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DISTRIBUTION AND HABITAT USE OF THE BOREAL CHORUS FROG (*PSEUDACRIS MACULATA*) AT ITS EXTREME NORTHEASTERN RANGE LIMIT

MARTIN OUELLET[1,2], CHRISTIAN FORTIN[3], AND MARIE-JOSÉE GRIMARD[4]

[1]*Amphibia-Nature, 469 route d'Irlande, Percé, Québec G0C 2L0, Canada*
[2]*Corresponding author, e-mail: mouellet@amphibia-nature.org*
[3]*FORAMEC, 70 rue Saint-Paul, Québec, Québec G1K 3V9, Canada*
[4]*Hydro-Québec, 855 rue Sainte-Catherine Est, Montréal, Québec H2L 4P5, Canada*

***Abstract.*—The Boreal Chorus Frog (*Pseudacris maculata*) reaches its northeastern range limit in west-central Québec, Canada. We surveyed 84 stations in 2002-2003 to assess the current distribution and habitat use of the species in the James Bay area of Québec during breeding season. We heard the species calling between 25 May and 11 June at 10 stations located in four coastal bays: Chiyask, Cabbage Willows, Rupert, and Boatswain. *Pseudacris maculata* was associated with shallow pools less than 35 cm deep in upper marshes and thicket swamps. These habitat types were vegetated by sedges, grasses, and willows. Water pH of breeding pools ranged from 7.3 to 7.8 and salinity from 0.1 to 2.0 g/L. These pools were fishless, but were by other early-breeding anuran species. The predominance of sites with open canopy suggests that *P. maculata* is an open habitat generalist, at least during breeding season in west-central Québec. Data provided here help to define the life-history parameters of this species, but further research is needed to better address the status and dynamics of these northern populations.**

Key Words.—Boreal Chorus Frog; distribution; habitat use; James Bay; *Pseudacris maculata*; Québec; range limit

INTRODUCTION

The Boreal Chorus Frog (*Pseudacris maculata*, Fig. 1) occurs widely in north-central North America. In Canada, its distribution was previously thought to extend from northeastern British Columbia to northwestern Ontario (Smith 1956; Weller and Green 1997). The northern range limit reaches the southern portion of the Mackenzie River basin and Great Slave Lake in the Northwest Territories (Harper 1931; Fournier 1997), and the lower La Biche River valley in southeastern Yukon (Government of Yukon 2005; Slough and Mennell 2006). The range extends southeastward from near Churchill, Manitoba (Smith 1953; Harper 1963) along the coast of Hudson Bay and James Bay to the Moosonee area in northern Ontario (Schueler 1973). The species also occurs on Akimiski Island (Nunavut) in James Bay (Logier and Toner 1961). Schueler (1973) concluded that the Moose River watershed is a barrier to dispersal of the species farther east in the James Bay lowlands. Further to the south, recent phylogenetic analyses indicate that range boundaries for several taxa of trilling chorus frogs (*Pseudacris*), including *P. maculata* and the Western Chorus Frog (*P. triseriata*) require revision (Lemmon et al. 2007a, b).

In Québec, Bider and Matte (1994) anecdotally reported Boreal Chorus Frogs in 1991 from the Baie Cabbage Willows in James Bay. They also mentioned that *P. maculata* tadpoles had been collected from an area north of Chibougamau in 1974. The latter account, however, proved to be a misidentification (Desroches 2003). In 2002, we captured the Boreal Chorus Frog in Baie Cabbage Willows, extending its known range eastward by more than 100 km (Fortin et al. 2003). The previous report represented the first documented occurrence of the species in northern Québec.

In Canada, *P. maculata* inhabits a variety of usually open, moist, and grassy habitats. It occurs in prairies, aspen parklands, boreal forest regions, and forest-tundra transition zones. It is found in shallow pool waters in

FIGURE 1. Two adult Boreal Chorus Frogs (*Pseudacris maculata*) found in amplexus in Baie Boatswain, Québec (station W21) (Photographed by Martin Ouellet).

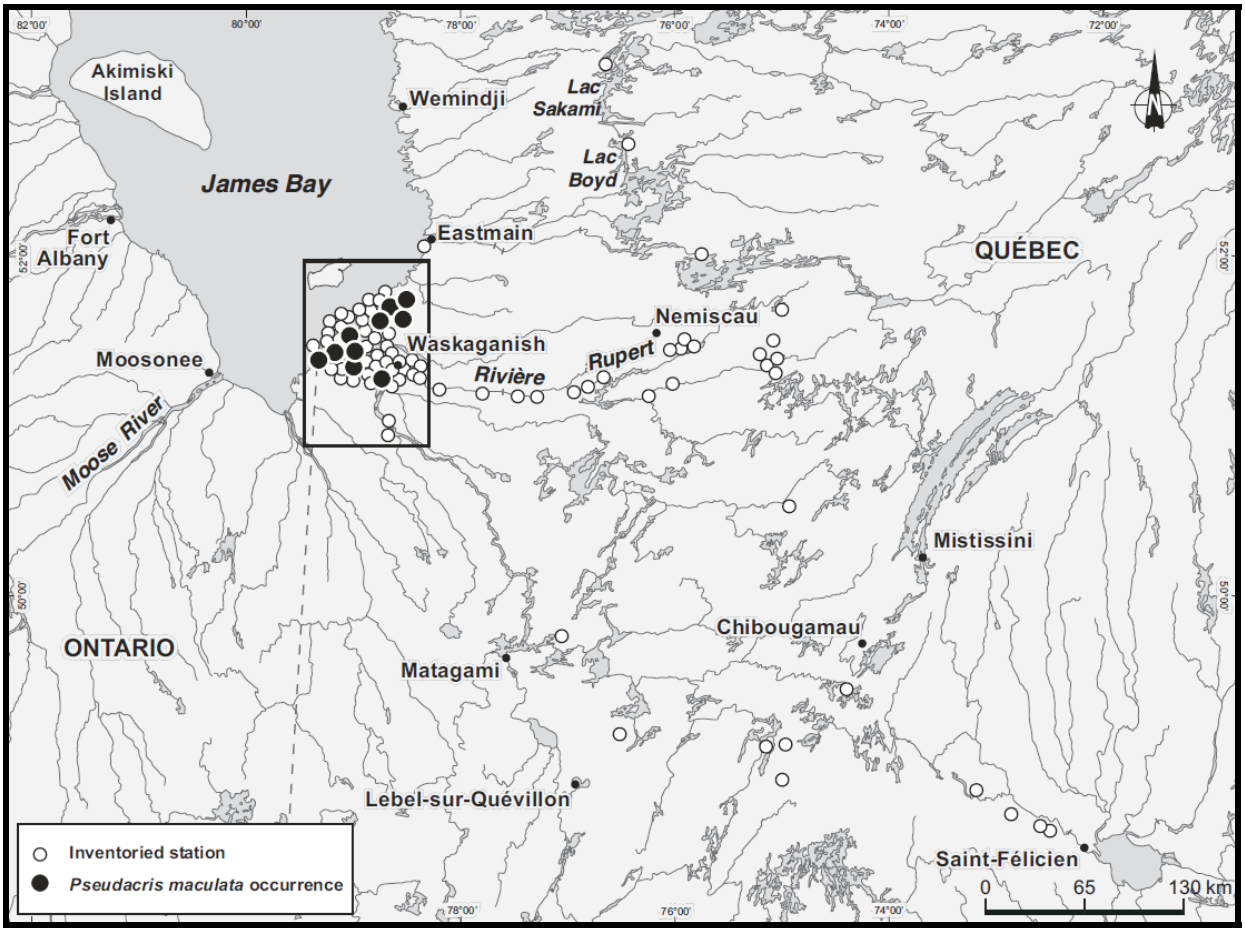

FIGURE 2. Map of west-central Québec showing 84 stations inventoried for the presence of *Pseudacris maculata* during 2002-2003. Toponymy is according to the Commission de toponymie du Québec.

the borders of puddles, ditches, borrow pits, ponds, lakes, deltas, and rivers (e.g., Cook 1964; Schueler 1973; Roberts and Lewin 1979). The species is freeze-tolerant and hibernates in a terrestrial setting (MacArthur and Dandy 1982). This natural tolerance to freezing is an adaptation for winter survival and persists after spring emergence (Storey and Storey 1987). It enables the species to cope with high latitudes and to survive extremely variable and occasionally sub-zero temperatures during its breeding season. Detailed information on the distribution, life history, and habitat preferences of *P. maculata* in the northern portion of its range is meager. We report the current distribution of *P. maculata* at the extreme northeastern limit of their range in Québec, including habitat characteristics of breeding sites and information on the life history of this species.

MATERIALS AND METHODS

Study area.—We conducted our study in west-central Québec, between latitudes 48°00′ and 54°00′ N, and longitudes 72°00′ and 80°00′ W (Fig. 2). Underlying bedrock of most of the area is part of the Canadian Shield. Landscape topography is a rolling plateau with an altitude of about 400 m, gently decreasing from east and south toward the shore of James Bay. The entire area was heavily glaciated until 8000 years before present (Dyke and Prest 1987). The study area is subject to a boreal climate with long, cold winters and short, cool summers. Mean annual temperatures range from –3 to 0°C, and mean July temperatures range from 12 to 18°C (Hydro-Québec 2004). Precipitation averages over 700 mm annually, with 35 % falling as snow. The growing season is about 90 days. Vegetation is characteristic of the boreal forest. Peatlands are widespread on clay sediments at low altitudes. Extensive coastal marshes and willow thickets occur along the James Bay shores.

Field protocol.—We surveyed 35 stations from 8–14 June 2002 and 49 stations from 23 May to 3 June 2003. We selected stations stratified by habitat at random to

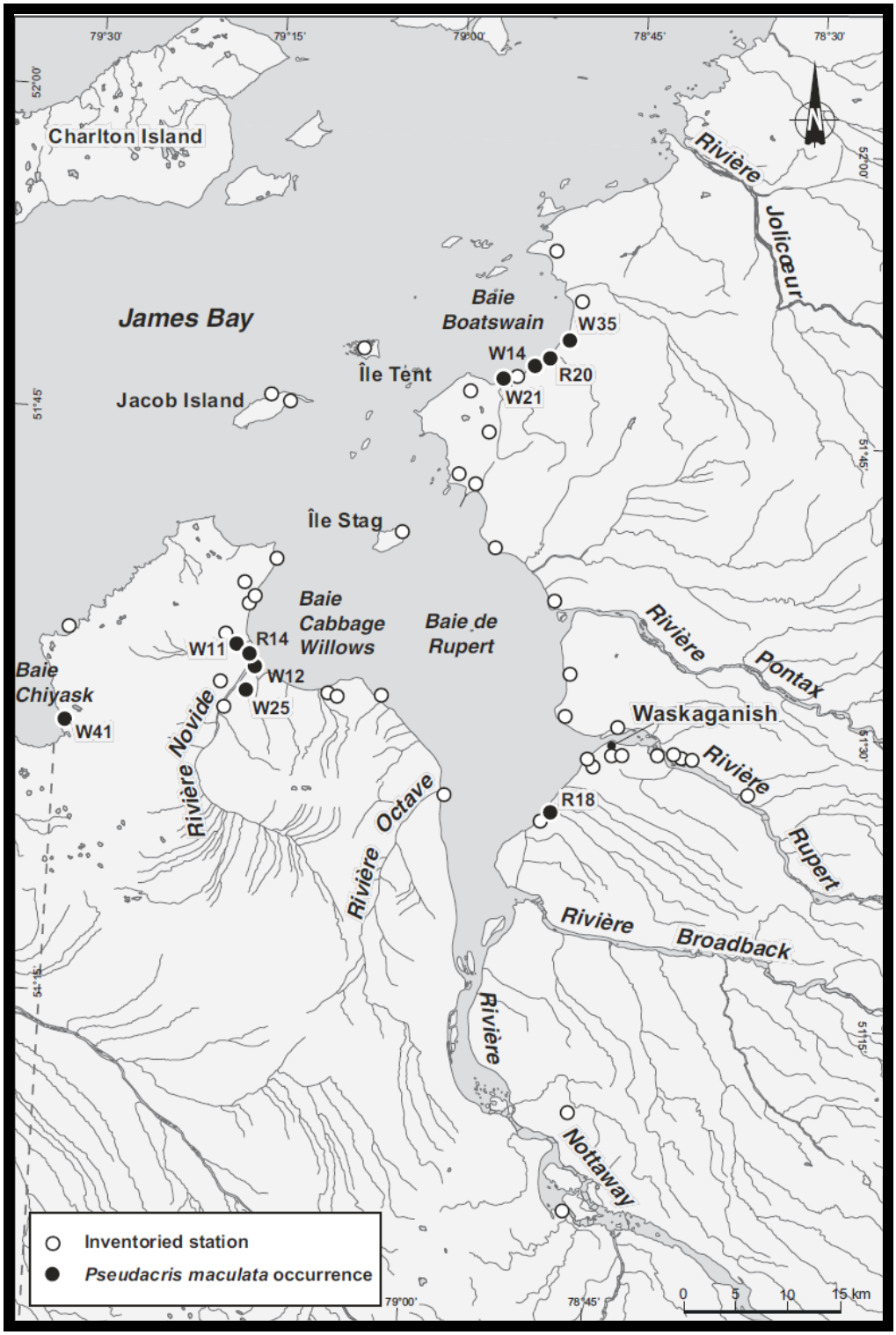

FIGURE 3. Detailed geographic distribution of 10 *Pseudacris maculata* occurrence stations in the James Bay area of Québec. The two stations on Jacob Island legally belong to Nunavut. Toponymy is according to the Commission de toponymie du Québec.

cover the study area and to define the Québec distribution of *P. maculata* in this part of James Bay (Appendix). We visited each station at least once, but sometimes up to six times, within daylight hours. Stations were reached by helicopter, or by car for 11 stations located in the Chibougamau area. We (three

TABLE 1. Description of 10 *Pseudacris maculata* occurrence stations in the James Bay area of Québec during 2002-2003. Abbreviations are *Anaxyrus americanus*, ANAM; *Lithobates sylvaticus*, LISY; *Pseudacris crucifer*, PSCR.

Station	Date	Coordinates (NAD83)	Temperature (°C)		Depth (cm)	pH	Salinity (g/L)	*P. maculata* abundance	Interspecific association
			Air	Water					
R14	10 June 2002	51°32′26.6″ N 79°16′05.9″ W	7	14	-	-	-	< 10 males calling	ANAM
R18	10 June 2002	51°24′52.7″ N 78°50′44.7″ W	8	12	-	-	-	2 males calling	ANAM, PSCR
R20	11 June 2002	51°48′10.8″ N 78°53′19.5″ W	9	17	-	-	-	Full breeding chorus	ANAM, LISY
W11	25 May 2003	51°32′36.4″ N 79°16′22.4″ W	16	16	< 35	7.6	1.1	3 males calling	LISY
W12	25 May 2003	51°32′24.1″ N 79°15′54.8″ W	19	17	< 32	7.6	1.4	1 male calling	ANAM, LISY
W14	25 May 2003	51°48′09.3″ N 78°53′20.9″ W	12	18	< 33	7.5	0.1	Full breeding chorus	ANAM, LISY, PSCR
W21	26 May 2003	51°47′26.5″ N 78°55′52.7″ W	13	17	< 33	7.8	0.1	> 10 males calling + 1 amplexing pair	ANAM, LISY
W25	26 May 2003	51°30′42.6″ N 79°15′41.6″ W	14	19	< 30	7.3	2.0	Full breeding chorus	ANAM, LISY
W35	28 May 2003	51°49′34.5″ N 78°50′33.2″ W	9	19	< 35	7.8	0.5	Full breeding chorus	ANAM, LISY, PSCR
W41	2 June 2003	51°28′39.4″ N 79°30′26.4″ W	5	18	< 18	7.5	0.7	5 males calling	ANAM, LISY

persons) performed anuran call counts and visual and pool margin surveys with dip nets. We recorded numbers and life stages of each amphibian and reptile species that we encountered. We obtained three measurements of the snout-vent and right tibiafibula lengths with an electronic caliper and then averaged these for each of five live-captured *P. maculata*. Overall, we spent between 30 and 270 minutes at each of the 84 stations.

In 2003, we determined water depth, pH, and salinity in seven *P. maculata* occurrence stations. For each station, we ascertained the maximal depth from 25 measurements taken in five different pools. We measured pH in breeding pools using a portable waterproof pH meter (pHTestr 2, Oakton Instruments, Vernon Hills, Illinois, USA) and salinity at 5-cm depth with a waterproof salinometer (SaltTestr, Oakton Instruments, Vernon Hills, Illinois, USA).

Vegetation analysis.—We described the vegetation at each *P. maculata* occurrence station based on field observations and interpretation of aerial photographs. We identified six major vegetation types: fen, bog, lower marsh, upper marsh, thicket swamp, and forest. Data were computed using MapInfo Professional version 7.5 (MapInfo, Troy, New York, USA).

RESULTS

Distribution.—*Pseudacris maculata* called at 10 of the 84 stations during 2002–2003 (Fig. 2). All occurrence stations (where the species was heard) were located on the coast of James Bay (Fig. 3, Table 1). From west to east, *P. maculata* occupied the coastal habitat along four different bays: Chiyask, Cabbage Willows, Rupert, and Boatswain, but the species did not call on three nearby islands (< 25 km from the nearest occupied coast). We did not hear any individuals along the Rivière Rupert, nor further east in the Chibougamau area. We recorded one or more other amphibian or reptile species at most of the 84 stations, including the American Toad (*Anaxyrus americanus*), Common Gartersnake (*Thamnophis sirtalis*), Mink Frog (*Lithobates septentrionalis*), Spotted Salamander (*Ambystoma maculatum*), Spring Peeper (*Pseudacris crucifer*), and Wood Frog (*Lithobates sylvaticus*). On islands, we observed *L. sylvaticus* on Île Stag (51°39′23.0″ N, 79°03′23.5″ W), and *L. septentrionalis* and *T. sirtalis* on Jacob Island (51°46′05.6″ N, 79°14′50.5″ W).

Habitat use and natural history.—Among the six major vegetation types identified in this study, we encountered *P. maculata* in one fen, four thicket swamps, and five upper marshes (Table 2). Vegetation at the occurrence stations included Baltic Rush (*Juncus balticus* var. *balticus*), Bebb Willow (*Salix bebbiana*), Buckbean (*Menyanthes trifoliata*), Chaffy Sedge (*Carex paleacea*), Mud Sedge (*Carex limosa*), Purple Marshlocks (*Comarum palustre*), Red Fescue (*Festuca rubra*), Sageleaf Willow (*Salix candida*), Silverweed Cinquefoil (*Argentina anserina*), Slimstem Reedgrass (*Calamagrostis stricta*), and/or Sweetgrass (*Hierochloe odorata*).

We heard full breeding choruses of *P. maculata* during the day between 25 May and 11 June 2002–2003

TABLE 2. Major vegetation types and most common vascular plants at 10 *Pseudacris maculata* occurrence stations in the James Bay area of Québec during 2002-2003.

Station	Vegetation type	Vascular plants
R14	Upper marsh	*Festuca rubra, Hierochloe odorata, Calamagrostis stricta*
R18	Fen	*Menyanthes trifoliata, Carex limosa*
R20	Thicket swamp	*Salix candida, Calamagrostis stricta, Carex limosa, Comarum palustre*
W11	Upper marsh	*Festuca rubra, Hierochloe odorata, Calamagrostis stricta*
W12	Upper marsh	*Festuca rubra, Hierochloe odorata*
W14	Thicket swamp	*Salix candida, Calamagrostis stricta, Carex limosa, Comarum palustre*
W21	Thicket swamp	*Salix candida, Calamagrostis stricta, Carex limosa, Comarum palustre*
W25	Upper marsh	*Festuca rubra, Hierochloe odorata, Calamagrostis stricta*
W35	Upper marsh	*Calamagrostis stricta, Festuca rubra, Carex paleacea, Argentina anserina*
W41	Thicket swamp	*Salix bebbiana, Calamagrostis stricta, Juncus balticus* var. *balticus, Hierochloe odorata*

(ambient temperature > 5°C). Water temperatures varied from 12 to 19°C. Water pH ranged from 7.3 to 7.8 and salinity from 0.1 to 2.0 g/L at these stations. For comparison, the salinity was 0 g/L (no tidal influence) at all inland stations, but sometimes > 10.0 g/L (brackish and salt water) in lower marshes. Typically, we found *P. maculata* associated with shallow breeding pools less than 35 cm deep (mean = 15.1, SD = 5.3, $N = 175$) in upper marshes and thicket swamps (Fig. 4). Twice in 2003, we revisited a fen where two *P. maculata* had been heard calling on two consecutive days in 2002 (station R18), with no further evidence of breeding activity.

Together, *P. maculata* and *A. americanus*, *L. sylvaticus*, and/or *P. crucifer* breed in fish-free habitats. We captured five adult *P. maculata* during the day (Table 3) and observed one amplexing pair. Mean snout-vent and right tibiafibula lengths for these adults were 32.1 mm ± 3.4 (SD) and 11.7 mm ± 0.9, respectively. When positioned for photographic documentation, a female released 384 eggs, suggesting that resident gravid females at these sites were primed for egg deposition. However, we did not find egg masses or tadpoles in the field. We deposited the five specimens at the New Brunswick Museum (specimen numbers: NBM-008796–008799, and 008851).

FIGURE 4. Representative thicket swamp breeding habitat of *Pseudacris maculata* in Baie Boatswain, Québec (station R20) (Photographed by Martin Ouellet).

DISCUSSION

Distribution.—Our observations demonstrate that *P. maculata* occupies the east coast of James Bay in Québec. Contrary to the hypothesis advanced by Schueler (1973), the Moose River drainage in Ontario is not a barrier to easterly colonization for this anuran. We suggest that populations of *P. maculata* might be found at higher latitudes, north of Baie Boatswain where upper marshes, thicket swamps, or equivalent habitats are present along the coast. There is no evidence, however, of its occurrence far inland in the boreal forest of Québec (this study; Desroches et al. unpubl. data).

The littoral region in the lower portions of eastern James Bay is particularly dynamic due to ice action (Dionne 1976) and isostatic uplift of the area, the latter favoring the development of tidal flats extending offshore (Champagne 1982). Except for habitat constraints, there are no obvious barriers to migration, and *P. maculata* is biologically well adapted to deal with environmental conditions of this region. *Pseudacris maculata* occupies a cooler temperature domain relative to most other amphibian species (McKenney et al. 1998). In Manitoba, *P. maculata* has been documented north of 58°00′ N on the coast of Hudson Bay in an open forest-tundra transition zone (Smith 1953).

Habitat use and natural history.—All 10 occurrence stations were in coastal wetland habitats, mainly in upper marshes and thicket swamps. Forests, bogs, and lower marshes seem to be avoided during the breeding season. Limiting factors such as cover, food availability, pH, wave action, and salinity might play a role in determining occupied habitat. For example, the understory may be cover and/or food-deficient in forests. In bogs, embryos and larvae of *P. maculata* might be sensitive to the acidic environment, as has been shown for other amphibian species (Saber and Dunson 1978). Lower marshes are subjected to wave action and

TABLE 3. Sex, general coloration, and morphometric measurements of five adult *Pseudacris maculata* from the James Bay area of Québec. The two individuals from station W21 were found in amplexus.

Station	Sex	General coloration	Snout-vent length (mm)	Right tibiafibula length (mm)
R14	♂	Green	37.2	12.9
W21	♀	Green	33.9	12.4
W21	♂	Green	28.7	10.7
W25	♂	Green	31.1	11.3
W25	♂	Green	29.8	11.1

evaporation, and *P. maculata* is undoubtedly intolerant of brackish water. The majority of amphibian species avoid osmotically stressful environments due to their poor osmoregulatory ability (Boutilier et al. 1992), but the ability to tolerate and breed in slightly brackish waters has been documented for a few species (Ruibal 1959; Gomez-Mestre and Tejedo 2003; Karraker 2007). The dominance of occupied sites with open canopy suggests that *P. maculata* is an open habitat generalist, at least during breeding season in this area of Québec.

Results concur with those reported by Roberts and Lewin (1979) and Constible et al. (2001) in the boreal forest of northeastern Alberta, and with Schueler (1973) along the Ontario coast of Hudson Bay and James Bay. Roberts and Lewin (1979) found that *P. maculata* frequented a variety of open moist habitat types and was rarely observed in dry forest habitats. In northeastern Alberta, *P. maculata* more often used sites with tall herbaceous plants and shrubs but low canopy cover, which provide extensive ground cover (Constible et al. 2001). In Ontario, *P. maculata* is common in the grassy borders of small ponds, but scarce or absent in spruce forest and muskeg (Schueler 1973).

In our study area, *P. maculata* bred in pools that were shallow, fish-free, and probably ephemeral. Calling males were found in or just at the margins of the pools. We easily detected calling activities of *P. maculata* at the end of May and early June, which coincides with its breeding season along the east coast of James Bay. Due to the secretive nature of this species, searching during this period may better delineate its actual distribution. Some calling may, however, be heard sporadically through the summer (Harper 1931; Schueler 1973). During the breeding season, *P. maculata* occurred sympatrically with other early-breeding amphibians with no apparent competitive exclusion.

Habitat use of *P. maculata* on the east coast of James Bay after breeding season is unknown. In northeastern Alberta, the species is uncommon at distances greater than 20 m from the water margin; it is absent at distances greater than 100 m from the water from May/June to August (Roberts and Lewin 1979; Constible et al. 2001). We suggest that this behavior, together with vegetation structure, may be important for thermoregulation and feeding habits, as well as providing protection against predators and desiccation.

This is the first attempt to define the distribution, habitat characteristics, and life-history parameters of *P. maculata* at the extreme northeastern limit of its range. This information is particularly relevant in times of declining amphibian populations and climate change (Pounds et al. 2006; Wake and Vredenburg 2008).

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APPENDIX. Locality data of 84 stations surveyed in 2002-2003. NAD83 coordinates (latitude north-longitude west) are in degrees, minutes, and seconds.

2002.—51,41,16.2-76,08,17.6; 51,42,10.5-76,02,12.4; 51,41,15.8-76,09,42.6; 51,33,12.3-75,15,19.2; 51,33,05.5-75,15,02.8; 51,33,48.0-75,13,41.0; 51,41,04.3-76,01,06.2; 51,28,26.8-78,45,10.3; 51,30,53.0-79,08,47.5; 51,30,44.4-79,08,00.1; 51,36,21.2-79,16,08.8; 51,30,55.6-79,04,22.6; 51,28,33.2-78,41,24.4; 51,32,26.6-79,16,05.9; 51,37,39.2-79,13,36.2; 51,35,16.2-79,15,40.1; 51,29,53.2-79,17,16.6; 51,24,52.7-78,50,44.7; 51,28,28.2-78,39,25.2; 51,48,10.8-78,53,19.5; 51,42,31.5-78,58,58.2; 51,36,14.5-78,50,31.2; 51,32,31.8-78,48,56.7; 51,22,40.8-

77,04,00.3; 51,24,41.5-76,56,10.6; 51,21,55.6-76,21,49.6; 51,26,23.0-76,08,30.8; 51,42,00.9-75,11,45.5; 51,52,52.9-75,06,53.7; 51,37,07.2-75,19,22.6; 52,12,18.1-75,53,03.1; 52,12,05.2-78,32,13.9; 52,50,43.4-76,36,28.4; 53,18,40.5-76,50,51.2; 51,28,13.5-76,47,30.4.

2003.—48,47,29.4-72,43,19.7; 48,48,54.6-72,47,09.7; 48,53,44.1-73,03,48.2; 49,02,30.9-73,22,10.5; 49,38,48.0-74,31,27.2; 49,06,52.2-75,06,20.1; 49,18,34.4-75,15,05.6; 49,19,19.9-75,04,34.4; 49,22,20.3-76,34,10.2; 49,56,27.2-77,06,58.7; 51,32,36.4-79,16,22.4; 51,32,24.1-79,15,54.8; 51,39,23.0-79,03,23.5; 51,48,09.3-78,53,20.9; 51,29,54.6-78,44,47.2; 51,28,29.4-78,39,17.8; 51,28,26.4-78,39,09.0; 51,46,49.4-78,58,23.8; 51,28,28.9-78,45,08.6; 51,24,53.2-78,50,45.0; 51,47,26.5-78,55,52.7; 51,44,45.2-78,56,40.7; 51,42,03.0-78,57,33.7; 51,38,49.0-78,55,38.4; 51,30,42.6-79,15,41.6; 51,28,08.6-78,46,59.6; 51,21,50.7-78,19,47.8; 51,26,44.5-78,33,49.7; 51,30,20.3-78,49,09.0; 51,28,12.6-78,47,09.3; 51,45,47.9-79,13,14.4; 51,46,05.6-79,14,50.5; 51,54,14.7-78,51,52.3; 51,51,42.3-78,49,31.5; 51,49,34.5-78,50,33.2; 51,47,41.4-78,54,34.4; 51,48,43.0-79,07,22.4; 51,35,40.2-79,15,13.0; 51,33,39.2-79,17,27.8; 51,33,33.6-79,30,23.0; 51,28,39.4-79,30,26.4; 51,31,11.5-79,17,40.0; 51,04,54.7-78,47,18.1; 51,09,58.5-78,47,17.9; 51,21,04.9-77,55,28.4; 51,20,34.3-77,35,32.0; 51,20,36.1-77,24,39.9; 51,25,59.6-78,58,46.5; 50,43,28.7-75,02,40.0.

MARTIN OUELLET is a wildlife veterinarian and herpetologist for the Amphibia-Nature research group in Québec, Canada. He received his Doctor of Veterinary Medicine from Université de Montréal (D.M.V., I.P.S.A.V.) and completed graduate courses in the Biology Ph.D. Program of McGill University. He studied amphibians as indicators of ecosystem health and integrity. His current research focuses on the distribution, conservation, and health issues of amphibians, reptiles (including sea turtles), and marine mammals. Martin is pictured in Baie de Rupert (Photographed by Yves Pépin).

CHRISTIAN FORTIN is a biologist for FORAMEC, an environmental consulting firm in Québec City. He received his M.Sc. in Wildlife Ecology from Université Laval, Québec City. His studies involved ecology and conservation of terrestrial mammals in Canadian National Parks. He is currently working on impact assessment, species at risk, wildlife habitat, and conservation of mammals and herpetofauna. Christian is pictured in Baie Boatswain (Photographed by Martin Ouellet).

MARIE-JOSÉE GRIMARD is a biologist working as an environmental advisor for Hydro-Québec Équipement. She received her M.Sc. in Environmental Sciences from Université du Québec à Montréal. She studied under Dr. Pierre Dansereau and conducted ecological impact assessment studies on wetlands in southern Québec. She is now in charge of the Wetlands Committee for Hydro-Québec and working on impact assessments on wetlands and vegetation. Marie-Josée is pictured in Baie Cabbage Willows (Photographed by Martin Ouellet).