Pilot study of beetle diversity in the Mackenzie Delta region of the Northwest Territories in 2000 and 2001

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Background and Rationale:

In 2000 and 2001 pitfall traps and funnel traps were deployed in the Inuvik area on a demonstration basis to assess arthropod diversity. The Canadian Forest Service (CFS) and the Government of Northwest Territories Department of Environment and Natural Resources (ENR) deployed the traps as a joint project.

The target groups for study were ground-dwelling beetles, bark beetles, and wood-boring beetles. The traps were deployed for a limited amount of time at two sites in 2000. In 2001, a more thorough pilot study was carried out at three sites near Inuvik. Originally, it was intended to sample three undisturbed sites in the Mackenzie Delta as well; however, these were not sampled due to a lack of resources. Trap samples were sorted and curated by Jason Machney, a private contractor with ENR, under the supervision of CFS employees in Edmonton. Identification of specimens and analysis of results was carried out by the authors.

Materials and Methods:

Sites and Trapping Protocols:

Study sites were located in the Mackenzie Delta area of the Northwest Territories. The Campbell River site is in the Gwich'in Territorial Park, in pristine forest approximately 25 km South of Inuvik. All the other sites are near Inuvik, and have been disturbed by human activity. Details of the sites and locations appear in Table 1.

Table 1: details of collection localities and habitats.

SITE DESCRIPTION	FOREST TYPE	LOCATION
2000 sites:		
Campbell River Forest Health Plot #829	spruce forest	68.1274°N 133.7346°W
Inuvik, Bypass Road	scrub birch/spruce	68.3500°N 133.7167°W
2001 sites:		
Site 1, 5km S.E. Inuvik	scrub birch/spruce	68.32781°N 133.63517°W
Site 2, 1km E Inuvik	scrub birch/spruce	68.35536°N 133.69403°W
Site 3, 2km N Inuvik	scrub birch/spruce	68.37583°N 133.76447°W

Pitfall traps were 10 cm diameter plastic cups containing 2.5 cm of propylene glycol as a preservative. They were protected from precipitation by an elevated wooden cover, as per Spence and Niemelä (1994).

Funnel traps were 8-funnel Lindgren traps, containing baits obtained from Pherotech Inc. (www.pherotech.com). They were hung approximately 1.5 m above the ground.
In 2000, 6 pitfall traps were deployed at each site. They were placed 25 m apart in a 50 m diameter circle around the center-point of each plot. Three Lindgren funnel traps were deployed at each site, around the same 50 m diameter circle, as far as possible from the pitfall traps. Each trap at a site contained a different bait; one each of ultra-high release (UHR) α-pinene and ethanol, low release (LR) α-pinene and ethanol, and spruce oil. The traps were deployed from 27-28 July to 30 August.

In 2001, pitfall traps were placed equidistant around a 50 m circle at each site. Three traps each were deployed at Sites 1 and 2; four traps were deployed at Site 3. Three Lindgren funnel traps were also deployed around the same 50 m diameter circle, one each containing UHR α-pinene and ethanol, LR α-pinene and ethanol, and an *Ips* bait (ips-dienol, methyl butenol, and cis-verbenol). A fourth funnel trap containing lineatin was deployed at Site 3. The traps were deployed from 26 June to 23 August; samples were collected approximately every three weeks.

Samples were collected into vials containing 70% ethanol, and transferred to Edmonton, where specimens were extracted, curated, and identified. All ground beetles (Carabidae), rove beetles (Staphylinidae), wood-boring beetles (Buprestidae, Cerambycidae, and Tenebrionidae), and bark beetles (Curculionidae: Scolytinae) were identified. A list of taxonomic resources consulted for determinations and biological information appears at the end of the references cited.

Statistical methods:
When trapping efforts were equal between compared samples, raw abundances were used. For comparisons involving unequal trapping efforts, standardized abundance was calculated by dividing the beetle catch by the number of trap-days (number of traps times number of days each was deployed). Species richness of the pooled 2001 sample was examined via rarefaction, a method for estimating the number of species present in

random subsamples of varying size drawn from the larger sample. Rarefaction estimates provide measures of species richness which allow comparison of samples of different size (Sanders 1968; Hurlbert 1971). The resulting value can be interpreted as a diversity measure because the method takes into account the number of species as well as the relative abundance. Rarefaction estimates were calculated from raw data, using a program published by Brzustowski (1999).

For the comparison of the sites sampled in 2001, the lineatin funnel trap and the fourth pitfall trap deployed at Site 3 were deleted, so that the same type and number of traps were compared at each site. For the comparison of funnel trap bait types, the abundances were standardized by dividing the catch by the number of traps of that type; this allowed direct comparison of the single lineatin-baited trap to the other bait types.

Results and Discussion:

General characteristics of the beetle catch:

A total of 605 specimens belonging to 70 species were identified (see Appendix for full species list). In 2000, 42 specimens belonging to 20 species were collected. In 2001, 563 specimens belonging to 60 species were collected.

Ten species are reported here from the Northwest Territories for the first time: the carabids *Amara pseudobrunnea* Lindroth, *Notiophilus aquaticus* Linnaeus, and *Pterostichus empetricola* Dejean; the staphylinids *Aleochara castaneipennis* Mannerheim, *Dropephylla longula* (Mäklin), *Quedius impar* Smetana, and *Tachinus basalis* Erichson; the buprestid *Chrysobothris verdigripennis* Frost; and the scolytine species *Trypodendron lineatum* (Olivier) and *Trypophloeus striatulus* (Mannerheim).

Most of these new records were previously known from Yukon Territory or Alaska. They are almost certainly native to the region and have simply not been collected before; this simply demonstrates that very little arthropod collecting has taken place previously in the Mackenzie Delta. Many of the species collected have a northern boreal distribution, and the Mackenzie Delta is at the northern limits of their known distributions. This fauna is quite distinct from that found in the southern boreal forest, South of the limits of permafrost. Several of the species are known to be holarctic in distribution, but none are considered to be exotic introductions. There is no concrete evidence that the appearance of these species is a result of climate change. However, these records provide an important baseline measure of the existing fauna, prior to the climate change which is expected to affect the region in the near future.

Although a limited amount of sampling in closed canopy spruce forest took place in 2000, most trapping effort took place in a single forest type; the scrub birch/spruce forest in the vicinity of Inuvik. A more thorough sampling of other habitats in the area, including the closed canopy forest, stream and pond margins, and tundra, would likely result in many more species being collected.

A summary of abundance and species richness appears in Table 2.

Table 2: Raw catches of target beetle groups in 2000 and 2001.

	2000		2001	
	No. Specimens	No. Species	No. Specimens	No. Species
ground beetles	15	8	74	12
rove beetles	14	9	79	23
wood borers	1	1	107	11
bark beetles	12	2	303	14

The 2001 data was examined via rarefaction (Figure 1), to estimate how completely the beetle fauna of the scrub birch/spruce habitat has been sampled. Based on the shapes of these rarefaction curves, it appears that the wood-boring beetle fauna has been almost completely sampled, but many more ground-dwelling beetles likely remain uncollected in this habitat.

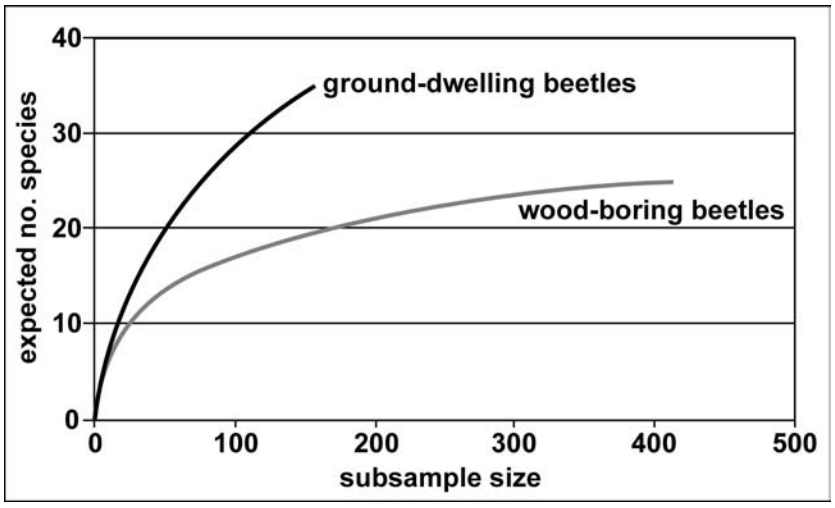

Figure 1: Rarefaction estimates for beetle catches in 2001.

Comparison of 2000 and 2001 samples:

The trapping efforts and locations were quite different between 2000 and 2001, so the results are difficult to compare. However, standardized catches are compared in Table 3. Clearly, the collecting in 2000 was much less efficient than in 2001. The low catch in the former year was likely due to traps being deployed late in the season. The catch of wood-inhabiting insects was particularly low that year, because their flight period is primarily early in the summer. However, the diversity of the 2000 catch is quite high, because two very different forest types were sampled. Ten species collected in 2000 were not collected in 2001; seven of these species (five carabid and two staphylinid species) were collected only at the Campbell River site, which was not sampled in 2001. Due to the small samples obtained, no further analyses were carried out on the 2000 samples.

Table 3: Standardized catches (beetles per 100 trap-days) of beetles in 2000 and 2001.

	2000	2001
ground-dwelling beetles	5.64	18.98
wood-inhabiting beetles	6.37	68.47

Comparison of sites:
In 2001, three sites were sampled in the Inuvik area. Abundance and species richness at each site appears in Table 4. Note that this comparison omits the lineatin funnel trap and the fourth pitfall trap deployed at Site 3. Site 1 had the lowest abundance for each of the four groups, and had a particularly low catch of bark beetles due to the low catch of *Ips perturbatus* and *I. borealis* in Site 1. There may be something about this site that makes it less suitable for these bark beetle species, perhaps an absence of large diameter trees. Otherwise, the differences among sites are not large; more thorough sampling would likely reduce the number of species currently considered to be unique to a site.

Table 4: Abundance and species richness (with number of species unique to the site in brackets), collected at each of three sites in 2001.

	Site 1		Site 2		Site 3	
	abundance	richness	abundance	richness	abundance	richness
carabids	12	5 (1)	12	8 (4)	23	4 (2)
staphylinids	15	10 (5)	25	9 (3)	17	9 (2)
wood borers	30	6 (3)	36	6 (1)	33	5 (1)
bark beetles	34	8 (1)	112	8 (1)	121	11 (3)
total	*91*	*29 (10)*	*185*	*31 (9)*	*194*	*29 (8)*

Comparison of trap types and baits:
Pitfall traps have a long history of use in sampling ground-dwelling beetles (Spence and Niemelä 1994), and were clearly very effective in this study. However, a few carabid and staphylinid species were collected in the funnel traps as well. The carabids *Bembidion nigripes* and *B. versicolor* (Carabidae) were each collected as singletons in the funnel traps. They are not known to be associated with living or dead trees, and were likely collected while dispersing. Likewise, two staphylinid species, *Gabrius picipennis* and *Philonthus subvirescens*, were likely caught while dispersing to new habitats as well, since they are not known to be associated directly with trees. However, some other species of staphylinids collected in this study are known to be associated with bark beetle galleries, and could actually be considered as part of the tree-dwelling fauna rather than the ground-dwelling fauna. These include *Dropephylla longula*, which is known to inhabit bark beetle galleries where it preys on bark beetle larvae (Arnett and Thomas 2000), and *Phloeostiba lapponicus*, which lives under the bark of trees, where it probably feeds on sap (Arnett and Thomas 2000). Several staphylinids in the subfamily Aleocharinae were also collected in funnel traps, including *Dimetrota sp.*, *Philhygra sp*. *Mocyta sp.*, *Phloeopora sp.*, *Placusa sp.*, and several unidentified Aleocharinae. This subfamily of beetles is very poorly known, but several species are known to be associated with bark beetle galleries, where they likely prey on bark beetle larvae (Arnett and Thomas 2000).

The pitfall traps collected a few wood-boring beetles, besides the ground dwelling catch. These can all be considered accidental catches, except for *Upis ceramboides* (Tenebrionidae), all four of which were collected via pitfall trap. This species attacks logs and stumps (Ives and Wong 1988), and probably seeks out suitable host material by walking on the ground rather than flying.

Different assemblages of wood-inhabiting beetles were attracted to the four different baits used in funnel traps (Table 5). The trap baited with UHR α-pinene/etOH was very effective at attracting bark beetles, and the trap baited with LR α-pinene/etOH was very effective at attracting wood borers. These are exactly the groups they have been formulated to attract, so they functioned as expected. The *Ips* bait was designed to attract exotic bark beetle species such as *Ips typographus*. It collected a number of native species of bark beetles and wood borers, but no exotics were found in this or any other trap in the Inuvik study. This bait was inferior to the two α-pinene/etOH baits as an overall inventory tool. The lineatin-baited trap collected considerable numbers and species of bark beetles, but only one species (*Phloeosinus pini* Swaine) was not collected in any other trap type. Overall, the combination of UHR and LR α-pinene/etOH baits served very well as a tool for surveying the wood-inhabiting beetles in this study. Given the good results from them, it probably is not worth the extra time and expense deploying the *Ips* bait and lineatin baited traps.

Table 5: Number of individuals per trap, and number of species (with number of species unique to the bait type in brackets), collected from differently baited funnel traps in 2001.

	UHR α-pinene/etOH		LR α-pinene/etOH		*Ips* bait		Lineatin	
	No. Indiv.	No. Species	No. Indiv.	No. Species	No. Indiv.	No. Species	No. Indiv.	No. Species
wood borers	4	7 (2)	23.3	7 (3)	4.3	2 (0)	8.0	2 (0)
bark beetles	73.3	13 (4)	5.0	7 (0)	10.3	6 (0)	35.0	6 (1)
total	77.3	20 (6)	28.3	14 (3)	14.7	8 (0)	43.0	8 (1)

Summary and Conclusions:

Ground-dwelling beetles were collected via pitfall traps, and wood-inhabiting beetles were collected via baited funnel traps, in the Mackenzie Delta of NWT in 2000 and 2001. Seventy species were identified from these collections, including 10 species reported here for the first time from NWT. No exotic species were collected.

In the scrub birch/spruce habitat, the wood-inhabiting beetles are estimated to be fairly completely sampled, but many more elements of the ground-dwelling fauna there are thought to remain uncollected. Other habitats in the region besides the scrub birch/spruce habitat are expected to harbour unreported species as well. The beetle species collected represent primarily a northern boreal fauna at the northern limits of their distribution. This fauna provides a useful tool for the study of climate change, since the Mackenzie Delta region is expected to be significantly affected in coming years.

The 2000 sample was very small because it missed the most of the active season for beetles. There were no large differences among the 3 sites sampled in 2001. The funnel trap baits UHR α-pinene/etOH (for bark beetles), and LR α-pinene/etOH (for wood borers) were most useful. The other baits (*Ips* bait and lineatin) were largely redundant, attracting low numbers and few unique species.

Overall, this study provided much valuable information on the beetle fauna of this little-studied area. A larger study involving more sites and traps would be required to more fully survey the beetle fauna, and examine biotic differences among habitats.

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Appendix: List of beetle species and number of individuals collected in 2000 and 2001.

Group and Family	Species	Remarks	2000	2001
ground-dwelling beetles:				
Carabidae	*Agonum bicolor* (Dejean)	Boreal holarctic species.	1	0
	Amara hyperborea Dejean	Northern holarctic species.		6
	Amara pseudobrunnea Lindroth	New record for NWT; previously known from AK, YT and across boreal forest in southern Canada.		2
	Bembidion nigripes Kirby	Northern boreal species.		1
	Bembidion versicolor LeConte	Northern boreal species.		1
	Carabus chamissonis Fischer	Northern boreal species.	1	3
	Elaphrus lapponicus Gyllenhal	Northern boreal species.		4
	Nebria frigida R.F. Sahlberg	Northwestern NA species.	1	0
	Notiophilus aquaticus Linnaeus	New record for NWT; previously known from AK, YT, and across southern boreal forest in Canada. Also known in Eurasia.	2	0
	Pelophila borealis Paykull	Northern holarctic species.	1	0
	Pterostichus chipewyan Ball	Northern boreal species.	1	0
	Pterostichus empetricola Dejean	New record for NWT; previously known from AK, YT, and northern BC and AB. Species is composed entirely of parthenogenetic females.		37
	Pterostichus mandibularoides Ball	Northern boreal species.		1
	Pterostichus nr. pinguedineus (Eschscholtz)	Determination uncertain; northern holarctic species.		3
	Pterostichus nr. planus (Sahlberg)	Determination uncertain; previously known only from central AK.		1
	Pterostichus punctatissimus Randall	Northern boreal species.	1	1
	Stereocerus haematopus Dejean	Holarctic species of the tundra and northern boreal forest.	7	14
Staphylinidae	*Acidota quadrata* (Zetterstedt)	Northern holarctic species.	1	10
	Aleochara castaneipennis Mannerheim	New record for NWT; previously known from Dempster Highway YT. Parasitoid of fly larvae in decomposing matter.		5
	Aleocharinae spp.	Species ID not possible; poorly known group.		9
	Atheta sp. prob. granulata (Mnh.)	Species ID not possible; poorly known group.	1	0
	Athetini, prob. *Atheta sp.*	Species ID not possible; poorly known group.		1

Appendix, continued.

	Athetini, prob. *Dimetrota sp.*	Species ID not possible; poorly known group.	1	0
	Athetini, prob. *Philhygra sp.*	Species ID not possible; poorly known group.		1
	Athetini sp.	Species ID not possible; poorly known group.		3
	Bryophacis smetanai Campbell	Boreal and mountain species.		2
	Dropephylla longula (Mäklin)	New record for NWT; previously known from AK, BC, AB. Known to feed on bark beetles in their galleries.		3
	Eucnecosum prob. tenue (LeConte)	Determination uncertain; northern holarctic species.		1
	Gabrius picipennis (Mäklin)	Common transcontinental species.		1
	Holoboreaphilus nordenskioeldi (Mäklin)	Holarctic tundra species.	2	0
	Lordithon fungicola Campbell	Common boreal species associated with mushrooms.		4
	Mocyta sp.	Species ID not possible; poorly known group.		1
	Mycetoporus nigrans Campbell	Northern range extension in Canada; previously known as far North as Fort Simpson and Dawson City.	1	1
	Philonthus subvirescens Thomson	Holarctic species.		3
	Phloeopora sp.	Rarely collected genus.		1
	Phloeostiba lapponicus (Zett.)	Holarctic species. Lives under bark of trees; adult is probably a sap feeder.	5	22
	Placusa sp.	Species ID not possible; poorly known group.		1
	Pselaphinae sp.	Species ID not possible; poorly known group.		4
	Quedius fellmani (Zett.)	Boreal holarctic species.	1	0
	Quedius impar Smetana	New record for NWT; previously known from Rocky Mountains in BC, AB.		1
	Quedius simulator Smetana	Boreal species.		1
	Quedius sublimatus Mäklin	Boreal holarctic species.		1
	Tachinus basalis Erichson	New record for NWT; previously known from AK, YT, and temperate NA and Eurasia.		2
	Tachyporus inornatus Campbell	Boreal species.	1	0
	Tachyporus rulomus Blackwelder	Boreal species.	1	1
wood-inhabiting beetles:				
Buprestidae	*Chrysobothris verdigripennis* Frost	New record for NWT and nothern Canada; previously known across Canada only as far North as Kettle Rapids MB. Reported from a variety of conifers including *Picea* species.		1
	Melanophila acuminata (DeGeer)	Common holarctic species. Feeds on many conifers; adults are attracted to fire-killed trees via heat sensors.		1
	Melanophila fulvoguttata (Harris)	Northern boreal species. Feeds on a number of conifers including *Picea*.		7

Appendix, continued.

Cerambycidae	*Acmaeops pratensis* (Laicharting)	Northern holarctic species. Feeds under bark of *Picea* and *Pinus* species.		1
	Acmaeops proteus proteus (Kirby)	Northern boreal species. Feeds under bark of various conifers.		72
	Meriellum proteus (Kirby)	Northern boreal species. Feeds under bark of *Picea* and *Pinus* species.		3
	Monochamus scutellatus scutellatus (Say)	Common borer of recently killed conifer trees.		4
	Pogonocherus penicillatus LeConte	Northern boreal species. Feeds under bark of *Picea* species.		2
	Pygoleptura nigrella nigrella (Say)	Transcontinental boreal species. Feeds in the heartwood of many conifer species.		1
	Xylotrechus undulatus Say	Common northern boreal species. Feeds under the bark of *Picea* and other conifer species.	1	11
Tenebrionidae	*Upis ceramboides* (Linnaeus)	Common holarctic species. Feeds under bark of many species of dead trees.		4
Curculionidae: Scolytinae	*Carphoborus andersoni* Swaine	Northern boreal species. Feeds on *Picea glauca*.	11	30
	Crypturgus borealis Swaine	Boreal species. Feeds on all conifers; attacks trees already killed by other bark beetles.		1
	Dendroctonus punctatus LeConte	Northern boreal species. Attacks living and dead *Picea* species and occasionally other conifers. Occasionally a pest.		5
	Dendroctonus rufipennis (Kirby)	Northern boreal species. Attacks living and dead *Picea* species. Often becomes a pest of living trees, after populations build up on windthrow and other dead material.		15
	Dryocoetes affaber (Mannerheim)	Transcontinental boreal species. Feeds on *Picea, Pinus* and other conifers.		13
	Ips borealis Swaine	Transcontinental species. Feeds on dead and dying *Picea* species.		104
	Ips perturbatus (Eichhoff)	Transcontinental species. Feeds on dead and dying *Picea* species and other conifers.		74
	Phloeosinus pini Swaine	Transcontinental species. Feeds on *Pinus* and *Picea* species.		2
	Pityophthorus sp. prob. borealis Swaine	Species ID not possible; poorly known group.		6
	Pityophthorus sp. 2	Species ID not possible; poorly known group.		2
	Polygraphus rufipennis (Kirby)	Common transcontinental species. Feeds on dead and dying *Picea* and other conifers.	1	14
	Scolytus piceae (Swaine)	Northern range extension from Fairbanks AK. Feeds on dead and dying limbs of *Picea* species.		11
	Trypodendron lineatum (Olivier)	New record for NWT, and northern range extension; previously known from Dawson City YT. Feeds on dead and dying conifer trees; galleries penetrate deep into the heartwood.		25
	Trypophloeus striatulus (Mannerheim)	New record for NWT; previously known from Eagle Plains YT. Feeds on *Alnus* and *Salix* species.		1