

Harlequin Duck *Histrionicus histrionicus* distribution and stonefly nymph availability in the Maligne Valley watershed – a preliminary study

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The relationship between Harlequin Duck *Histrionicus histrionicus* distribution and stonefly (Plecoptera) nymph availability in the Maligne Valley watershed, Jasper National Park, Canada, was investigated from 1999 to 2000. Invertebrate sampling and duck counts were concentrated in the Maligne Lake Outlet (MLO), Middle Maligne River and Lower Maligne River. Harlequin Ducks were more likely to use the two sites with high nymph availability (MLO and Lower Maligne) than the site with low nymph availability (Middle Maligne). The relationship between Harlequin Duck distribution and other invertebrates was less consistent. These results suggest that stonefly nymphs play an important role in the distribution of Harlequin Ducks in the Maligne watershed.

Key Words: *Histrionicus histrionicus*, Plecoptera, pre-breeding foraging

Introduction

Harlequins Ducks *Histrionicus histrionicus* are Holarctic sea ducks that migrate inland in spring to breed on rivers and streams after wintering on coastal waters. Breeding sites for the Pacific population are found throughout the Western Cordillera and include the Maligne Valley watershed in Jasper National Park, Canada (Hunt & Ydenberg 2000 and references therein). Harlequin Ducks feed in the lower reaches of the watersheds before egg laying and incubation (Hunt & Ydenberg 2000). Use of feeding sites varies spatially and temporally. For example, Harlequin Duck use of the Maligne Lake Outlet (MLO) is typically high whereas use of the Middle Maligne River is rare (Hunt & Ydenberg 2000). In years when use of the MLO is low, Harlequin Ducks increase their use of other feeding sites, including the Lower Maligne River (McCUTCHEON 2001).

Prey availability may account for at least part of the variation in the distribution of Harlequin Ducks along the Maligne (Hunt 1998). The importance of prey availability to Harlequin Duck productivity has been shown previously (Bengtson & Ulfstrand 1971; Gardarsson & Einarsson 1994; Rodway 1998a; Wright et al. 2000) and ultimately suggests that Harlequin Ducks that feed in areas with the most prey have the highest reproductive success. The Harlequin Duck diet is composed mainly of aquatic invertebrates that are found on and under rocks on the river bottom (Bengtson & Ulfstrand 1971; Gardarsson & Einarsson 1994; Rodway 1998a, b; Wright et al. 2000). In the Maligne, stonefly (Plecoptera)

nymphs seem particularly important to the distribution of Harlequin Ducks (Hunt 1998; McCUTCHEON 2001), although detailed diet studies have not been conducted. These nymphs are relatively large, common and conspicuous invertebrates that are available throughout the Harlequin Duck breeding season (McCUTCHEON 2001).

In a previous study, Hunt (1998) suggested that Harlequin Duck feeding sites depended on the availability of stonefly nymphs. The main objective of this study was to further investigate this link, although small sample sizes and limited spatial and temporal scope still render the study correlative. Nonetheless, if stonefly nymphs are key to the distribution of Harlequin Ducks, Harlequin Ducks should use sites with high nymph availability (as determined by biomass/m²) more than sites with low nymph availability. This study is important for Harlequin Duck management in Jasper National Park, where recent variance in Harlequin Duck numbers at the MLO has raised concerns about the stability of the local duck population (Hunt 1998). However, this study will not only provide insight into Harlequin Duck ecology in the Maligne watershed. Harlequin Ducks are a poorly studied species, despite concern about their status in North America (COSEWIC 2001). Therefore any information on the ecology of this species will be useful for supporting relevant conservation actions.

Methods

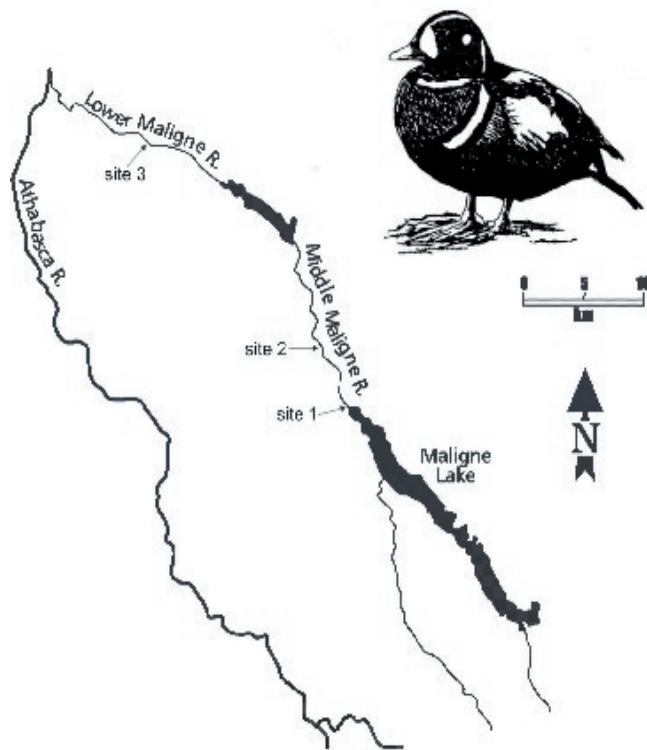
Study Area – This study was conducted in the Maligne Valley watershed

in Jasper National Park, Alberta, Canada (**Figure 1**). This 70-km-long, glacially fed watershed includes two lakes (Maligne and Medicine Lake) and three main river sections (Upper Maligne, Middle Maligne and Lower Maligne). The valley bottom contains mixed-species forests dominated by Lodgepole Pine *Pinus contorta*, White Spruce *Picea glauca*, Engelmann Spruce *Picea engelmannii* and Trembling Aspen *Populus tremuloides*. Average annual water discharge (i.e. rate of flow) at the MLO is $15.9 \text{ m}^3/\text{s}$.

Glacial meltwater drains from the Upper Maligne River into Maligne Lake

and then into the Middle Maligne River via the MLO. Most of the glacial silt settles in this large lake before it enters the Middle Maligne. The Middle Maligne joins Medicine Lake approximately 15 km downstream of the MLO. A karst system of caves connects Medicine Lake to the Lower Maligne, which eventually drains into the Athabasca River. This water system is part of the Mackenzie watershed, which eventually empties into the Arctic Ocean. Rainbow Trout *Oncorhynchus mykiss* and Brook Char *Salvelinus fontinalis* were introduced into Maligne Lake in the 1920s and 1960s and are now universally distributed

Figure 1. The Maligne Valley watershed, Jasper National Park, Alberta, Canada.



between Maligne and Medicine Lakes (Sullivan 1989). No fish populations are established in the Lower Maligne as the karst system of caves upstream and the Maligne Canyon downstream act as barriers to colonisation (Sullivan 1989).

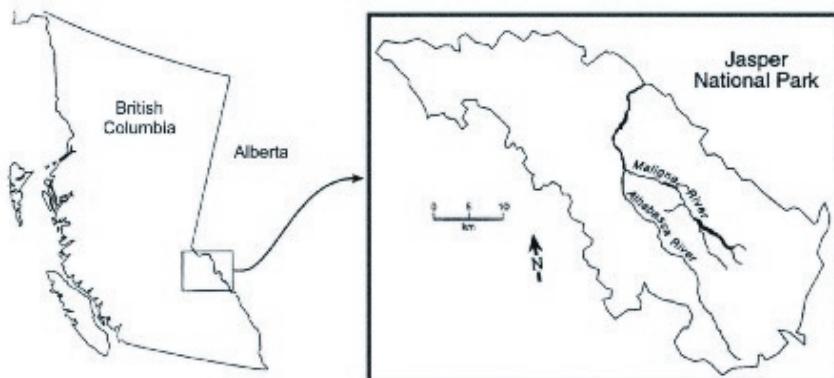
Harlequin Duck counts – This study concentrated on Harlequin Duck use of the MLO, Middle Maligne and Lower Maligne (**Figure 2**). The MLO is traditionally used as a 'club site' (i.e. a relatively large gathering of non-territorial birds) by up to 12 Harlequin Ducks while the Lower Maligne is defended by a few territorial pairs (Hunt & Ydenberg 2000). Harlequin Ducks are rarely observed on the Middle Maligne River (Hunt & Ydenberg 2000). In 1999 and 2000, Harlequin Duck distribution in the watershed was measured using surveys made at 38 sites along the Maligne Valley Road. This road runs parallel to the Lower and Middle Maligne and ends at a bridge that crosses over the MLO. Consequently, most of the two rivers and all of the MLO could be surveyed

for ducks. Surveys were made every week from the beginning of May to the end of June.

Surveys started at 0600 h at the bottom of the watershed (i.e. the Lower Maligne) and usually ended at 1200 h. At each site, the upstream and downstream sections of the river/outlet were searched for birds. All birds were counted and identified to species. Banded Harlequin Ducks were identified where possible, and this made it possible to determine whether the ducks were moving up and down the watershed during the survey. Weekly counts were averaged to yield an estimate of mean Harlequin Duck numbers in each section of the watershed. Visual observations were aided by a telescope and binoculars.

Prey availability – Invertebrate biomass (mg/m^2) on the substrate surface was used to estimate prey availability in the MLO, Middle and Lower Maligne in 1999 and 2000. Surber and Hess sampling, which are more traditional methods of sampling substrate invertebrates, could not be

Figure 2. Map of the sampling sites in this study. Site 1 refers to the Maligne Lake Outlet, Jasper National Park, Alberta, Canada. Site 2 was located about 5 km downstream of the MLO, while Site 3 was located about 8 km downstream of Medicine Lake.



used in this study because the surface substrate was too large (i.e. medium to large rocks interspersed with boulders, Hunt 1998; McCutchen 2002). Instead, invertebrates were collected using 'five-rock' sampling: an aquatic D-net was positioned downstream of a rock (medium sized, 8–12 cm wide). The rock was lifted into the net and all the invertebrates on and around the rock were washed into the net. The volume of the rock was then estimated using water displacement. This procedure was repeated four more times. Rocks in the sample were approximately 1 m apart and selected randomly as the collector moved progressively upstream. The total sample was transferred to a sampling vial and preserved in a 70% ethanol solution. Sampled rocks were not returned to the river. This procedure was repeated five times to give five 'five-rock' samples per site each sampling day. Replicates were about 10 m apart. Samples were collected once or twice a week from the beginning of April to the end of June. Collection areas within each of the three sites were restricted to areas where Harlequin Ducks had previously been observed.

In the laboratory, invertebrates were sorted into two groups using Clifford (1991): stonefly nymphs and other invertebrates (mainly mayfly (Ephemeroptera) nymphs, blackfly (Diptera) larvae, and caddisfly (Trichoptera) larvae). Samples were dried for 24 h at 80 °C and weighed with an Ohaus Precision Standard Balance (accuracy to 1 mg). Total rock volume for each sample was converted to surface area, where surface area = $13.875 \cdot \log \text{volume}^3 \cdot 603$, $r^2 = 0.97$

(see McCutchen 2002 for detailed methods for obtaining this function). Biomass estimates for each sample were log transformed (i.e. $\ln(x+1)$) to normalise the distributions (e.g. Elliott 1977). Invertebrate biomasses were compared among sites in 1999 and 2000 using two-way ANOVAs in which site and year were the main factors ($\alpha = 0.05$). All analyses are based on transformed data, although back-transformed means are also provided.

Results

Harlequin Ducks arrived in the Maligne watershed by mid-May in 1999 and 2000, generally increasing in number until June (Hunt & Ydenberg 2000; McCutchen 2002). Based on ring readings, individual Harlequin Ducks did not move up and down the watershed during any of the surveys. Most of the ducks were observed on the MLO (**Table 1**). Use of the Middle Maligne was rare whereas use of the Lower Maligne was low but consistent.

Stonefly nymph biomass was higher in the Lower Maligne and MLO than in the Middle Maligne in both years (site: F₂, 394 = 24.8, $P < 0.001$; year: F₁, 394 = 0.2, n.s.; site*year: F₂, 394 = 0.7, n.s.). The biomass of other invertebrates decreased with distance upstream towards the MLO (site: F₁, 394 = 84.4, $P < 0.001$; site*year: F₂, 394 = 3.3, n.s.). This trend was consistent across both years (F₁, 394 = 2.2, n.s.). In all sites, other invertebrates were more abundant than stonefly nymphs. Total invertebrate abundance was highest in the Lower Maligne and lowest in the Middle Maligne.

Table 1. Harlequin Duck abundance, mean stonefly nymph biomass and mean other invertebrate biomass in the Lower Maligne and Middle Maligne River and Maligne Lake Outlet, Jasper National Park, Canada, in 1999 and 2000. Harlequin Duck abundance is represented as percentage use (counts are in parentheses). Invertebrate biomasses \pm 95% confidence intervals are log transformed (untransformed data are in parentheses).

Measure	Lower	Middle	MLO
1999			
% Harlequin Ducks	13 (2)	0 (0)	87 (13)
Stonefly nymph biomass (mg/m ²)	1.3 \pm 0.2 (5.9 \pm 2.4)	0.7 \pm 0.3 (6.1 \pm 4.1)	1.4 \pm 0.3 (9.1 \pm 4.3)
Other invertebrate biomass (mg/m ²)	3.7 \pm 0.2 (50.3 \pm 7.2)	2.9 \pm 0.2 (24.2 \pm 4.5)	2.5 \pm 0.2 (17.9 \pm 3.5)
2000			
% Harlequin Ducks	8 (4)	8 (4)	84 (42)
Stonefly nymph biomass (mg/m ²)	1.4 \pm 0.3 (13.6 \pm 14.0)	0.5 \pm 0.2 (2.8 \pm 2.7)	1.6 \pm 0.3 (9.2 \pm 3.4)
Other invertebrate biomass (mg/m ²)	3.7 \pm 0.2 (49.3 \pm 9.7)	3.0 \pm 0.2 (26.8 \pm 7.3)	2.1 \pm 0.3 (13.3 \pm 4.2)
Both years combined			
% Harlequin Ducks	11	4	85
Stonefly nymph biomass (mg/m ²)	1.4 \pm 0.2 (9.3 \pm 6.3)	0.6 \pm 0.2 (4.6 \pm 2.5)	1.5 \pm 0.2 (9.1 \pm 2.8)
Other invertebrate biomass (mg/m ²)	3.7 \pm 0.1 (49.9 \pm 5.8)	2.9 \pm 0.2 (25.4 \pm 4.1)	2.3 \pm 0.2 (15.9 \pm 2.8)

Discussion

This study suggests that the distribution of Harlequin Ducks in the Maligne watershed is most closely associated with stonefly nymphs. Harlequin Ducks were predominantly found in the MLO and the Lower Maligne, which are sites with relatively high stonefly nymph biomass. Harlequin Ducks were rarely observed in the Middle Maligne, which is a relatively poor source of

stonefly nymph prey. The relationship between Harlequin Ducks and other invertebrates was less consistent. For example, Harlequin Ducks were less likely to use the Lower Maligne than the MLO despite its having the most total invertebrates, the most other invertebrates and the second highest biomass of stonefly nymphs. The biomass of other invertebrates was also higher in the Middle Maligne than in the MLO.

These findings are consistent with the results of previous work in the Maligne watershed (Hunt 1998; Hunt & Ydenberg 2000). It is not known why nymphs are so scarce in the Middle Maligne, although Brook Char and Rainbow Trout use it as a nursery (Sullivan 1989). Predation by these introduced fish may keep nymph biomass low, and, as a direct consequence, render the Middle Maligne a poor feeding site for Harlequin Ducks. Low, though consistent, use of the Lower Maligne is harder to explain. However, nymphs in the Lower Maligne are primarily herbivorous (e.g. Nemouridae) while those in the MLO are primarily predatory (e.g. Perlidae) (McCutchen 2001). In other studies, the presence of predatory stoneflies results in higher rates of fish growth and reproduction (Soluk 1993; Soluk & Richardson 1997). It is possible that a similar relationship is occurring in the Maligne watershed, ultimately meaning that the MLO is the best place to forage. Nymphs also influence the distribution of breeding Harlequin Ducks in Labrador (Rodway 1998b), though work in other countries suggest that blackfly and caddisfly larvae are more important (Bengtson & Ulfstrand 1971; Gardarsson & Einarsson 1994; Wright *et al.* 2000). These differences suggest that Harlequin Duck feeding ecology cannot be generalised because it is system-specific.

The evidence from the present study is correlative, limited to small sample sizes and based on one watershed in the Rocky Mountains. Consequently, the results should be interpreted with caution. Moreover, the study did not investigate other factors that could

affect Harlequin Duck habitat use (e.g. pH, temperature, river width, predators, etc.; e.g. Rodway 1998b). Such research is necessary before more definitive conclusions about Harlequin Duck-prey interactions can be made. However, these results are suggestive of a relatively strong link between Harlequin Ducks and stonefly nymphs, warranting further research in the Maligne and in other Harlequin Duck breeding sites where Harlequin Duck-prey relationships remain unknown. Such information may be critical to the conservation of local Harlequin Duck populations.

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References

- Bengtson, S-A. & Ulfstrand, S. 1971. Food resources and breeding frequency of the Harlequin Duck *Histrionicus histrionicus* in Iceland. *Oikos* 22: 235-239.
- Clifford, H.F. 1991. *Aquatic Invertebrates of Alberta*. University of Alberta Press, Edmonton, Alberta, Canada.
- COSEWIC 2001. *Species at Risk in Canada*. Committee on the Status of Endangered Wildlife in Canada. URL: http://www.cosewic.gc.ca/eng/sct5/index_e.htm (Last Updated: May 2001).
- Elliott, J.M. 1977. *Some Methods for the Statistical Analysis of Samples of Benthic Invertebrates*, 2nd edn., Scientific Publication No. 25. Freshwater Biological Association, Ambleside, England; 160 pp.
- Gardarsson, A. & Einarsson, A. 1994. Responses of breeding duck populations to changes in food supply. *Hydrobiologia* 279/280: 15-27.
- Hunt, W.A. 1998. *The Ecology of Harlequin Ducks *Histrionicus histrionicus* Breeding in Jasper National Park, Canada*. Unpublished MSc thesis, Simon Fraser University, Burnaby, BC, Canada.
- Hunt, W.A. & Ydenberg, R.C. 2000. Harlequins *Histrionicus histrionicus* in a Rocky Mountain watershed. 1: Background and general breeding ecology. *Wildfowl* 51: 155-168.
- McCutchen, N.A. 2001. *Temporal and Spatial Patterns of Stonefly (Plecoptera) Nymph Abundance Relative to Predation Risk in the Maligne River, Jasper National Park, Canada*. Unpublished MSc thesis, Simon Fraser University, Burnaby, BC, Canada.
- McCutchen, N.A. 2002. The response of stonefly (Plecoptera) nymphs to seasonal increases in predation risk. *Canadian Journal of Zoology* 80: 967-972.
- Rodway, M.S. 1998a. Activity patterns, diet, and feeding efficiency of Harlequin Ducks breeding in northern Labrador. *Canadian Journal of Zoology* 76: 902-909.
- Rodway, M.S. 1998b. Habitat use by Harlequin Ducks breeding in Hebron Fiord, Labrador. *Canadian Journal of Zoology* 76: 897-901.
- Soluk, D.A. 1993. Multiple predator effects: predicting combined functional response of stream fish and invertebrate predators. *Ecology* 74: 219-225.
- Soluk, D.A. & Richardson, J.S. 1997. The role of stoneflies in enhancing growth of trout: a test of the importance of predator-predator facilitation within a stream community. *Oikos* 80: 214-219.
- Sullivan, M.G. 1989. *Sport Fishery on the Maligne River during August 1989*. Fish and Wildlife Division, Alberta Forestry, Lands and Wildlife, Edmonton, Alberta, Canada; 30 pp.
- Wright, K.K., Bruner, H., Li, J.L., Jarvis, R. & Dowlan, S. 2000. The distribution, phenology, and prey of Harlequin Ducks, *Histrionicus histrionicus*, in a Cascade Mountain stream, Oregon. *Canadian Field Naturalist* 114: 187-195.