A DECLINE IN THE NUMBER OF LONG-HORNED WOOD BORING BEETLE (COLEOPTERA: CERAMBYCIDAE) SPECIES IN ONTARIO DURING THE 20TH CENTURY?

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Abstract
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Documenting loss of biodiversity in insects is hindered by the lack of species level inventories for many taxa. In Canada we have a better understanding of Coleoptera distributions than for most other taxa. Here we ask if we know how many species of Cerambycidae occur in Ontario, and whether there has been a change in the number of species over the past 100 years. More than 18,000 specimens collected since 1862 were examined. A species accumulation curve demonstrates that the inventory is reasonably complete. Rarefaction estimates of species richness by decade show that fewer species were collected after 1950 than before. Most of the 20 species collected only prior to 1950 were associated with hardwood trees in the Carolinian zone of extreme southern Ontario. Loss of forested habitat and replacement of old growth forests with younger forests may have played a role in the decline. Nine species were first collected after 1950, resulting in a net loss of 11 species. Selected records from after 2000 suggest that the introduction of species, range expansions into Ontario, and discovery or rediscovery of rare species is continuing.

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Introduction

Entomologists have difficulty documenting biodiversity losses because species-level inventories do not exist for most taxa for most locations. In Canada, only about 60-65% of all arthropod species that exist in the country have been documented (Danks 1979). For many insect groups we lack keys, comprehensive revisions, or the expert taxonomists able to identify species, undertake the revisions, and write the keys necessary for species identification; in short there is a 'taxonomic impediment' (Taylor 1983).

The insect fauna of Ontario is incompletely known, although two approaches, broad scale inventories and curation of existing collections, have expanded our knowledge in the past 20 years. These approaches have produced species-level inventories for a few

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locations (e.g. Skevington et al. 2001; Paiero et al. in press) and many newly recorded species in relatively well known taxa, such as aculeate Hymenoptera (Buck 2004; Buck et al. 2006), Hemiptera (Paiero et al. 2004), Orthoptera (Marshall et al. 2006), and Mecoptera (Cheung et al. 2006). For Cerambycidae, McCorquodale (2002) documented 14 new records for Ontario, including seven new records for Canada, and clarified the status of 11 other species for which there was equivocal evidence of occurrence in Ontario.

The Cerambycidae are plant-feeding beetles with about 1,100 species in North America (Linsley 1961; Linsley and Chemsak 1997; Allison et al. 2004). A series of taxonomic monographs by Linsley (1962a; 1962b; 1963; 1964), Linsley and Chemsak (1972; 1976; 1985; 1995), and Chemsak (1996), as well as a recent field guide, make taxonomic information accessible (Yanega 1996). Although most species of Cerambycidae in North America are well known taxonomically, new taxonomic notes on the genus *Oberea* (Yanega 1996) and current work on *Tetropium* by Serge Laplante, Canadian National Insect Collection, indicate that systematics work is still required.

Most cerambycids depend on tree or shrub hosts for development. Therefore host availability and changes in host distribution and abundance should influence the distribution and abundance of these beetles. In Ontario, land use and forest cover have changed dramatically over the past 300 years, particularly south of the Canadian Shield (Keddy 1997; Larson et al. 1999; Armson 2001; Suffling et al. 2003). Forests were converted to agricultural fields and timber was extracted from large areas during the 1800s; forest area was at a minimum in the 1920s, with about 10% of the original forest cover remaining south of the Canadian Shield (Larson et al. 1999). Besides the loss of forested area, there has been a change in the character of forests. Larson et al. (1999) explain that forests in southern Ontario are younger, more fragmented, and more homogeneous now compared to 300 years ago. North of the French and Mattawa Rivers, the area of forest cover has changed less dramatically, but composition of the forest has changed through forest harvesting (Jackson et al. 2000).

Land use change is expected to change the insect fauna. About 60% of nationally listed species of vertebrates and vascular plants occur in Ontario, with most of these occurring only in Ontario and only in the Carolinian or Deciduous Forest zone (Canadian Wildlife Service 2006). Habitat loss through clearing for agriculture and urbanization are prime factors.

Here we ask whether there is a good inventory of the Cerambycidae in Ontario. Given that recent work on a variety of groups has increased the number of species known for Ontario, it is important to assess the completeness of our inventory. Next, because of land use changes and decrease in older forests, we ask whether there are fewer species represented in collections from 1950 to 1999 compared to before 1950. At a finer level, the same question is asked for eight shorter time periods, roughly decades, four before 1950 and four from 1950–1999. Host preferences and geographic range of the species in collections only from before 1950 and only from 1950–1999, are compared to test whether potential losses are mostly from the extreme south of the province. Finally, significant records from after 2000 are considered.

This analysis is possible because of the efforts of many generalist insect collectors, epitomized and encouraged by D. H. Pengelly. Beetles were not his focus, yet while pursuing bees, many beetles ended up on pins. For each of more than 30 consecutive years starting in the mid-1950s, there are cerambycids collected by Pengelly in the University of Guelph collection. These are of inestimable value in documenting faunal change. Perhaps more important are the hundreds of specimens collected by dozens of young students motivated by Pengelly to learn about where insects live and what they do. From the 1960s to the 1980s students in his insect collection course collected beetles across southern Ontario. These students, including several contributors to this volume, are prominent on labels of cerambycids. The specimens deposited in the University of Guelph collection, are more important than numbers alone indicate, because at the same time relatively few cerambycids were being deposited in the other major collections in Ontario. D. H. Pengelly's genuine curiosity about insects and his ability to ignite curiosity in others made this contribution possible.

Methods

We identified all pinned adult specimens of Cerambycidae collected in Ontario (N=18,469) in five major insect collections: Canadian National Insect Collection, Ottawa, ON [CNC, n=6,050 specimens]; Royal Ontario Museum, Toronto, ON [ROME, n=4,517]; University of Guelph, Guelph, ON [DEBU, n=4,511]; Great Lakes Forestry Centre, Sault Ste. Marie [GLFR, n=2,142]; Canadian Museum of Nature, Aylmer, PQ [CMNC, n=705]; and in collections with smaller holdings: Lyman Entomological Museum, McGill University, Montreal, PQ [LEMQ, n=397]; Canadian Forestry Service-Fredericton, NB [FRLC, n=80]; Algonquin Provincial Park Visitors Centre, ON [APVC, n=67]; and the Nova Scotia Museum of Natural History, Halifax, NS [NSMC, n=1].

The primary source for identifications and taxonomy was Yanega (1996), supplemented with Linsley (1962a; 1962b; 1963; 1964), Linsley and Chemsak (1972; 1976; 1985; 1995), Chemsak (1996), and a few recent revisions to nomenclature (e.g. Napp 1994). McNamara (1991) provided a checklist of species in Ontario. Non-native species collected in Ontario but presumed not to be established, such as *Physocnemum andreae* (Laplante 1989; McCorquodale 2002), *Phymatodes lividus*, and *Prionus californicus* (Fletcher 1907), are not included.

Label data were recorded for all specimens collected up to and including 1999. All specimens from the same location in one year were considered one record. Specimens from a more specific locality and a less specific locality in the same year were counted as one record (i.e. Ottawa in 1905 and Eastern Ontario in 1905 counted as one record). Selected specimens collected since 2000 and deposited in the University of Guelph collection are included separately and are not considered in the main analysis.

Old specimens with no year indicated on the label made up a substantial proportion of all specimens (McCorquodale 2002) and were combined in the category 'Limited Data' and then with all specimens from the 1860s to 1919 in the category 'Before 1920'. The importance and the limitations of these data were explained in McCorquodale (2002). These specimens represent the fauna of Ontario prior to 1920, despite having incomplete label information.

From the specimen label data, we tallied the number of records before 1950, from 1950–1999, and in eight 'decade' categories (before 1920, 1920s, 1930s, 1940s, 1950s, 1960s, 1970s, 1980s+1990s), four before 1950 and four from 1950–1999. These latter categories are referred to as 'decades'. Some analyses compare pre-1950 and 1950–1999 records, two categories with an approximately equal number of records (Fig. 1; 3,902 and 4,160). Others compare the eight 'decades', again each having a similar number of records (range 855 to 1,284). The biased sample of specimens from after 2000 is only considered separately.

Individual-based rarefaction, using records as defined above, was used to calculate expected species richness for each of the time categories (before 1950 and 1950–1999 and decade) to test whether species richness changed. Rarefaction iteratively sub-samples a data set to produce a taxon-sampling curve that represents the expected number of species for a given sample size (Krebs 1999; Buddle et al. 2005; Gotelli and Entsminger 2005). This allows comparisons between data sets with different sample sizes by comparing expected species richness for a common number of individuals (i.e. the sample size is set slightly smaller than the smallest sample). Expected species richness was compared at 3,800 records for before 1950 compared to 1950 to 1999 and at 800 records for the eight 'decades'. Estimates of the expected species richness, variance and 95% confidence intervals were based on 1,000 iterations using EcoSim 7.72 (Gottelli and Entsminger 2005).

Results

Completeness of inventory. Two hundred species, approximately 95% of the 211 species of Cerambycidae now known from Ontario, had been collected before 1950 (Table 1). The many old specimens collected prior to 1920, some with incomplete label data, included 179 species; the next highest 'decade' total is 157 species from the 1930s (Fig. 1). The 1930s also had the fewest records. The asymptotic nature of the species accumulation curve (Fig. 2) suggests the inventory of Cerambycidae of Ontario is relatively complete. Between 1950 and 1999 one species was added to the fauna about every 5 years.

We here add the following species not recorded in Ontario by McNamara (1991) or McCorquodale (2002).

Cerambycinae, Clytini, *Xylotrechus mormonus* (LeConte): Ontario, Deux-Rivieres, 26 July 1956, F[orest] I[nsect] S[urvey], CNC.

Lamiinae, Ataxiini, *Ataxia brunnea* Champlain and Knull. Ontario, Chatham Lab, Summer 1937, CNC; Ontario, Harrow, 1 July 1961, R. S. Dickout, DEBU.

Comparison of species richness before 1950 and 1950 to 1999. Fewer species of Cerambycidae were collected between 1950 and 1999 than prior to 1950. Raw species richness prior to 1950 was 200, compared to 191 for 1950–1999. However, it is more appropriate to compare species richness with rarefaction estimates that control for unequal sample size. The rarefied expected species richness prior to 1950, 199.5 (198–200, 95% CI), was higher than for the period 1950–1999, 188.3 (186–190, 95% CI). Comparison of rarefaction estimates for the eight 'decades' (Fig. 3) demonstrates the decline in species richness for collections from 1950 to 1999 compared to prior to 1950. All four pre-1950 'decades' had higher species richness than all four 1950 to 1999 'decades'.

TABLE 1. The number of records by decade based on 18,469 specimens of Cerambycidae collected in Ontario. For analyses of 'decades' Limited data, 1800s, 1900s, and 1910s were combined in Before 1920 and 1980s and 1990s were also combined.

	Limited Data	1800s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	Total
Aseminae													
Asemini													
Arhopalus foveicollis (Haldeman)	7	4	2	4	11	14	8	9	9	5			73
Arhopalus rusticus obsoletus (Randall)						1							1
Asemum striatum (Linnaeus)	9	2	2	3	11	13	12	16	22	12	6	3	111
Tetropium cinnamopterum Kirby	3	1		1	2		5	2	2	3	3		22
Tetropium parvulum Casey				2	3		1	1					7
Tetropium schwarzianum Casey	1	1					2			3			7
Atimiini													
Atimia confusa confusa (Say)	1				1	3		1	2	2	1	2	13
Cerambycinae													
Anaglyptini													
Cyrtophorus verrucosus (Olivier)	6	1	3	2	11	13	16	16	16	21	16	7	128
Microclytus compressicollis (Laporte and Gory)	2			3		1	3						9
Bothriospilini													
Knulliana cincta cincta (Drury)	3	1		1		2		1	2	5	2		17
Callidiini													
Callidium antennatum Newman	1												1
Callidium frigidum Casey	3	2		2	5	4	2	2	7	5	4		36
Callidium violaceum (Linnaeus)	4		2	5	5	1	3	2	2	2	3		29
Meriellum proteus (Kirby)	4	1	1		10	4		1		2		1	24
Phymatodes aereus (Newman)	2				3				1	1			7
Phymatodes amoenus (Say)	1		1		7	4	11	1	5	6	4	2	42
Phymatodes dimidiatus (Kirby)	4		1	3	11	2	1	1	1		1		25

TABLE 1. Continued.

	Limited Data	1800s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	Total
Callidiini continued													
Phymatodes maculicollis LeConte											1		1
Phymatodes testaceus (Linnaeus)	3				2	1	2	3	4	4	9	1	29
Phymatodes varius (Fabricius)	1					1	1	1					4
Physocnemum brevilineum (Say)	5		2	4	5	6	11	7	5	7			52
Pronocera collaris (Kirby)		1			7		2	6	4	1	1	1	23
Ropalopus sanguinicollis (Horn)	1				2	2	1	2	1		1		10
Semanotus ligneus (Fabricius)	5	3	2	2	1	4	4	1	4	1	1	2	30
Semanotus litigiosus (Casey)	1		1	2	1				3		1		9
Clytini													
Calloides nobilis (Harris)	3	5	2	1	1	1	2	1					16
Clytoleptus albofasciatus (Laporte and Gory)								1	1	1			3
Clytus marginicollis Laporte and Gory										2			2
Clytus ruricola (Olivier)	8	8	7	14	26	19	21	27	40	39	31	27	267
Glycobius speciosus (Say)	6	2			4	2	5	3	1	3	2		28
Megacyllene caryae (Gahan)	2	1	2		1					2			8
Megacyllene robiniae (Forster)	7	9	8	6	13	12	9	16	10	19	12	14	135
Neoclytus acuminatus (Fabricius)	3			4	13	20	15	11	10	17	8	4	105
Neoclytus caprea (Say)	1						1						2
Neoclytus leucozonus (Laporte and Gory)	4		4	4	7	5	1	11	2	2	2		42
Neoclytus mucronatus (Fabricius)	2			1		2	1						6
Sarosesthes fulminans (Fabricius)	4	1		1	4	1	1		1	3	3	5	24
Xylotrechus aceris Fisher	2				1	1	2	2	1	1			10
Xylotrechus annosus (Say)	2				4	2	1	7	11	5	2	1	35
Xylotrechus colonus (Fabricius)	6	1	2	2	8	15	4	6	10	12	13	6	85

TABLE 1. Continued.

	Limited Data	1800s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	Total
Clytini continued													
Xylotrechus convergens LeConte	1								1		1		3
Xylotrechus mormonus (LeConte)								1					1
Xylotrechus quadrimaculatus (Haldeman)	2			1	1			2				2	8
Xylotrechus sagittatus (Germar)	4	3		2	1	2	3	5	3	2		2	27
Xylotrechus undulatus (Say)	9	7	1	3	15	2	13	16	20	5	4	5	100
Elaphidiini													
Anelaphus parallelus (Newman)	2			1	4	8		15	5	9	4	5	53
Anelaphus pumilus (Newman)									1	1			2
Anelaphus villosus (Fabricius)	2	1		2	6	8	3	1	5	4		3	35
Elaphidion mucronatum (Say)	1					6			2	3	2	1	15
Enaphalodes atomarius (Drury)	1										1		2
Enaphalodes cortiphagus (Craighead)	1				1	2			1	1			6
Enaphalodes rufulus (Haldeman)	3	3	2	2	7	7	2	2	8	3		6	45
Parelaphidion aspersum (Haldeman)	4	1				3			1	2	1		12
Psyrassa unicolor (Randall)	2		1	1	2	3	2	1	4	5	1	1	23
Stenosphenus notatus (Olivier)	1						1						2
Hesperophanini													
Eburia quadrigeminata (Say)	2				1	5	1		1			1	11
Hesperophanes pubescens (Haldeman)	1				2	1			3	1	1	2	11
Tylonotus bimaculatus Haldeman	3	1	3	5		1	4	5	5	2	2	1	32
Ibidionini													
Heterachthes quadrimaculatus Haldeman	1			1	2	1		4	1				10
Molorchini													
Molorchus bimaculatus Say	5	1	4		7	13	3	10	7	3	14	4	71

TABLE 1. Continued.

	Limited Data	1800s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	Total
Obriini													
Obrium maculatum (Olivier)	1												1
Obrium rufulum Gahan	2		1		6	7	7	3	6	3	2	1	38
Smodicini													
Smodicum cucujiforme (Say)									1	2			3
Stenopterini													
Callimoxys sanguinicollis (Olivier)	3		2	1	7	6	6	5	2	5	4		41
Tillomorphini													
Euderces picipes (Fabricius)	4	4	4	1	6	14	7	4	12	16	5	7	84
Trachyderini													
Batyle suturalis (Say)	1	3	2	1	1	4	3			1	1	6	23
Purpuricenus humeralis (Fabricius)	2				2		4	3	1	2			14
Lamiinae													
Acanthocinini													
Acanthocinus obsoletus (Olivier)	2	1				2			1				6
Acanthocinus pusillus Kirby	5	3	1	5	3	7	9	9	7	6	1	1	57
Astylopsis collaris (Haldeman)					1	1						2	4
Astylopsis macula (Say)	5			2	15	3	5	7	2	2	1	1	43
Astylopsis sexguttata (Say)	3			1	7	7	8	4	5	3	2	1	41
Dectes sayi Dillon and Dillon						2	1				1	2	6
Hyperplatys aspersa (Say)	5	3		2	10	12	12	12	12	17	15	3	103
Hyperplatys maculata Haldeman	4		1	4	13	7	3	10	6	5	1		54
Leptostylus transversus (Gyllenhal)	2			1	2	2	1	3	1				12
Lepturges confluens (Haldeman)	1				3	1	1				1		7
Lepturges symmetricus (Haldeman)	2			1	6	1	3	3	2	2	2		22

TABLE 1. Continued.

	Limited Data	1800s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	Total
Acanthocinini continued.													
Liopinus alpha (Say)	3		2	5	11	14	13	10	10	4	5	1	78
Sternidius variegatus (Haldeman)	2		2	1	2	4	8	1	4	10	1		35
Urgleptes facetus (Say)	1					1		1		1		1	5
Urgleptes querci (Fitch)	2			2	7	5	13	7	7	7	6	1	57
Urgleptes signatus (LeConte)	1		1	2	8	2	4	6	1	1	3	1	30
Urographis despectus (LeConte)	2	1			1	3	1	1					9
Urographis fasciatus (DeGeer)	5	2	2	2	11	4	3	2	6	4	10	6	57
Acanthoderini													
Aegomorphus modestus (Gyllenhal)	3		1	4	7	2	1	2	3	6	3		32
Aegomorphus quadrigibbus (Say)	1												1
Oplosia nubila (LeConte)	2			3	9	3	3		6		1		27
Apodasyini													
Eupogonius pauper LeConte	1		1	2	3	3	3	2	2	2	2		21
Eupogonius subarmatus (LeConte)	2				7	6	5	7	3	1	2	1	34
Eupogonius tomentosus (Haldeman)	2			1	1		1	1				1	7
Psenocerus supernotatus (Say)	4		3	3	9	10	13	9	17	23	13	2	106
Ataxiini													
Ataxia brunnea Champlain and Knull						1			1				2
Cyrtinini													
Cyrtinus pygmaeus (Haldeman)	1												1
Dorcaschematini													
Dorcaschema alternatum (Say)	1												1
Dorcaschema cinereum (Olivier)			1				1			1			3
Dorcaschema nigrum (Say)	3		1	2	2	11	4	1	1				25

TABLE 1. Continued.

	Limited Data	1800s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	Total
Hippopsini													
Hippopsis lemniscata (Fabricius)						1	1			2	4		8
Lamiini													
Goes debilis LeConte	5	2	1		2	1	1	1	2	1	1	1	18
Goes pulcher (Haldeman)	3	1	1			3	1						9
Goes pulverulentus (Haldeman)	2			1		1	2	2	1	1			10
Goes tigrinus (DeGeer)	1												1
Hebestola nebulosa Haldeman					1				1	1			3
Microgoes oculatus (LeConte)	3	1	1	1	8	3	3	5	6	1	3	1	36
Monochamus carolinensis (Olivier)	2	1	2	2	3	2	4		2	1	1	2	22
Monochamus marmorator Kirby			1	2	6	2	9	3	8		1		32
Monochamus mutator LeConte	1	1			1	1	2	13	5	1	3	1	29
Monochamus notatus (Drury)	8	7	7	9	16	12	28	17	22	18	8	12	164
Monochamus scutellatus (Say)	8	2	8	6	18	23	23	18	24	55	45	30	260
Monochamus titillator (Fabricius)				1	1							1	3
Onciderini													
Oncideres cingulata (Say)	2												2
Phytoecini													
Oberea affinis Leng and Hamilton	4	1	4	3	9	9	14	6	5	20	3	2	80
Oberea caseyi Plavilstshikov	2				2	1		2					7
Oberea deficiens Casey					1		1	1	1	1		1	6
Oberea delongi Knull					2		5	1		2			10
Oberea erythrocephala (Fabricius)										1	1		2
Oberea ocellata Haldeman							1				2		3
Oberea oculaticollis (Say)							1						1

TABLE 1. Continued.

	Limited Data	1800s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	Total
Phytoecini continued.													
Oberea pallida Casey						1	1	1		1	1		5
Oberea perspicillata Haldeman	4		1	1	2	4	5	3	3	8	3	2	36
Oberea praelonga Casey	1		1	2	6	5	11	11	3	9	6	1	56
Oberea pruinosa Casey						1	2		2				5
Oberea schaumii LeConte					1	3	3	2	1	2	1		13
Oberea tripunctata (Swederus)	1			2	8	26	17	24	21	38	19	7	163
Pogonocherini													
Ecyrus dasycerus dasycerus (Say)	2					2	6	2		6		1	19
Pogonocherus mixtus Haldeman	3	3	1	2	10	5	2	9	2	3			40
Pogonocherus parvulus LeConte					1	2	4		1	3			11
Pogonocherus penicillatus LeConte	2		2		1	4	3	8	4	1			25
Saperdini													
Saperda calcarata Say	7	3	4	4	2	9	9	11	18	11	4	3	85
Saperda candida Fabricius	4	3		1	1	3	4	10	4	4	3	6	43
Saperda cretata Newman	1				3	2						1	7
Saperda discoidea Fabricius	1				3	3	1	2	1			1	12
Saperda fayi Bland	3				2	7	3	2	2	1			20
Saperda imitans Felt and Joutel	1				2	2		3		2		3	13
Saperda inornata Say	2	3	2	3	2	3	11	9	7	2	3	1	48
Saperda lateralis Fabricius	3			2	7	5	8	3	2	2	4	1	37
Saperda mutica Say	1		1	1	3	2	7	3	2	5			25
Saperda obliqua Say				2	1	3	1	3	9	2	1	1	23
Saperda populnea moesta LeConte	1	4		1	4	7	8	8	3	7	4		47
Saperda puncticollis Say	2	1	2	2	1	9	7	8	1	4	5	3	45

TABLE 1. Continued.

	Limited Data	1800s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	Total
Saperdini continued.													
Saperda tridentata Olivier	8	3		3	15	16	18	21	42	40	13	2	181
Saperda vestita Say	7	4	1	4	16	19	10	9	10	9	4		93
Tetraopini													
Tetraopes femoratus LeConte					1		1	1					3
Tetraopes melanurus Schonherr	1		1		1						1		4
Tetraopes quinquemaculatus Haldeman	1						1					3	5
Tetraopes tetrophthalmus (Forster)	7	8	11	5	17	18	13	31	34	73	59	20	296
Lepturinae													
Desmocerini													
Desmocerus palliatus (Forster)	6	1		3	4	8	12	10	13	7	8	2	74
Lepturini													
Acmaeops pratensis (Laicharting)	6	2	3	2	5	6	3	3	6	2	4		42
Acmaeops proteus (Kirby)	6	1	1	4	10	7	9	15	19	10	5	2	89
Acmaeopsoides rufula (Haldeman)								2	4		3		9
Analeptura lineola (Say)	6		2	4	10	8	9	6	11	22	19	11	108
Anastrangalia sanguinea (LeConte)	1				4		1		3		4		13
Anoplodera pubera (Say)	6	6	3	3	10	13	9	14	19	21	18	4	126
Anthophylax attenuatus (Haldeman)	2				1	2	5	1	5	3	6	3	28
Anthophylax cyaneus (Haldeman)	2		1	1	2	3	2	3	6	1	4	4	29
Anthophylax viridis LeConte									2		1		3
Bellamira scalaris (Say)	4	1		2	8	4	6	7	9	4	9	3	57
Brachyleptura champlaini Casey	3	5		3	2	2	1	1	3	4	2	5	31
Brachyleptura rubrica (Say)	2		1		5	3	4	1	1	4	3	1	25
Brachysomida bivittata (Say)	1												1

TABLE 1. Continued.

	Limited Data	1800s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	Total
Lepturini continued.													
Centrodera decolorata (Harris)	5	3		4	3	1	3	2	6	1		1	29
Charisalia americana (Haldeman)					2		1				1		4
Encyclops caerulea (Say)	6	1	4	1	2	2	2	1	1				20
Evodinus monticola (Randall)	2	1	4	1	9	3	11	16	9	8	4	9	77
Gaurotes cyanipennis (Say)	4	6	1	1	11	14	10	9	6	7	4	6	79
Grammoptera exigua (Newman)	2		2		5	1	4	1	1	1	1		18
Grammoptera haematites (Newman)	4		1		6	4	8	7	1	2	3		36
Grammoptera subargentata (Kirby)	1	1	2	1	5	7	2	7	10	9	7	2	54
Idiopidonia pedalis (LeConte)				1					3	1		2	7
Judolia montivagans (Couper)	4	3			3	1	4	5	7	7	11	3	48
Judolia quadrata (LeConte)					2	1		1					4
Leptura emarginata Fabricius	1					2			1	4		1	9
Leptura plebeja Randall	2	4		3		2			4		2	3	20
Leptura subhamata Randall	5	7	3	3	6	9	5	6	4	6	3	1	58
Lepturobosca chrysocoma (Kirby)	4	3	1	2	10	6	5	12	20	18	14	3	98
Lepturopsis biforis (Newman)	3	4	2	1	9	6	7	8	5	7	5	6	63
Neoalosterna capitata (Newman)	3		2	2	5	3	7	1	3		5	1	32
Pachyta lamed Kirby	2				2	1		2			1		8
Pidonia ruficollis (Say)	6	1	3	3	10	6	9	3	8	16	21	5	91
Pseudogaurotina abdominalis (Bland)	1	2				2	2	2	2	3	1	2	17
Pseudostrangalia cruentata (Haldeman)							1		1				2
Pygoleptura nigrella (Say)	4	1			7	2	2	2	6	1	2		27
Rhagium inquisitor (Linnaeus)	5	3	3	1	6	5	6	12	5	7	8		61
Sachalinobia rugipennis (Newman)			1	1	1	1	5	3	3	1	1	1	18

TABLE 1. Continued.

	Limited Data	1800s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	Total
Lepturini Continued.													
Stenocorus schaumii (LeConte)	1		2	3	3	3	3		2	1	1		19
Stenocorus vittiger (Randall)	6	2	1		6	1	8	1			1		26
Stictoleptura canadensis (Olivier)	9	8	8	5	21	16	12	22	17	12	12	10	152
Strangalepta abbreviata (Germar)	7	8	7	7	22	28	11	14	17	36	19	14	190
Strangalia acuminata (Olivier)	1						1						2
Strangalia bicolor (Swederus)						1							1
Strangalia luteicornis (Fabricius)	2				3	4	6			3	4		22
Strophiona nitens (Forster)	5	4		2	4	6	5		1	1	5	5	38
Trachysida aspera brevifrons (Howden)		1		1	1			3	3	2	2	1	14
Trachysida mutabilis (Newman)	5	3	2	1	20	10	10	18	21	19	21	10	140
Trigonarthris minnesotana (Casey)	1	5		1	18	2	8	12	22	11	15	9	104
Trigonarthris proxima (Say)	7	12	2	6	10	10	15	9	16	10	7	9	113
Typocerus acuticauda Casey	1			1	3		3	1		2	1		12
Typocerus lugubris (Say)	3		2	1									6
Typocerus octonotatus (Haldeman)							1						1
Typocerus sparsus LeConte	3	2	2	2	5	7	10	7	18	15	5	4	80
Typocerus velutinus (Olivier)	6	7	5	8	16	24	19	30	28	48	13	15	219
Xestoleptura octonotata (Say)	4				1	1					1	2	9
Xestoleptura tibialis (LeConte)					3			3	2	2		3	13
Necydalini													
Necydalis mellita (Say)	2				1	2						1	6
Parandrinae													
Parandrini													
Neandra brunnea (Fabricius)	7	5	8	4	16	13	9	7	22	32	12	6	141

TABLE 1. Continued.

	Limited Data	1800s	1900s	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	Total
Prioninae													
Meroscelisini													
Tragosoma depsarium (Linnaeus)	5	4	6		1	1	1	6	7	3		1	35
Prionini													
Orthosoma brunneum (Forster)	3	5	4	2	13	6	9	12	12	11	7	4	88
Prionus laticollis (Drury)	1												1
Prionus pocularis Dalman	3				1	2			2	1	1	1	11
Spondylidinae													
Spondylidini													
Neospondylis upiformis (Mannerheim)									1				1
TOTAL	**535**	**248**	**219**	**282**	**902**	**855**	**861**	**894**	**1010**	**1075**	**750**	**430**	**8062**

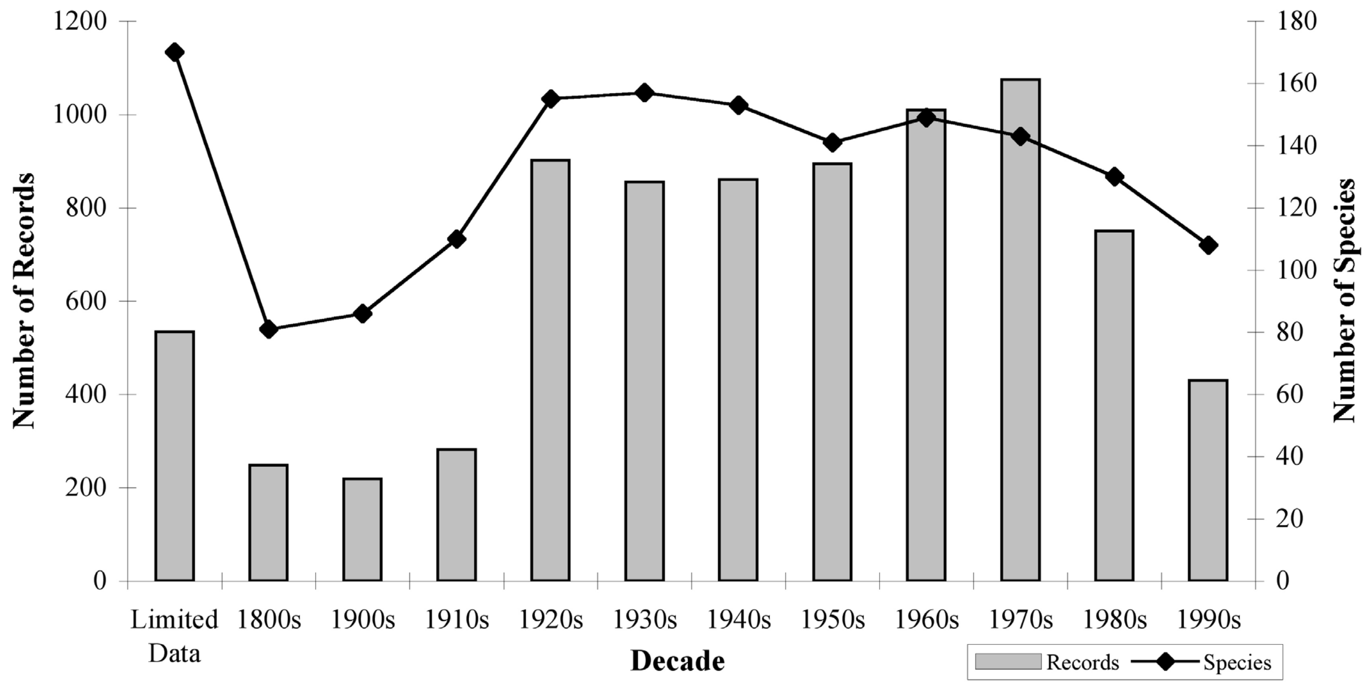

FIGURE 1. Temporal distribution of records (1/location/year) for the 18,469 specimens of Cerambycidae from Ontario. The 'Limited Data' are combined with those from the 1800s, 1900s and 1910s as Before 1920, and those from 1980s and 1990s as 1980–1989 for some analyses.

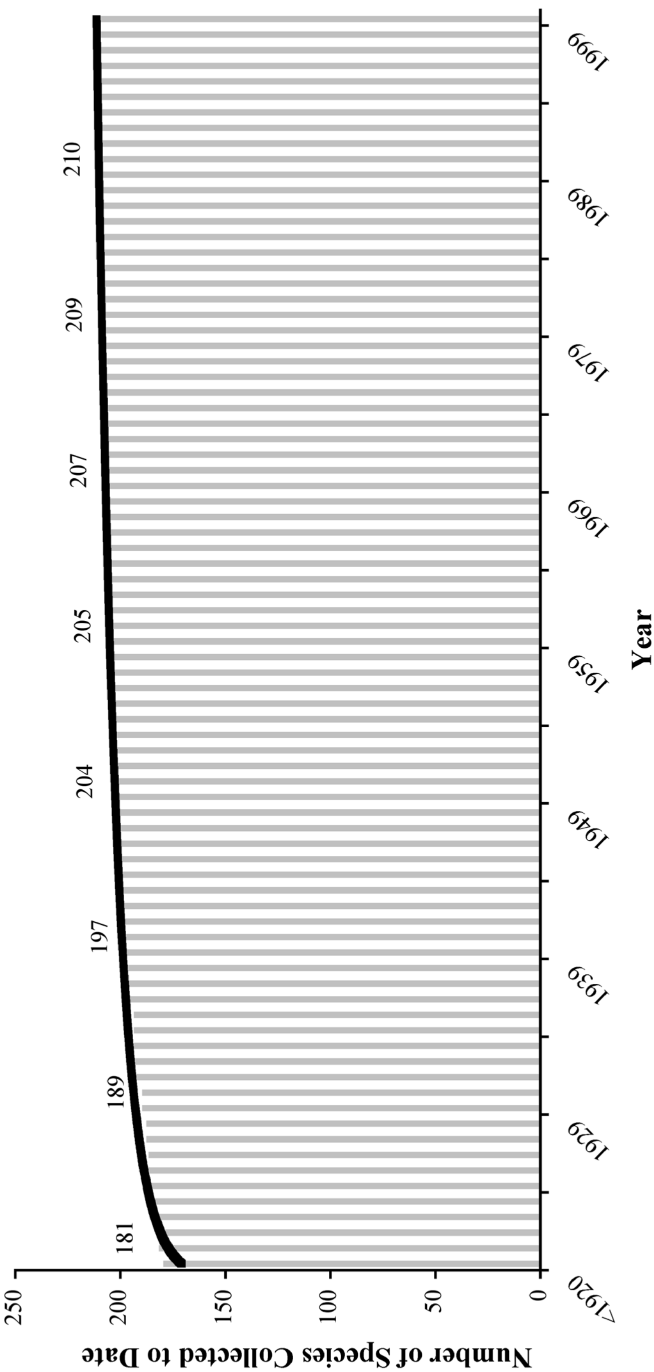

FIGURE 2. Species accumulation curve for Ontario Cerambycidae. The first category represents all cerambycids with limited data on the labels, that is collected prior to 1920.

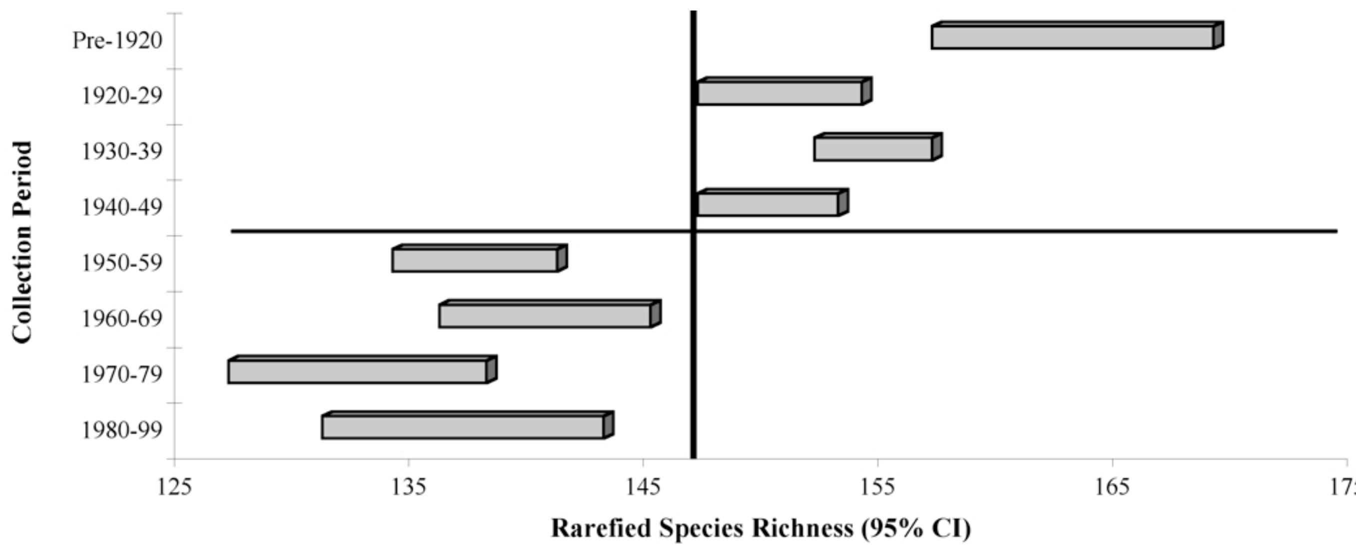

FIGURE 3. Rarefied species richness for Ontario cerambycids for eight ‘decades’. The vertical line shows that the 95% confidence intervals of the four ‘decades’ from before 1950 do not intersect with the 95 % confidence intervals of the four ‘decades’ from after 1950–1999. Estimates are based on a sub-sample of 800 records and 1,000 iterations using EcoSim (Gotelli and Entsminger 2005).

Species only in collections from prior to 1950 or 1950 to 1999. Twenty species were collected prior to 1950, but not between 1950 and 1999 (Table 2). Nine species not collected before 1950 are first represented in collections by specimens collected between 1950 and 1999 (Table 3).

Most species collected only before 1950 or only between 1950 and 1999 were from southern Ontario, that is south of the Canadian Shield (Tables 2, 3). Locality information on labels from 100 years ago is often imprecise. However, most of these species were collected in extreme southern Ontario, along the Lake Ontario shore, Lake Erie shore, or in southwestern Ontario. Of the 28 species in these two categories, only two were collected in central and northern Ontario, with one, *Microclytus compressicollis*, also collected further south.

Many of the species only collected prior to 1950 use hardwoods as larval hosts (Table 2). The relatively few, 3 of the 20, that use conifers are associated with pines. The nine species collected only between 1950 and 1999 included three that use conifers as hosts.

Four significant records since 2000. Since 2000, three species have been detected in Ontario for the first time:

Disteniinae, Disteniini, *Distenia undata* (Fabricius). Ontario, Essex, 10 km E of Essex, 1 August 2000, R. Marchese, Det. BD Gill 2003, CNC. Ontario, Pelee Island, Porchuk property malaise trap 17-22 July and 28 August–10 September 2001, S. A. Marshall and B. Porchuk, DEBU.

Lamiinae, Lamiini, *Anoplophora glabripennis* (Moltschulsky). First identified in Canada on the basis of specimens brought to University of Guelph from packing crates shipped to an industry in Waterloo, Ontario in June of 1998, but not detected outdoors in Canada until 2003 (in northwest Toronto and Vaughan). The Canadian Food Inspection Agency (2005) reports on ongoing attempts to eradicate and maps occurrences up until September 2005.

Lamiinae, Tetraopini, *Tetrops praeusta* (Linnaeus). ONT: Halton (Reg.), Milton, Woodland Trails Cape, 6th Line Nassagewaya, meadow, yellow pans, 5-6 June 2001, S. Paiero, DEBU 00172650 and 00172655. ONT. Wellington Co., Guelph, meadow, 6 June 2002, O. Lonsdale, DEBU00185522.

One species that was not collected between 1950 and 1999 was found after 2000. Cerambycinae, Anaglyptini, *Microclytus compressicollis* (Laporte and Gory). ON Cornwall, 14 May 2003, Old-growth forest F[light] I[ntercept] T[rap]-20, 45° 02.160’ N, 74° 47.470’ W, OG2-COR, R. Zeran, LEMQ.

Discussion

Do we know the Ontario cerambycid fauna? The Cerambycidae in Ontario are well known, in contrast to many insect taxa. Three pieces of evidence support this assertion. About 95% of the species were collected prior to 1950, the species accumulation curve approaches an

TABLE 2. Number of specimens and records of the 20 species of Cerambycidae collected prior to 1950 but not between 1950 and 1999 in Ontario. Locations are from label data and hosts are from Linsley and Chemsak (1997) and Yanega (1996).

Species	Specimens	Records	Locations	Hosts	Collections
Arhopalus rusticus obsoletus (Randall)	5	1	Grand Bend	Pine	CNC
Microclytus compressicollis (Laporte and Gory)	20	9	Thunder Bay, Peterborough, Ottawa, Kitchener, Hamilton	?	CNC, GLFR, ROME, DEBU
Callidium antennatum Newman	1	1	Ridgeway	Pine, Spruce	DEBU
Neoclytus caprea (Say)	2	2	St. Catharines, London	Hickory, Hackberry, Ash, Walnut, Other hardwoods	CNC, DEBU
Neoclytus mucronatus (Fabricius)	11	6	Harrow, Grimsby, Jordan, St. Davids, Ridgeway	Hackberry	CNC, LEMQ, ROME, DEBU
Stenosphenus notatus (Olivier)	2	2	Ridgeway, Prince Edward Co.	Hickory, Hackberry	CNC, DEBU
Obrium maculatum (Olivier)	5	1	Ridgeway	Hickory, Hackberry, Mulberry, Oak	DEBU
Aegomorphus quadrigibbus (Say)	1	1	Eastern Ontario	Maple, Birch, Hickory, Other hardwoods	CNC
Cyrtinus pygmaeus (Haldeman)	9	1	Ridgeway	Maple, Hickory, Redbud, Other hardwoods	CNC, ROME, DEBU
Dorcaschema alternatum (Say)	2	1	Ontario	Mulberry	DEBU

TABLE 2. Continued.

Species	Specimens	Records	Locations	Hosts	Collections
Goes pulcher (Haldeman)	33	9	Ridgeway, Leamington, Cobourg, London, Ottawa	Hickory, Oak, Elm	CNC, ROME, DEBU
Goes tigrinus (DeGeer)	4	3	Ridgeway	Hickory, Walnut, Oak, Elm	DEBU
Oncideres cingulata (Say)	9	2	Guelph, London	Ironwood, Hickory, Hackberry, Other hardwoods	CNC, GLFR, DEBU
Oberea oculaticollis (Say)	1	1	Ojibway	?	CNC
Brachysomida bivittata (Say)	1	1	Toronto	Hardwoods?	DEBU
Strangalia acuminata (Olivier)	3	2	Leamington, Greenwood Lake	Alder, Ironwood, Hop Hornbeam, Ninebark	CNC, DEBU
Strangalia bicolor (Swederus)	1	1	Simcoe	Maple, Oak	CNC
Typocerus lugubris (Say)	24	6	Port Hope, Ridgeway, Peterborough, London	Pine	CNC, ROME, DEBU
Typocerus octonotatus (Haldeman)	1	1	La Salle	Grasses	CNC
Prionus laticollis (Drury)	2	1	London	Hardwoods	DEBU

TABLE 3. Number of specimens and records of the 9 species of Cerambycidae collected only between 1950 and 1999 in Ontario. Locations are from label data and hosts are from Linsley and Chemsak (1997) and Yanega (1996).

Species	Specimens	Records	Locations	Hosts	Collections
Phymatodes maculicollis LeConte	1	1	Alfred	Fir	CMNC
Clytoleptus albofasciatus (Laporte and Gory)	4	3	Hamilton, Pt. Pelee, Prince Edward Co.	Grape	CNC, DEBU
Clytus marginicollis Laporte and Gory	2	2	Constance Bay, Owen Sound	Pine	CMNC, DEBU
Xylotrechus mormonus (LeConte)	1	1	Deux Rivieres	Willow	CNC
Anelaphus pumilus (Newman)	8	2	Rondeau Park	Hickory, Chestnut, Oak, Basswood, Elm	ROME
Oberea erythrocephala (Schrank)	1	2	Braeside, Windsor	Spurge	CNC, DEBU
Acmaeopsoides rufula (Haldeman)	13	9	Searchmount, Icewater Creek, Black Sturgeon Lake, Sault Ste. Marie, Kerr, Vermillion Bay, Quibell, Sudbury	Spruce?	CNC, GLFR, DEBU
Anthophylax viridis LeConte	4	3	Bruce Mines, Tenby Bay	Maple, Birch, Beech	GLFR, ROME
Neospondylis upiformis (Mannerheim)	3	1	Searchmount	Spruce, Pine	GLFR

asymptote, and with a similar collecting effort to before 1950, only 9 additional species were found in the 50 years after 1950. This has been achieved largely through efforts of general collectors. Four significant contributions by cerambycid specialists are by Brimley (1941) from Prince Edward County and environs, Gardiner (e.g. 1957; 1975) in the Sault Ste. Marie area, Hicks from Windsor and Ottawa (e.g. 1947; 1962; 1971), and E. J. Zavitz from Ridgeway in the Niagara Peninsula in the early 1900s.

Four significant records of Cerambycidae collected since 2000 demonstrate that the Ontario fauna is not static. Ranges change through both contraction and expansion, and for many species our understanding of their distributions within Ontario is rudimentary. The arrival of *Anoplophora glabripennis* in northwestern Toronto was expected (Allen and Humble 2002). Its potential to wreak havoc on suburban trees and potentially on native hardwoods in the Carolinian forest has prompted eradication efforts (Ontario Ministry of Natural Resources 2006). Another non-indigenous species, *Tetrops praeusta*, continues to expand its range in eastern North America. *Distenia undata* ranges from Ohio south to the southern Appalachians, and since 2000, it has been found twice in extreme southwestern Ontario, at Harrow and Pelee Island. In fact it is surprising that more species have not expanded their ranges north to include extreme southern Ontario. Species with a wide geographic range, hence more subpopulations, may have a better chance of surviving significant population declines. Prior to 1950 *M. compressicollis* was collected from Thunder Bay to Hamilton and Ottawa, a widespread distribution in Ontario. A specimen collected in 2003 as part of intensive sampling of saproxylic beetles in hardwood forests of eastern Ontario (Zeran et al. 2006) demonstrates it persists in Ontario. As with many other species the specimen raises more questions than it answers. Is it still widespread? What is the host plant? What are its habitat requirements? Is it endangered in Ontario?

Has the number of species in Ontario declined? Both raw species richness and rarefied estimates show about a 10% decline in the number of species collected since 1950. A contributing factor is the 20 species not collected between 1950 and 1999. In addition, 23 species were minimally represented between 1950 and 1999, 20 with only one record and another three collected in only one decade. Only 9 species were first recorded between 1950 and 1999, a net loss of 11 species. The date 1950 is not of special significance, but merely a convenient split to produce two samples with similar collecting effort. Using 1940 or 1960 as the break results in similar patterns. The general trend for lower species richness per decade (Fig. 3) supports this assertion.

The decline in number of species of cerambycids in Ontario may have been driven by environmental change; for cerambycids the most likely changes are in the abundance and distribution of host plants and their habitats. Alternatively, the apparent decline may be a function of collecting biases.

Forest regions: The cerambycids collected only prior to 1950 were concentrated in the southern part of the province, primarily the Carolinian Forest Region. Most of Ontario is boreal forest (dominated by coniferous trees) and Great Lakes-St Lawrence mixed forest (Rowe 1972; Hosie 1990; Armson 2001). Only one species from the boreal forest in northern Ontario, *Microclytus compressicollis*, was not collected 1950–1999; it was also collected further south. In contrast, many species from the Carolinian or deciduous forest region of extreme southern Ontario were not collected from 1950 to 1999. This forest region occupies a limited area along the north shore of Lake Ontario, west to Pinery Provincial Park on Lake Huron and all areas to the south, including the Niagara Peninsula and the north shore of Lake Erie (Rowe 1972; Larson et al. 1999). Despite the limited geographic area, at least 16 of the 20 species collected only prior to 1950 are known only from this area. In contrast only two of the nine species collected only between 1950 and 1999 were restricted to the Carolinian forest region.

Clearing land for farms, towns and cities, and for timber extraction removed most of southern Ontario's original forest cover before 1900 (Armson 2001). Reduction of forest area is most pronounced in the Carolinian because of intensive agriculture and the concentrations of urban centres (Austen et al. 1994; Larson et al. 1999; Armson 2001). Significant forest loss from the small overall area of Carolinian forest in Ontario has contributed to the reduction in its unique cerambycid fauna and consequently to the Ontario fauna as a whole.

Host plants: The distribution of each cerambycid species depends on the range of appropriate host plants. Southern hardwoods, such as hickory and hackberry, are the host plants of half of the 20 species collected only before 1950. Given the decline of Carolinian forests, it is not surprising many of these apparently declining species use southern hardwoods as hosts. Of the 9 species collected only between 1950 and 1999, only *Anelaphus pumilus* uses southern hardwoods (hickories) as hosts.

The lack of collections after 1950 of three species that feed on pine was not expected, because White Pine, *Pinus strobus* L., is still a reasonably common and widespread tree, even if there are fewer really old trees now. In addition, Red Pine, *P. resinosa* Soland and Jack Pine, *P. banksiana* Lamb, are now more common in southern Ontario in plantations, especially on abandoned farms on poor sandy soils.

Are the species not collected between 1950 and 1999 extirpated? Our understanding of current distributions of cerambycids is based on specimens in insect collections, as are the compilations of Linsley and Chemsak (e.g. 1985; 1995), McNamara (1991) and McCorquodale (2002). Unlike the recent atlas of bird distributions in Ontario (Cadman et al. 1987), we have no broad, recent, focused, geographical surveys of cerambycids. Though we do have a reasonable inventory, and an apparent decline in the number of species, we do not have sufficient information to assert that the lack of specimens of a particular species in post-1950 collections represents a significant population decline or an extirpation.

At first glance the decline in the number of species does not appear to be the result of a lack of collecting because there are more specimens and records from 1950–1999 than prior to 1950. It seems unlikely that the ability of collectors has declined since 1950, and certainly our understanding of natural history and host plant use has increased. General collecting has revealed new records for Ontario, for example *Anelaphus pumilus*, *Clytoleptus albofasicatus*, *Anthophylax viridis*, and *Clytus marginicollis*. All were part of general insect collecting rather than focused collecting for cerambycids.

However, since 1950 there has been limited collecting in southern Ontario by cerambycid specialists and this may have reduced the number of species collected. The hard to collect specimens may have been missed because specialized knowledge and collecting techniques were lacking. In southern Québec, where similar changes in forest cover have occurred, there has been not been a similar decline in species richness in collections of cerambycids. The main reason is a cadre of keen amateur coleopterists with specialized knowledge of cerambycid natural history (e.g. Laplante 1989).

The hypothesis that the number of cerambycid species in Ontario has declined since 1950 is eminently testable. Focused collecting of cerambycids in the Carolinian forests of extreme southern Ontario, specifically the Niagara Peninsula, Long Point, Rondeau, Point Pelee, and Pinery, could provide the data. If many of the species in Table 2 were to be collected, the logical conclusion would be that the decline is more apparent than real, wheras if these species were not found, the contention that the decline is real would be supported.

Data on phenology, distribution, and abundance would be useful. The COSEWIC species at risk ranking (Committee on the Status of Endangered Wildlife in Canada 2004) for the 20 species only collected prior to 1950 and the 9 collected only between 1950 and 1999, would likely be 'Data Deficient'. The lack of information about population size, population trends, geographic range in Ontario, and the paucity of records would all contribute to this designation.

Challenges: Understanding wood boring beetles has not been a priority for the public, government agencies, or research institutions in Ontario or Canada. Phenology and host preferences of only a few species of cerambycids have been studied in Ontario (e.g. Hicks 1947; 1962; 1971; Gardiner 1954; 1955; 1957; 1975). Therefore specific habitat requirements and phenology in Ontario are largely unknown. With such a low priority, the opportunity to develop expertise has been limited. This lack of interest is not limited to the Cerambycidae, as shown by this quote from a recent book on forest insect pests in Canada: 'There is no current research being conducted in Forestry Canada on any of the wood-boring insects described in this chapter' (Safranyik and Moeck 1995). Since then, spurred by the detection of Brown Spruce Long-horned Beetle, *Tetropium fuscum*, in Nova Scotia and Asian Long-horned Beetle, *Anoplophora glabripennis*, in Illinois, New York, and recently Ontario, there has been a redirection of efforts by Canadian researchers (e.g. Allison et al. 2001; Peddle et al. 2002). If we are going to understand what changes are occurring in the Ontario cerambycid fauna, understand the reasons behind the changes and be prepared to detect novel introductions, it is necessary to consider native and introduced species, and have the expertise to identify both (Huber and Dang 2003).

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