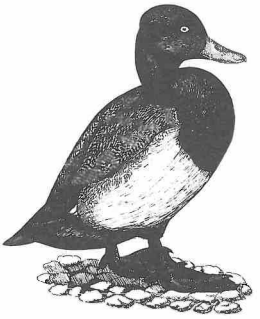
Stomach contents of diving and dabbling ducks during fall migration in the St. Lawrence River, Quebec, Canada



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Stomach contents of ten duck species feeding on benthos were analysed in the context of new prey species invading the St. Lawrence river, eastern Canada. One hundred and twenty-three stomachs (123) belonging to eight species of diving ducks and two species of dabbling ducks were analysed. The amount of food found in the stomachs was low and seems to be related to the fact that the great majority of ducks were collected while flying. A bias in food composition was associated with duck species characterized by residual contents in their gizzard, which were discarded from our analysis. In general, the diet of diving ducks was mainly animal while plant material dominated the diet of dabbling ducks. The most important group of animal prey was the gastropods, two species from which dominated the diet of diving ducks, namely Bythinya tentaculata and Viviparus sp. These two prey species are European in origin and were apparently introduced in the St. Lawrence several decades ago. This leads us to suggest that the recent introduction of the Zebra Mussel Dreissena polymorpha in the St. Lawrence could significantly alter the diet of diving ducks in the future. Incidently, one specimen of Surf Scoter Melanitta perspicillata had its gizzard filled with this species.

Keywords: Rivers, Migration, Feeding, Gastropods, Zebra Mussel

About 700,000 individuals, including 33 species, of geese and ducks, use the St. Lawrence system during the fall migration. Diving ducks make up about 48% of this number and represent 64% of the species that visit the St. Lawrence during the fall, while dabbling ducks make up 20% of the population and account for 27% of the species number (Lehoux *et al.* 1985). Most diving duck species are known to feed on animal matter, normally found at the bottom of shallow lakes or in intertidal and infralittoral areas of marine regions (Cottam 1939). In contrast, most dabbling ducks are often considered to be omnivorous because of the amount of plant and animal material in their diets (Bellrose 1976).

Although the abundance and diversity of ducks using the St. Lawrence during fall migration is extraordinary, there is no information concerning their food habits. The purpose of this article is to document the diets of ten species of ducks feeding mainly or occasionally on benthos, in relation to the proliferation of new prey species introduced into the St. Lawrence through human activity. Accordingly, we used specimens, collected as part of an extensive programme dealing with toxic residues in the flesh of game species, to identify the taxonomic nature and the relative importance of prey species consumed by ducks using the St. Lawrence river during fall.

Study area

The region under study extends from Lake St. Francois to Montmagny (**Figure 1**), a linear distance of about 500 km. This stretch of the St. Lawrence river is characterized by fairly level topography, as well as lacustrine and fluvial habitats associated mainly with fresh water or slightly brackish water, as in the Montmagny area (< 1% salinity; Vincent 1979).

Methods

The specimens used for our analysis were collected by hunters who had shot the ducks in flight. The contents of the oesophagus (including the proventriculus) and the gizzard were analysed separately for each specimen. Morphological criteria were used to differentiate pelecypods from gastropods, and morphological and colour criteria to distinguish the various families and genera of gastropods. In many cases, how-

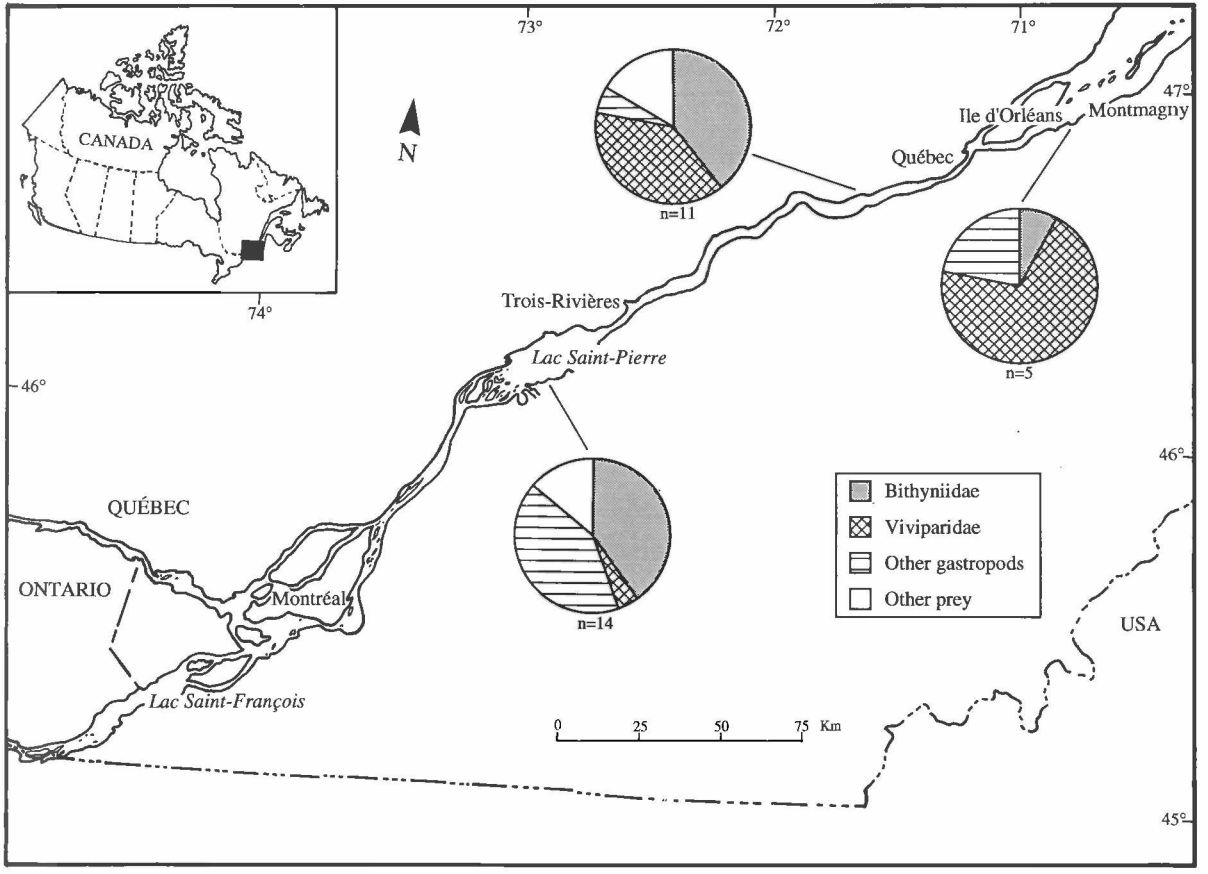

Figure 1. The Saint-Lawrence river and the diet of Lesser Scaups on their 3 main capture locations.

ever, it was difficult to identify the genera of the food items, particularly those that had been subject to grinding in the gizzard. The problem was partially overcome by grinding known prey items and comparing them with material found in the gizzard.

The relative importance of each type of food item found in either of the two organs was then determined by dividing the wet mass of the item by the wet mass of the total content. When the contents were finely triturated we measured the wet mass of the total contents of the organ. We then spread the contents on a tray and rated the importance of each item according to a scale of 1 to 10. This rating was then converted to a gravimetrical index by multiplying it with the total content.

Results

Quality of the samples

One hundred and twenty-three ducks were obtained from hunters operating in the fall on the St. Lawrence from Lake St. Francois to Montmagny. Of these, 12 contained no trace of food and were excluded from our analysis (**Table 1**). In all, 111 specimens were analysed, 66 of which were diving ducks and 45 dabbling ducks. There were eight species of diving ducks and only two species of dabbling ducks, namely American Black Duck *Anas rubripes* and Mallard *A. platyrhynchos* (**Table 1**).

The average quantity of food items in the stomachs was generally very low, ranging from 0.7 g for Black Scoter *Melanitta nigra* to 9.7 g for American Black Duck (**Table 1**). Few specimens had food items in the oesophagus, and we combined the results for both organs (oesophagus + gizzard = stomach). Generally speaking, the dabbling ducks had consumed more plant material than had the diving ducks (**Table 2**). Our analyses did show, however, that the diets of several species of the diving ducks, such as the scoters *Melanitta* spp. and Bufflehead *Bucephala albeola*, were characterized by high proportions of plant material. This latter observation appears to be linked to the low stomach contents of these species. In fact, there is a high inverse correlation (r_p= -0.929, n = 5, $P<0.05$) between the relative mass of plant material and the

Table 1. Characteristics of stomach contents of ducks collected on the St. Lawrence river during the fall of 1991.

Species	Number of individuals			Mean (± SD)
	collected	having at least one prey in the oesophagus[a]	having at least one prey in the oesophagus or the gizzard	fresh mass of prey found in both organs
Lesser Scaup (*Aythya affinis*)	30	5	30	7,3 ± 4,6
Greater Scaup (*Aythya marila*)	5	3	5	7,3 ± 5,8
Ring-necked Duck (*Aythya collaris*)	7	-	6	4,9 ± 3,6
Surf Scoter (*Melanitta perspicillata*)	7	1	6	4,0 ± 3,6
Black Scoter (*Melanitta nigra*)	7	-	5	0,7 ± 0,6
White-winged Scoter (*Melanitta fusca*)	7	-	3	1,5 ± 1,4
Bufflehead (*Bucephala albeola*)	10	-	7	1,3 ± 1,0
Common Goldeneye (*Bucephala clangula*)	4	-	4	7,4 ± 4,6
American Black Duck (*Anas rubripes*)	23	9	23	9,7 ± 10,5
Mallard (Anas platyrhynchos)	23	3	22	8,8 ± 9,0

[a] Including the proventriculus.

Table 2. Frequency and proportion (wet mass) of the principal dietary components found in stomach (gizzards and oesophagus) of ducks collected on the St. Lawrence river during the fall of 1991. Number of individuals analysed is shown in parenthesis under each duck species.

	Aythya *affinis* (n = 30)	Aythya *marila* (n = 5)	Aythya *collaris* (n = 6)	Melanitta *perspicillata* (n = 6)	Melanitta *nigra* (n = 5)	Melanitta *fusca* (n = 3)	Bucephala *albeola* (n = 7)	Bucephala *clangula* (n = 4)	Anas *rubripes* (n = 23)	Anas *platrhynchos* (n = 22)
Animal matter	**30 (0,928)**	**5 (0,865)**	**4 (0,309)**	**2 (0,396)**	**1 (0,153)**	-	**3 (0,301)**	**3 (0,964)**	**8 (0,058)**	**5 (0,011)**
Pelecypoda	3		2	2	1					
**Unionacea*			1 (0,179)	1 (0,115)						
Dreissenidae				1 (0,274)						
Sphaeriidae	3 (0,010)			1 (0,004)	1 (0,153)					
Undetermined	1 (0,005)		1 (0,003)							
Gasteropoda	29	5	3	1			2	2	8	2
Hydrobiidae	1 (0,002)								2 (0,012)	
Viviparidae	16 (0,345)	4 (0,552)								
Valvatidae	3 (0,002)									
Planorbidae	1(<0,000)		1 (0,034)						1 (0,003)	
Bithyniidae	19 (0,346)	2 (0,050)	2 (0,061)				1 (0,272)	2 (0,117)	3 (0,004)	
Pleuroceridae	5 (0,033)	2 (0,183)	2 (0,032)	1 (0,003)				1 (0,018)	1 (0,002)	
Lymnaeidae	3 (0,036)									
Physidae							2 (0,023)			
Undetermined	9 (0,149)	2 (0,0880)							4 (0,020)	2 (0,001)
Crustacea									1 (0,015)	3 (0,007)
Insecta							2 (0,006)	3 (0,829)	2 (0,002)	2 (0,003)
Plant matter	**4 (0,073)**	-	**3 (0,397)**	**6 (0,603)**	**4 (0,847)**	**3 (1,000)**	**5 (0,699)**	**2 (0,036)**	**22 (0,941)**	**22 (0,980)**
Gramineae	2 (0,071)								5 (0,350)	1 (0,240)
Cyperaceae	1 (0,002)		1 (0,003)					1 (0,004)	11 (0,101)	13 (0,222)
Polygonaceae									1 (0,002)	7 (0,053)
Algae						1 (0,620)				
Undetermined	1(<0,000)		2 (0,394)	6 (0,603)	4 (0,847)	2 (0,380)	5 (0,699)	1 (0,032)	13 (0,488)	17 (0,453)
Undetermined organic matter		2 (0,135)	2 (0,295)							1 (0,009)

* Superfamily

average quantity of the stomach contents of a duck species known to feed mainly on animals (**Figure 2**). This relationship suggests that plant material may be ingested involuntarily by diving ducks and be found in a residual state in gizzards that are almost empty. For this reason, the following analysis will bear mainly on the scaups, Common Goldeneye *B. clangula* and the dabbling ducks.

Diet of diving ducks

Animal material dominated the diet of the diving ducks, comprising 100, 93, 44 and 96 % (excluding non-identified organic material) of the food items found in the stomachs of the Greater Scaup *Aythya marila*, Lesser Scaup *A. affinis*, Ring-necked Ducks *A. collaris* and Common Goldeneyes, respectively. Gastropods were found to be the most important food item for diving ducks (**Table 2**), occurring very frequently in the Greater and Lesser Scaup and to a lesser degree in the Ring-necked Ducks and Common Goldeneyes. The prey species most commonly found were *Bithynia tentaculata* and *Viviparus spp.*, two gastropods belonging to the Bithynidae and Viviparidae families, respectively (**Table 2**). Note that *Bithynia* was commonly in six species of ducks, five of which were diving ducks, while *Viviparus* was found solely in the Greater and Lesser Scaup. Finally, the proportion of the other species of gastropods (Valvatidae, Planorbidae, Pleuroceridae, Lymnaeidae Physidae) was lower in the diets of ducks frequenting the St. Lawrence river (**Table 2**).

Pelecypods were next in frequency of occurrence in the diving ducks (**Table 2**). Pelecypods of the genus *Sphaerium* were found in three species (Greater Scaup, Surf Scoter and Black Scoter), while one bivalve of the Unionidae superfamily was found in two species (Ring-necked Duck and Surf Scoter). The Zebra Mussel *Dreissena polymorpha* was also found in the stomach of one Surf Scoter. Finally, insects of the order trichoptera were also found to be part of the diet of diving ducks, particularly in the case of the Common Goldeneye (**Table 2**).

Diet of dabbling ducks

The diet of dabbling ducks was predominantly plant food, which comprised over 94% of the wet mass. Cyperaceae seeds were the most frequently found food of the American Black Duck and the Mallard but formed a low mean proportion of the wet mass (**Table 2**). Frequency of occurence of the seeds of these aquatic plants was identical for both these species of dabbling ducks (≠50%). Although Gramineae were found less often in both species, this type of plant formed a high proportion of the wet mass. For example, it comprised 24% of the wet mass for the Mallard even though only one specimen had fed on it. On the other hand, five Black Ducks had fed on Gramineae, making it proportionately the most important food item for this species. Polygonaceae seeds were second in frequency of occurrence in the diet of the Mallard, but were almost absent from the diet of the Black Ducks (**Table 2**). Insects belonging to the orders coleoptera and diptera were consumed by the Mallard much less frequently than was plant material. The situation was identical for crustaceans of the genus Gammarus, although this type of food was found in the stomachs of three Mallard and one Black Duck. Gastropods (mainly Bithyniidae and Hydrobiidae) comprised the remainder of the animal matter consumed by the dabbling ducks.

Discussion

Quality of the samples

Most of the ducks taken from the St. Lawrence river had a low quantity of food in their digestive systems (**Table 1**). Moreover, in many cases, only the gizzard contained food, which made identification difficult, given the extent of grinding. This phenomenon is particularly true of ducks shot during flight, as was the case in this study. In a study on the Common Eider *Somateria mollissima*, Guillemette (1994) found that only 2.2% of the 92 individuals taken in flight had food in the oesophagus. Moreover, 36% of these had less than 5 g of food in the gizzard, or in other words, four times less than what would be normally found in a well-filled gizzard. These results clearly show that ducks taken in flight are not ideal samples for diet analysis.

Swanson & Bartonek (1970) also observed that the stomach contents of ducks

taken by hunters left much to be desired as to the informative value of the results. These authors, however, attributed the potential bias that such specimens represent to differential digestion; the difference in the proportion of food found in the gizzard and oesophagus could be due to more rapid digestion of certain parts of the prey over others (Swanson & Bartonek 1970). Although this bias might be considerable for certain species, it is plausible that it is minimal in the case of diving ducks, because of the rough exoskeletons of most benthic prey. It nonetheless remains that the low quantity of material found in the stomachs of diving ducks taken from the St. Lawrence river could present a distorted picture of reality. The inverse correlation between the proportion of plant food and the average volume of material in the stomachs analysed supports this assertion (**Figure 2**). This is because it is highly unlikely that plant material would constitute a major food item in the diet of scoters (*Melanitta spp.*), as most studies indicate that molluscs constitute a major proportion of their diet (McGilvrey 1967, Stott & Olsen 1973, Vermeer & Levings 1977, Vermeer 1981). The same argument applies to the Bufflehead, which feeds mainly on crustaceans in marine habitats (Stott & Olsen 1973, Vermeer 1982) and on insects in freshwater habitats (Erskine 1972). We therefore suggest that the relatively high proportion of plant material in these diving ducks is due to involuntary ingestion and to their poorly adapted digestive system for this type of food.

Comparison with other studies

The quantity of material found in the stomachs of scaups, Common Goldeneyes and dabbling ducks taken from the St. Lawrence river (**Table 1**) was nonetheless sufficient for us to make a realistic assesment of their food habits. Animal food dominates the diet of Lesser Scaup feeding in the St. Lawrence. This result is similar to those of Rogers & Korschgen (1966) and Afton et al. (1991) for the Mississipi river which indicated that animal material constituted more than 90% of the contents found in Lesser Scaups in the fall. The relative importance of animal material in Greater Scaup migrating along the St. Lawrence is also quite high (86%) but contrasts sharply with the study of Jones & Drobney (1986) in Michigan where animal material constituted only 28% of the Greater Scaup diet during the winter sea-

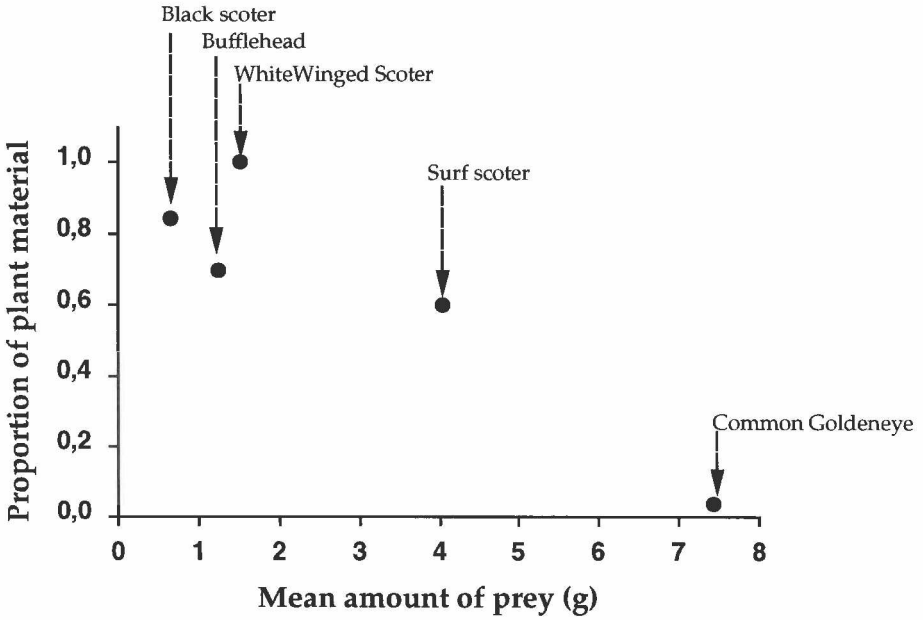

Figure 2. Relationship between the mean amount of prey and the mean proportion of plant material found in the stomach of a duck species known to be mainly animal feeder (rp=-0.929, p<0.05, n=5).

son. Jones & Drobney (1986) suspected, however, that Greater Scaup had ingested plant material involuntarily. In addition, their study was conducted during winter and it is possible that diet varies with season, as indicated by Rogers & Korschgen (1966) and Afton et al. (1991). Finally, the Ring-necked Duck appears to be more herbivorous than scaups since the relative importance of plant material (40%) is slightly higher than animal material in this species (**Table 2**). The dominance of plant material in the Ring-necked Duck has been reported in other studies (Cottam 1939, Hoppe et al. 1986) and our finding lend further support to what seems to be a common habit in this species.

Gastropods dominated the diet of Greater and Lesser Scaup in the St. Lawrence, comprising at least 87% of the wet mass of the ingested foods. The situation is similar to the fluvial habitat of the Mississippi river (70%, Rogers & Korschgen 1966) but is much different than lacustrine habitats, where this species feeds mainly on crustaceans (60.1%, Rogers & Korschgen 1966, 77.4%, Afton *et al.* 1991).

Animal material was clearly preponderant in the diet of Common Goldeneye (96%), although only four specimens were analysed (**Table 2**). Insects were the dominant food of this species, a finding that concurs with those of Olney & Mills (1963) in Great Britain, namely 54% in Ireland, 98% in Scotland and 58% in England. It is interesting to note that dabbling ducks consumed gastropods in a few instances, which allows us to assume that these species may on occasion dive when feeding, as noted by Bourget & Chapdelaine (1976). It is, however, possible that these gastropods were taken in shallow waters or ingested involuntarily, given that gastropods attach themselves to vegetation during the egg-laying stage of their reproduction phase (Bruno Vincent, pers. comm.). The diet of dabbling ducks is nonetheless composed mainly of plant material, mostly Gramineae and Cyperaceae. These results do not in any way belie the predilection of both species for plant material (Bellrose 1976). This author does however mention that the Black Duck consumes animal material more readily than the Mallard. The results of our study do not support these observations as plant material was found in equal amounts in both species.

Impact of introduced prey species on the diet of diving ducks

Gastropods of the genera Bithynia and Viviparus are species of European origin that were apparently introduced to the St. Lawrence 100 years ago in the former case and 40 years ago in the latter (Vincent 1979). These two gastropods are among the dominant organisms of the benthic community of the St. Lawrence (Vincent 1979) and, according to our study, the most frequently consumed food items of diving ducks (**Table 2**). These observations indicate that diving ducks in the St. Lawrence can benefit from the presence of introduced benthic species. According to Vincent (1979), Bithynia are found in shallow depths near the shore and can dominate shallow bays where there is little or no current. Viviparus is found in deeper waters where the current is stronger. This suggests that scaups can use either type of habitat indiscriminately and that the great importance of these prey in their diet is due to their high density in the habitat. Vincent (1979) observed moreover that Bithynia, the dominant species in Lake St. Pierre and in the fluvial section (between Trois Rivières and Québec City), was being gradually replaced by Viviparus in the Québec City region and around Ile d'Orléans. Interestingly, we also observed that Bithynia, a favourite food item of the Lesser Scaup, has been replaced by Viviparus in the Ile d'Orléans area (**Figure 1**).

The most recent example of an introduced benthic species in the St. Lawrence is the Zebra Mussel. The Zebra Mussel was first reported in our study area in 1989 (Doyon *et al.* 1992), and we recorded one specimen of Surf Scoter with its gizzard filled with this species (7 g, or 95% of the wet mass). This suggests that in 1991 Zebra Mussel density was already high enough for a bird to feed mainly on this species. Diving ducks have proven to be the main predators of the Zebra Mussel in Europe (Suter 1982, Bij de Vaate 1991), where this bivalve species was introduced many years ago. This suggest that the Zebra Mussel

could become a major food source for diving ducks, given its increasing proliferation in the St. Lawrence river. In several areas, diving ducks have benefited from this new food source, as indicated both by population increases and changes in distribution (Géroudet 1966, Leuzinger & Shuster 1970). Since some species seem to benefit more than others from that new food source (Géroudet 1966), this could change, ultimately, the relative importance of duck species using the St. Lawrence.

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References

Afton, A., Hier, R.H. & Paulus, S.L. 1991. Lesser scaup diets during migration and winter in the Mississipi flyway. *Can. J. Zool.* 69: 328-333.

Bellrose, F.C. 1976. *Ducks, geese and swans of North America.* Stackpole Books, Harrisburg Pa., USA, 540 pp.

Bij de Vaate, A. 1991. Distribution and aspects of population dynamics of the zebra mussel, *Dreissena polymorpha* (Pallas, 1771), in the Lake Ijsselmeer area (The Netherlands). *Oecologia* 86: 40-50.

Bourget A. & Chapdelaine G. 1976. Diving by wintering puddle ducks. *Wildfowl* 26: 55-57.

Cottam, C. 1939. Food habits of North American diving ducks. *Tech. Bull. No 643 U.S. Department of Agriculture*, Washington D.C., USA, 139 pp.

Doyon, N., Cusson, B., Fontaine, J., Ménard, C. & Lapierre, L. 1992. *Revue documentaire sur la biologie et l'écologie de la moule zébrée.* Rapport non-publié, Centre Saint-Laurent, Environnement Canada, Montréal, Canada, 58 pp.

Erskine, A.J. 1972. Buffleheads. *Can. Wildl. Serv. Monograph Series* no 4, Ottawa, Canada.

Géroudet, P. 1966. Premières conséquences ornithologiques de l'introduction de la moule zébrée *Dreissena polymorpha* dans le lac Léman. *Nos Oiseaux* 28: 301-307.

Guillemette, M. 1994. Digestive rate constraint in wintering Common Eiders *Somateria mollissima*: implications for their flying capabilities. Auk 111:897-906.

Hoppe R.T., Smith L.M. & Wester D.B. 1986. Food of wintering diving ducks in South Carolina. *J. of Field Ornithology* 57: 126-134.

Jones, J.J. & Drobney, R.D. 1986. Winter feeding ecology of Scaup and Common Goldeneye in Michigan. *J. Wildl. Manage.* 50: 446-452.

Lehoux, D., Bourget, A., Dupuis, P. & Rosa, J. 1985. *La sauvagine dans le système du Saint-Laurent.* Unpublished Report, Service Canadien de la Faune, Environnement Canada, 76 pp + Annexes.

Leuzinger, H. & Schuster, S. 1970. Auswirkungen der Massenvermehrung der Wandermuschel Dreissena polymorpha auf die Wasservögel des Bodensees. *Der Ornithologische Beobachter* 67: 269-274.

McGilvrey, F.B. 1967. Food habits of sea ducks from the north-eastern United States. *Wildfowl Trust. Ann. Rep.* 18: 142-145.

Olney, P.J.S. & Mills, D.H. 1963. The food and feeding habits of Goldeneye *Bucephala clangula* in Great Britain. *Ibis*: 105:293-300.

Rogers, J.P. & Korschgen, L.J. 1966. Foods of Lesser Scaups on breeding, migration and wintering areas. *J. of Wildl. Manage. 30*: 258-264.

Stott, R.S. & Olson, D.P. 1973. Food-habitat relationship of sea ducks on the New Hampshire Coastline. *Ecology 54*; 996-1007.

Suter, V.W. 1982. Der einfluss von wasservögeln auf population der wandermuschel (Dreissena polymorpha Pall.) am Untersee/ Hochrhein (Bodensee). *Schweiz. Z. Hydrol. 44*: 149-161.

Swanson, G.A. & Bartonek, J.C. 1970. Bias associated with food analysis in gizzards of Blue-winged Teal. J. of Wildl. Manage. 34:739-746.

Vermeer, K. & Levings, C.D. 1977. Populations, biomass and food habits of ducks on the Fraser Delta intertidal area, British Columbia. *Wildfowl 28*: 49-60.

Vermeer, K. 1981. Food and populations of Surf Scoters in British Columbia. *Wildfowl* 32: 107-116.

Vermeer, K. 1982. Food and distribution of three *Bucephala* species in British Columbia waters. *Wildfowl 33*: 22-30.

Vincent, B. 1979. Étude du benthos d'eau douce dans le haut estuaire du Saint-Laurent (Québec). *Can. J. Zool. 57*: 2171-2182.

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