. Of the females with transmitters observed ≥200 min, three spent 4%, 8%, and 57% of their preening time at their transmitter, antennae or harness. None of the 16 females harnessed in 2001-2003 were recaptured in nest boxes or seen again on the study area in 2002-2004. For comparison, 66% of adult female Barrow's Goldeneyes captured in nest boxes and marked with leg bands in 2000-2002 were recaptured or seen again in subsequent years. We do not recommend the use of harnesses on diving ducks and sea ducks as it may affect their behavior and survival, at least for birds wintering in areas where conditions are severe. Received 5 September 2005, accepted 16 December 2005.

Key words.—Barrow's Goldeneye, *Bucephala islandica*, radio-transmitters, Dwyer backpack, harnesses, telemetry, time-budgets, behavior.

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Various methods have been used for attaching transmitters to ducks and geese, including harnesses (Dwyer 1972), neck-collars (Sorenson 1989), tail-mounts (Giroux *et al.* 1990), anchors, sutures and glue (Mauser and Jarvis 1991; Wheeler 1991; Pietz *et al.* 1995). Harness-style transmitters have been used commonly on dabbling ducks, and although a few studies revealed no apparent effects (Raveling 1969; Gilmer *et al.* 1974; Houston and Greenwood 1993), others documented potential adverse effects on behavior, physical condition, return rate, and time budgets (Greenwood and Sargeant 1973; Conroy *et al.* 1989; Pietz *et al.* 1993; Rotella *et al.* 1993; Dzus and Clark 1996; Garrettson and Rohwer 1998; Fleskes 2003). Among diving ducks, Perry (1981) found that transmitters attached with backpack harnesses resulted in weight loss and abnormal behavior in the Canvasback (*Aythya valisineria*). Based apparently on this single study, diving ducks have been considered especially sensitive to radio monitoring, and techniques for implanting VHF or satellite transmitters in ducks' coelomic cavity have since been developed (Olsen *et al.* 1992; Korschgen *et al.* 1996), and are now commonly used by waterfowl biologists (e.g., Peterson *et al.* 1995; Robert *et al.* 2002). However coelomic implants have drawbacks, including the need for antiseptic conditions and specialized veterinarians required for performing surgeries under general anesthesia (Pietz *et al.* 1995), conditions often difficult to provide in the field.

As part of a larger study (Robert *et al.* 2000, 2002) on the eastern North American population of the Barrow's Goldeneye (*Bucephala islandica*), we tracked females using VHF transmitters to document their movements between breeding lakes (MR, unpubl. data). Here, we compare time-budgets and return rates of adult Barrow's Goldeneye females equipped, or not, with harnessed backpacks.

METHODS

The study was conducted in the Zone d'Exploitation Contrôlée Chauvin, about 40 km northwest of Tadoussac (48°09'N, 69°43'W), Québec, Canada. This study area is north of the St. Lawrence River estuary in the Balsam Fir (*Abies balsamea*)-White Birch (*Betula papyrifera*)

bioclimatic domain (Robitaille and Saucier 1998). From 2001-2004, we captured 18 adult (ASY) female Barrow's Goldeneyes and fitted them with transmitters (Advanced Telemetry Systems, Inc., model Dwyer backpack A1820, PVC and wire loops) attached with backpack harnesses. Sixteen females were captured in nest boxes, using a hand net, at the end of the incubation period (18-26 June) from 2001-2003 after ≥18 incubation days. The other two were captured using gill nets on lakes before incubation began on 4-5 June 2004. The backpacks were installed on the birds as recommended by Dwyer (1972) and Perry (1981). Mean weight of transmitters was 19.5 g (17.5-23.1) and represented ≤3.5% of females' body mass. All females were banded with aluminum and alpha-numeric plastic color leg bands, and two also received color shaped nasal disks.

We conducted behavioral observations only on brooding females (i.e., females with ducklings) including 7 with transmitters and 11 without. Ten of those 11 had never been captured and one had been captured and banded. Females with no transmitters were identified by the number and plumage development of the ducklings accompanying them (Bellrose 1980) and by lake location. Observations were conducted at irregular intervals during daylight hours, starting, on average, on 15 July (8-29 July). We used focal sampling (Altman 1974) and observed individual females for ≥30 min during each observation bout. At 1-min intervals, behavior was categorized as feeding, locomotion (walking, swimming, or flying), alert, resting, or preening. For each female, observation periods were spread over several days and duckling age.

Considering only females with a cumulative of ≥200 min of observation time, we used one-tailed *t*-tests (PROC TTEST; SAS Institute 2001) on arcsin-transformed data (residuals were normal) to compare the mean proportion of time devoted to feeding, locomotion, alert, resting, preening, and maintenance (i.e., resting + preening; Eadie *et al.* 2000) by females with and without backpacks. Females with backpacks were expected to spend less time feeding and moving, and more time resting, preening and alert, than females without backpacks (Greenwood and Sargeant 1973; Pietz *et al.* 1993). Because of our low sample size, we did not test for year effects.

We compared the proportion of females recaptured in nest boxes in subsequent years (return rate) for individuals with and without transmitters, using Fisher's exact tests (PROC FREQ; SAS Institute 2001). All usable nest boxes (N = 128 to 133, depending of year) were visited in 2002-2004 at least once in the second half of the incubation period. In addition, we conducted ground surveys on most lakes of the study area (N = 86, 78, and 71 in 2002, 2003, and 2004, respectively) at least twice in spring for pairs and at least twice in summer for broods.

RESULTS

Of the 16 females captured in nest boxes during incubation and fitted with transmitters, 11 hatched young, three incubated for 9-14 d but did not hatch young, and two abandoned incubation in ≤7 d. Neither of the two females captured before incubation actually incubated clutches. Upon release, all females appeared disturbed by the radio pack and behaved in a similar way, actively bathing, preening and/or flapping wings. One female harnessed in 2004, after having preened and splashed her wings upon release, flew over the lake up to ca. 8 m, and then dropped (collapsed) into the water. This female flew away normally a few minutes later, after a failed attempt to recapture her.

Females with transmitters spent significantly less time feeding (x ± SE: 25 ± 5% versus 43 ± 3%; $t_{10} = 2.7$, P = 0.01) and more time in maintenance activities (51 ± 6% versus 31 ± 4%; $t_{10} = 2.2$, P = 0.03) than females without transmitters. Mean time devoted to other behavior did not differ significantly (P ≥ 0.1; Table 1). Of females with transmitters observed ≥200 min (N = 5), three (G92, G91, and G511) spent 4%, 8%, and 57% of their preening time biting, scratching, or pulling at their transmitter, antennae or harness, respectively. One (G511) appeared particularly disturbed by the backpack, as apart from orienting 10% of her global time-budget to the radio-package, she was observed on 48 occasions biting, scratching, or pulling at the transmitter, its antennae or its harness. A fourth female (G510) was observed preening at her transmitter on 14 occasions, even though these observations were done during 1-min observation periods classified into behavior other than preening.

Each year, harnessed females were tracked on average up to 27 July (1 July-15 August). In 2003, we flew over the study area and the St. Lawrence River estuary after the breeding season to locate females marked that year, and re-located two individuals: one live individual at Baie-Comeau (49°13'N, 68°09'W; ca. 165 km from study area) on 8 September, and one dead (for ≥3 wk) individual at Saint-André-de-Kamouraska (47°40'N, 69°44'W; ca. 90 km from study area) on 11 September. The first female was resighted at Ragueneau (49°04'N, 68°32'W; ca. 30 km from Baie-Comeau) on 13 September, and was later shot by a hunter on 20 September at the same locality (Guy Lavoie, pers. comm.). The only other radio-tagged female (G92; harnessed in 2001) observed outside the study area was seen at Port-au-

Table 1. Proportion of time devoted to feeding, locomotion, alert, resting, preening, and maintenance (i.e., resting + preening) by brooding adult Barrow's Goldeneye females equipped, or not, with harnessed backpacks VHF transmitters in 2001-2003 on their breeding grounds in Québec. Only females with ≥200 min of observation are presented and were considered in the analysis. Asterisks indicate females also equipped with nasal disks.

			Behavior (% time)					
	Females	Min	Feeding	Locomotion	Alert	Resting	Preening	Maintenance
No harness	F1	664	46	14	12	22	7	29
	F5	339	45	30	14	3	8	11
	FG359	232	31	9	16	31	13	44
	F19-7	1142	38	6	23	24	9	33
	F19-2C	611	41	7	9	36	8	44
	FRA-2	325	59	3	14	5	20	25
	Mean	552.2	43.2	11.3	14.5	20.1	10.8	31.0
	SE	137.0	3.0	3.1	1.5	4.3	1.6	3.9
Harness	G91*	2400	28	6	12	37	18	54
	G92*	342	33	1	10	16	41	57
	G358	267	2	17	7	70	4	74
	G510	210	22	15	31	25	6	31
	G511	509	38	11	15	18	18	36
	Mean	745.6	24.6	10.0	15.0	33.2	17.3	50.5
	SE	416.6	4.9	2.3	3.4	7.8	5.2	6.0
	t-test (*t*)	0.40	2.70	0.27	0.11	1.20	1.00	2.20
	P	0.70	0.01	0.40	0.46	0.13	0.17	0.03

Persil (47°48'N, 69°54'W; ca. 75 km from study area) on 2 December 2001. None of the 16 females harnessed in 2001-2003 were recaptured in nest boxes or seen again on the study area in 2002-2004. For comparison, 66% (2/3) of adult female Barrow's Goldeneyes captured in nest boxes and marked with legs bands in 2000-2002 were either recaptured or seen again in subsequent years, a significant difference (Fisher's exact test; P = 0.02). If females marked with nasal disks are included, the return rate is 43% (3/7) and still significantly different (P = 0.02).

On 19 July 2002, using telemetry, we found a dead harnessed Barrow's Goldeneye that had been dragged to a Mink (*Mustela vison*) den located among the roots of a Black Spruce (*Picea mariana*) close to water. Further searching located the remains of two goldeneye ducklings in the same den.

DISCUSSION

To our knowledge, our study is the first to report on specific effects of harnessed backpacks on any species of sea ducks. Our results indicate that female Barrow's Goldeneyes equipped with radio-packages spent less time feeding and more time in maintenance activities than non-harnessed females. Similarly, Pietz *et al.* (1993) found that female Mallard (*Anas platyrhynchos*) with backpacks fed less and rested and preened more than unmarked females. Studies of captive Mallard and Blue-winged Teal (*A. discors*) yielded similar results (Greenwood and Sargeant 1973; Garrettson and Rohwer 1998; Garrettson *et al.* 2000), while captive White-faced Duck (*Dendrocygna viduata*) with backpacks also increased their preening time (Petrie *et al.* 1996).

Beyond time-budgets, we observed behavior indicating that harnessed Barrow's Goldeneyes were disturbed by their radio-package. Similar behavior has been observed in Common Goldeneye (*Bucephala clangula*) females equipped with backpacks in Finland: females were not willing to fly and clearly seemed to suffer from having the transmitter on their back, trying to remove it (H. Pöysä, pers. comm.). Maisonneuve *et al.* (2002), in attempts to locate natural breeding cavities in Québec, fitted with backpacks 55 female Common Goldeneyes and 16 female Hood-

ed Mergansers (*Lophodytes cucullatus*) captured in nest boxes before incubation, and found few cavities (six and four, respectively), indicating, as the authors suggest, that the birds may have been affected in some ways by their manipulation and/or radio-packages. Fortunately, as in other studies (e.g., Gilmer *et al.* 1974), most individuals tracked in our study did not exhibit long-term abnormal behavior. However we tracked only females with ducklings, and did not estimate duckling and brood survival of treated and untreated birds, so we can not evaluate the complete effect that backpacks may have had during the breeding season. We found one female depredated, and two others may have abandoned incubation because they were manipulated and harnessed, which suggests that backpacks may have affected seasonal productivity. Fortunately, harnessed females that hatched clutches were seen with their young for 30 d on average (range: 13-51 d), indicating that ducklings were accompanied by adult females during the first, critical, two weeks of their life (Eadie *et al.* 2000). Indeed, various studies (e.g., Bergmann *et al.* 1994; Gammonley and Kelley 1994; Dzus and Clark 1996) showed that in dabbling ducks, harness-type transmitters have no major effects in duck nest success and brood survival when birds are marked on their nests.

Our results also suggest that backpacks may have affected survival of female goldeneyes because none were ever recaptured or seen again in the study area. Most (69%) of these females had hatched broods successfully, so they would probably have returned to the same pair territory, nesting box and brood territory (Savard 1988). Sénéchal (2003) observed a similar detrimental impact on Common Goldeneye survival as none of her 12 harnessed birds returned to her study area the following year. Maisonneuve *et al.* (2002) recaptured 17% of Common Goldeneyes and 35% of Hooded Mergansers harnessed during their study, but all had lost their transmitters by the time of recapture. Few investigators have examined the effects of backpacks on return rates of ducks. Dzus and Clark (1996) found that female Mallards with backpacks had a lower return rate (23%) than females with implanted transmitters (55%). In contrast, the return rate of female Wood Ducks (*Aix sponsa*) fitted with backpacks during incubation did not differ from that of females with leg bands (Gammonley and Kelley 1994); however, 72% of females recaptured by these authors had lost their harnesses between breeding seasons, which evidently minimized the potential adverse impacts of radio-packages.

We do not know why none of the harnessed Barrow's Goldeneyes returned to our study area, although we consider icing and severe winter conditions may be a cause. Barrow's Goldeneyes from eastern North America winter mostly along the St. Lawrence River estuary and gulf (Robert *et al.* 2003), where conditions are extremely severe. At Baie-Comeau, where more than 1,000 Barrow's Goldeneyes may be found in mid-winter (Robert *et al.* 2003), the mean maximum and minimum temperatures for January 1971-2000 were -8.8°C and -20.0°C, respectively, while the extreme minimum was -47.2°C (G. Filion, Environment Canada, pers. comm.). Clearly, weather conditions conducive to icing (Zicus *et al.* 1983; Byers 1987) are probably of regular occurrence in wintering areas of the St. Lawrence River corridor. Yet it is not known if the backpacks we installed during this study easily accumulate ice during such conditions. In addition, the PVC loops, as well as the transmitter itself, which covers an area of ca. 6 cm^2 on the back of the duck, probably contribute to insulation losses that may affect goldeneyes wintering in harsh conditions, in particular females, which are smaller than males and may thus be more vulnerable to such conditions because of energetic considerations (Nilsson 1969; Campbell 1977; Sayler and Afton 1981). In addition, harnesses may have increased female vulnerability to predators and hunters.

Our result indicate that harnessed backpack transmitters increased comfort movements, decreased feeding activity, and affected the return rate (and probably the survival) of adult female Barrow's Goldeneyes. As a result, we do not recommend the use of harnesses on diving ducks and sea ducks, at

least for birds wintering in areas where conditions are severe. Although other techniques may be used to fit Barrow's Goldeneyes with external transmitters (Giroux *et al.* 1990; Pietz *et al.* 1995; Paasivaara and Pöysä 2004), additional studies are needed to verify retention time and effects of such transmitters for ducks like goldeneyes.

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