Habitat use by Harlequin Ducks breeding in Hebron Fiord, Labrador

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Abstract: Understanding of breeding habitat requirements is vital to recovery plans for the endangered eastern North American population of Harlequin Ducks (*Histrionicus histrionicus*). I compared habitat characteristics and benthic invertebrate fauna between streams in Hebron Fiord, Labrador, used and unused by Harlequin Ducks in 1996. Used streams were narrower, had higher pH and temperature, a larger substrate, steeper shorelines, and greater vegetation cover on islands and shorelines than unused streams. Greater numbers of invertebrates were recovered from kick samples, simuliid larvae and plecopteran nymphs were more frequent, and chironomid larvae and emphemeropteran nymphs were less frequent in used than in unused streams. Results from this study will help focus future survey and conservation efforts.

Résumé : Une bonne compréhension des besoins écologiques au moment de la reproduction est essentielle à l'ébauche des plans de rétablissement de la population menacée de l'Arlequin plongeur (*Histrionicus histrionicus*) de l'est nord-américain. J'ai comparé les caractéristiques de l'habitat et la faune des invertébrés benthiques dans des ruisseaux utilisés et des ruisseaux non fréquentés du fjord d'Hebron, Labrador, en 1996. Les ruisseaux fréquentés par les canards étaient plus étroits, avaient un pH et une température plus élevés, un substrat plus grossier, des rives plus abruptes et une végétation insulaire et riparienne plus abondante que les ruisseaux non fréquentés. Les échantillons obtenus au filet troubleau (kick samples) y ont donné une plus grande abondance d'invertébrés. Les larves de simuliies et de plécoptères étaient plus abondantes, les larves de chironomides et d'éphéméroptères moins abondantes dans les ruisseaux fréquentés que dans les ruisseaux non fréquentés. Les résultats de cette étude permettront de mieux planifier les inventaires et les efforts de conservation dans l'avenir.
[Traduit par la Rédaction]

Introduction

Harlequin Ducks (*Histrionicus histrionicus*) breed on swift-flowing streams in undisturbed forested, montane, and tundra habitats at coastal and inland locations (Bengtson 1966, 1972; Kuchel 1977; Dzinbal 1982; Wallen 1987; Inglis et al. 1989; Cassirer and Groves 1991; Rodway et al. 1998). Habitat requirements for breeding are known primarily from Iceland (Bengtson 1966, 1972) and have not been investigated in eastern North America (Montevecchi et al. 1995). The eastern North American population has been listed as endangered by the Committee on the Status of Endangered Wildlife in Canada because of its small size (Vickery 1988) and apparent decline (Goudie 1989, 1991). A lack of knowledge concerning breeding habitat requirements for this population prompted an investigation of a known breeding population in Hebron Fiord, Labrador (Goudie et al. 1994; A. Veitch, personal communication). Coastal tundra habitat in Hebron Fiord, consisting of rolling moorland rising to 400–700 m elevation with dense, shrub-covered sections along lower stream valleys, is similar to montane habitat used by Harlequin Ducks in Iceland (Bengtson 1966, 1972; Bengtson and Ulfstrand 1971). My objectives in this study were to determine which streams are used by Harlequin Ducks in Hebron Fiord and compare habitat characteristics and benthic invertebrate species composition between used and unused streams.

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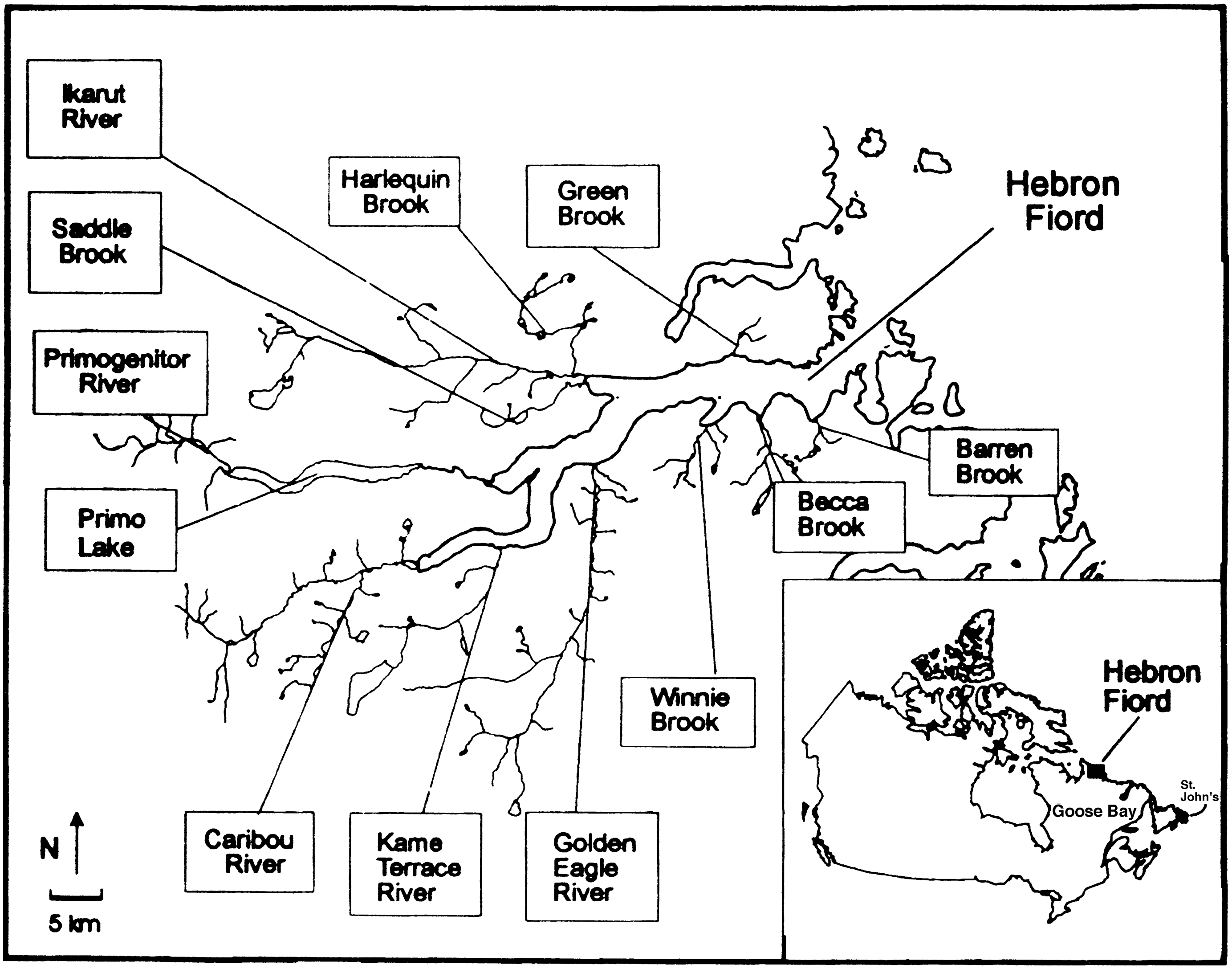
Methods

The study was conducted from 8 June to 14 August 1996. The lower 10 km of all larger streams emptying into Hebron Fiord except Harlequin Brook, which was used for more intensive studies (see Rodway 1998), was searched once for Harlequin Ducks (Fig. 1). Streams shorter than 10 km were searched to the point where they became small alpine rivulets or outflow streams from headwater ponds. Searches were conducted between 4 and 29 July during the incubation period after ice breakup allowed access and most males had left the area. Three observers, covering both stream banks whenever possible, walked upstream along all accessible sections of each stream. Perimeters of islands were explored whenever water depth allowed streams to be crossed. At least one night was spent camped at the estuary of each stream watching for Harlequin Duck activity. At Primogenitor River we boated up the lower river, across the lake, and then explored a further 10 km upstream on foot, camping at the inflow at the head of the lake (Fig. 1).

Three streams with and three streams without sightings of Harlequin Ducks within 10 km of their respective estuaries were chosen to compare habitat characteristics in "used" and "unused" streams. Sample streams could not be chosen randomly, as only 3 of 11 streams explored were unused. I selected used streams in the same part of the fiord as unused streams, but potential biases due to stream size, flow rate, aspect, etc. were not controlled for. The lower 5 km of each stream on a 1 : 50 000 scale topographic map was divided into 200-m intervals, of which 10 were chosen at random. If the stream was shorter than 5 km, 20% of the 200-m intervals were selected so as not to overrepresent small streams in the comparison. Random

Fig. 1. Locations of rivers explored for Harlequin Ducks in Hebron Fiord, Labrador, in 1996.



points were located on the stream by measuring from obvious landmarks (e.g., tributaries). Habitat measurements were taken between 22 and 29 July.

Habitat characteristics recorded at random points included stream width, depth, surface, substrate, pH, temperature, and flow rate, and, within a distance of 25 m either side of each point, number of exposed boulders, number of islands, composition of dominant vegetation cover or substrate on islands, height of island vegetation, slope, width and composition of stream shorelines, slope, composition and height of vegetation on stream banks, and distance and height of the closest shrub cover from the stream edge. Bottom kick samples for invertebrates (Frost et al. 1971) were also taken at each point, and captured invertebrates were later counted, measured to the nearest millimetre, and identified in the field to order or family using Pennak (1953). Shoreline was defined as the area immediately adjacent to the water and was distinguished from stream bank by an abrupt change in slope. No stream-bank characteristics were recorded if a shoreline extended more than 25 m at a constant slope from the water's edge. The codes used for discrete habitat variables are given in Table 1. Stream width was estimated to the nearest metre. Temperature was measured to the nearest 0.5°C with a Lamotte Model 545 Enviro-Safe thermometer, and pH was measured using an Oakton Model WD-35624–22 pH Testr2. Flow rate was determined by timing the passage of a plastic fish bobber along a 10-m stream interval. The average from three trials was used as the flow-rate estimate. Trials were repeated if the bobber became caught in an eddy or other obstruction. Some measurements could not be taken at inaccessible stations in canyons or where banks were overhung with snow, or where opposite shorelines were not visible past intervening islands. The inability to measure flow rates in canyons probably resulted in underestimates of average flow rates for streams with canyon habitat.

ANOVA and χ^2 tests were used to compare continuous and discrete habitat variables, respectively, between used and unused streams. Stream was included as a nested variable in ANOVAs to control for within-stream variation. Because measurements taken on either side of the stream for shoreline and bank variables were correlated, I averaged those from the two sides to provide single, independent measures at each habitat point. This was done for stream width and distance to nearest shrub cover, and for ranked codes for shoreline slope, bank slope, and shrub height (including that for islands). For nominal cover codes that could not be averaged, I randomly selected one side for each habitat sample.

Mean numbers of invertebrates recovered in kick samples taken

Table 1. Code numbers for discrete stream habitat variables.

Depth	
1	<0.5 m
2	0.5–1 m
3	1–2 m
4	>2 m
Surface	
1	Steady
2	Some riffles
3	Abundant riffles
Substrate	
1	Sand/silt
2	Gravel (<5 cm)
3	Cobble (5–30 cm)
4	Boulders (>30 cm)
5	Bedrock
Cover	
1	Shrubs
2	Grasses/forbs
3	Sand/silt
4	Stones
5	Boulders
6	Bedrock
7	Snow/ice
Vegetation height	
1	<0.5 m
2	0.5–1 m
3	>1 m
Slope	
1	<10°
2	10°–30°
3	30°–60°
4	60°–90°

from used and unused streams were compared using one-way ANOVA. Chi-squared tests were used to analyze differences in relative frequencies of invertebrate types.

Tolerance for type I error was set at 5% for all tests. Residuals from ANOVA models were inspected to insure that assumptions of normality and homoscedasticity were satisfied. Frequency tables were collapsed to fewer categories for χ^2 tests if more than 20% of expected cell frequencies from original tables were <5. Analyses were conducted using SYSTAT (Wilkinson 1990). Means are given ± 1 SD.

Results

Harlequin Ducks were observed on 8 of 11 streams explored in Hebron Fiord. Streams where no Harlequin Ducks were sighted were located in the Ikarut valley (Ikarut River and Saddle Brook) and the outer fiord (Barren Brook; Fig. 1). I compared habitat characteristics in these streams with those in three others located in the outer section of the fiord (Winnie, Becca, and Green brooks). Streams that were used were narrower, had higher pH and temperature, a larger substrate, steeper shorelines, and greater vegetation cover on islands and shorelines than unused streams (Tables 2 and 3). As with substrate, unvegetated shorelines and banks of used streams were more frequently composed of larger boulders and less frequently of sand or small stones (Table 3).

Greater numbers of invertebrates were recovered from kick samples in used (14 ± 15, N = 24) than in unused (3 ± 4, N = 24) streams (ANOVA, $F_{[1,46]} = 11.50$, $P = 0.001$). Simuliid larvae and plecopteran nymphs were more frequent, while chironomid larvae and ephemeropteran nymphs were less frequent, in used than in unused streams (Table 4).

Discussion

Eight of 11 is a conservative estimate of the number of streams in Hebron Fiord used by Harlequin Ducks, because streams were checked only once and because only the lower 10 km of each stream was searched. Harlequin Ducks may use the upper portions of the Ikarut River, because birds were occasionally observed heading up that river (one female at 21:53 on 10 June, one pair at 05:18 on 15 June) during observations at lower Harlequin Brook.

I suspect that the difference in widths between used and unused streams may represent a bias due to the fact that larger streams used by Harlequin Ducks (i.e., Primogenitor, Caribou, Kame Terrace, and Golden Eagle) were not included in the habitat comparison, while the unused section of Ikarut River, which is similar in size to excluded streams, was included in the comparison. However, differences were still substantial (22 ± 21 and 40 ± 41 m for used and unused streams, respectively), though not significant ($F_{[1,40]} = 3.24$, $P = 0.079$), when Ikarut River was excluded from the comparison. The narrower width of used streams probably relates to their steeper shorelines and thus more constricted stream flow. The higher frequency of very steep shorelines represents a greater incidence of canyon habitat on used streams. Harlequin Ducks were observed roosting in canyons, and they may use cavities and ledges in canyons for nest sites (Bengtson 1972; Campbell et al. 1990; Cassirer et al. 1993; Robert 1996). Canyons were used preferentially in Montana and were thought to provide good loafing sites and abundant insect populations (Kuchel 1977).

Lower temperatures, and possibly lower pH as well, probably indicate later retention of snow cover on unused streams. Banks were covered with snow and ice at the upper two stations on Saddle Brook on 23 July, and Barren Bay was located in the outer section of Hebron Fiord, where snowmelt was generally later than in the inner fiord. Ice and snow were also recorded on Becca Brook, which had the lowest temperatures of the used streams and is located towards the outer fiord. Lower temperatures probably reduce invertebrate productivity (Colbo and Porter 1981), and later snow cover may delay access to potential nest sites.

Vegetation on islands and shorelines appears to be important for Harlequin Ducks. Nest sites are located in dense vegetation on islands and close to the shore (Bengtson 1972; Rodway et al. 1998), and adults with broods make frequent use of vegetation cover along the edge of the stream for concealment (Bengtson 1966; Kuchel 1977; personal observation).

Numbers of invertebrates captured in kick samples and proportions of simuliids and plecopterans were higher in used than in unused streams. Higher frequencies of simuliids and plecopterans in used streams and chironomids in

Table 2. Comparison of habitat measurements for streams used and unused by Harlequin Ducks in Hebron Fiord, Labrador, 22–29 July 1996.

Variable	Used streams	Unused streams	*F*	Error df	*P*
Width (m)	22 (21)	48 (40)	7.38	46	0.009
pH	7.4 (0.1)	7.1 (0.1)	49.17	46	0.000
Temperature (°C)	12.9 (2.2)	10.7 (2.8)	320.26	42	0.000
Flow rate (m/s)	1.1 (0.6)	1.0 (0.3)	1.26	46	0.267
No. of islands	1.4 (2.7)	1.0 (1.3)	0.17	46	0.678
No. of exposed boulders	41 (96)	60 (140)	2.71	46	0.106
Shoreline width (m)	5 (8)	7 (9)	0.60	46	0.443
Shoreline slope[a]	3.0 (0.6)	2.5 (0.5)	13.82	46	0.001
Bank slope[a]	2.1 (0.7)	2.2 (0.7)	0.59	41	0.448
Distance to shrub cover (m)	18 (39)	20 (46)	0.14	46	0.715
Shrub height[a]	1.6 (0.6)	1.3 (0.7)	2.38	46	0.130

Note: Values are given as the mean, with the standard deviation in parentheses. Within-stream variance has been accounted for by including stream as a nested variable in ANOVA models.

[a]Means of average codes (see Methods and Table 1) at each sampling point.

Table 3. Frequency distributions of habitat-variable codes for streams used and unused by Harlequin Ducks in Hebron Fiord, Labrador, 22–29 July 1996.

	Used streams						Unused streams							
Variable	1	2	3	4	5	6	1	2	3	4	5	6	χ^2	*P*
Depth	11	14	2				11	10	4				1.26	0.533
Surface	1	10	16				0	15	10				3.31	0.191
Substrate	0	1	9	16			6	4	11	4			15.19	0.002
Cover														
Island	3	5	0	0	3	1	1	0	4	4	3	0	8.71	0.003[a]
Shoreline	3	9	0	0	10	5	3	3	2	9	8	0	15.08	0.001[b]
Bank	9	7	0	0	4	4	12	6	1	2	2	0	6.70	0.035[b]

Note: Single values for shoreline and bank cover were chosen randomly for each sampling point if they were recorded for both sides of the stream. See Table 1 for an explanation of codes.

[a]Because of low cell frequencies, the contingency table was collapsed to 2 × 2 comparing frequencies of codes 1 and 2 (vegetated) with codes 3–6 (nonvegetated).

[b]Because of low cell frequencies, the contingency table was collapsed to 2 × 3 comparing combined frequencies of codes 1 and 2, 3 and 4, and 5 and 6.

unused streams are consistent with their relative frequencies in Harlequin Duck feces collected on Harlequin Brook (Rodway 1998) and with diet information from Iceland (Bengtson 1972), Wyoming (Cottam 1939, cited in Breault and Savard 1991), and Montana (Wallen 1987).

The larger substrate in used streams may reflect a preference for faster water and may relate to Harlequin Ducks' dietary dependence on simuliid larvae, which concentrate on cobble or boulder substrates in fast-flowing water (McCreadie and Colbo 1993). Flow rates did not differ between used and unused streams, but the greater incidence of canyon habitat, where the flow rate often could not be measured, probably resulted in underestimates of mean flow rates on used streams.

Different requirements for nesting, feeding, resting, and brood rearing may result in a preference for streams with variable structure. Optimal habitat composition may include shrub-covered islands and shorelines, canyons, and slow- and fast-moving areas with variable depth and substrate. Future comparisons between used and unused streams could address this hypothesis by comparing within-stream variation in habitat structure. Greater understanding of habitat requirements for breeding from this and future studies will help focus survey and conservation efforts and aid recovery plans for Harlequin Ducks in eastern North America (Montevecchi et al. 1995).

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Table 4. Numbers of invertebrates recovered from kick samples taken at randomly chosen stations on streams used and unused by Harlequin Ducks in Hebron Fiord, Labrador, 22–29 July 1996.

	Used streams	Unused streams	χ^2	*P*
Acari	21 (6.3)	4 (5.3)	—	
Coleoptera	2 (0.6)	0	—	
Diptera	186 (55.7)	51 (68.0)	—	
Chironomidae	154 (46.1)	44 (58.7)	3.87	0.049
Simuliidae	32 (9.6)	1 (1.3)	5.62	0.018
Ephemeroptera	14 (4.2)	17 (22.7)	29.84	0.000
Nematoda	2 (0.6)	1 (1.3)	—	
Plecoptera	101 (30.2)	2 (2.7)	24.71	0.000
Trichoptera	4 (1.2)	0	—	
Unknown	4 (1.2)	0	—	
Total	334	75		
No. of samples	24	24		

Note: Values in parentheses are percentages.

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