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GROUND BEETLES OF ISLANDS IN THE WESTERN BASIN OF LAKE ERIE AND THE ADJACENT MAINLAND (COLEOPTERA:CARABIDAE, INCLUDING CICINDELINI)

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ABSTRACT

We report 241 species representing 63 genera of ground beetles from the islands of the western basin of Lake Erie and selected mainland sites from a 1991–93 survey, plus specimens examined in public and private collections, and previously published sources. Most species are generally distributed; however, a restricted population of *Sphaeroderus schaumii schaumii* we rediscovered is no doubt imperiled. Comparison of wing morphotype frequencies of the Lake Erie island species with mainland populations from studies in Ohio and Michigan support a hypothesis that vagility is of increased import in the islands. Regression and correlation analysis show a positive relationship between species number and island area, no correlation between species number and distance from the mainland and an improved fit for a multiple regression which includes collecting effort.

The beetle fauna of the islands of Lake Erie has not been studied intensively. Inventories of other terrestrial invertebrates such as Lepidoptera (Nault et al. 1989), spiders (Beatty 1988) and isopods (Dexter et al. 1988) have been published.

Lake Erie's western basin archipelago contains 22 islands which are of land-bridge origin (Fig 1). Water filled the Erie basin ca. 4000 years b.p. isolating pre-existing dolomitic and limestone hills as islands (Forsyth 1988). Oak and maple forest, typical of the region, were most likely predominant on the islands. Native Americans intermittently occupied the islands; immigrants arrived in the early in the 19th century and permanent settlements were established by 1822 (Mohr 1931). All islands larger than 0.01 km^2 have had or presently have human inhabitants. Mining (Mohr 1931, Courter 1974) and viniculture (Boerner 1984) rapidly transformed and dominated the landscape. Changes in flora of the islands are reported by McCormick (1968), Hamilton & Forsyth (1972), Boerner (1984), Duncan & Stuckey (1970). Raccoons, rats, and feral cats are abundant on inhabited islands. Historically, free-ranging swine were found on South Bass Island. Tourism has supplanted mining and viniculture as the major economic base of the islands and disturbance in upland areas has declined in recent years. Comparison of aerial photographs from 1985 (Musgrave & Derenger 1985) with those taken in 1993 during our survey showed no significant changes in the pattern of forestation.

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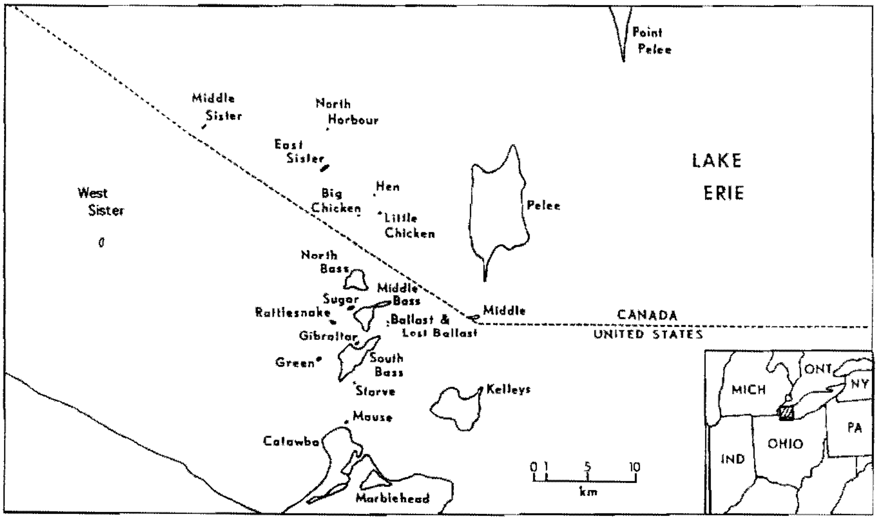

Figure 1. Lake Erie's western basin archipelago.

South Bass Island is a notable exception. Permanent structures have been built recently, primarily in forested areas. The history of severe perturbation in this region has no doubt altered the composition of the beetle fauna.

The survey area contains a wide variety of habitats. The lake shore has sand, gravel or bedrock beaches, cliffs and coastal marshes (Herdendorf & Monaco 1988a, 1988b). Uplands are wooded with thin rocky soils and are typically mesic though extremely dry during mid-summer. Dominant hardwoods are maples (*Acer* sp.) and hackberries (*Celtis occidentalis*). A few wet lowland areas support ash (*Fraxinus* sp.) and cottonwood (*Populus deltoides*). Abandoned agricultural sites are found in all stages of succession. Many of the islands are largely fallow or cultivated fields.

MATERIALS AND METHODS

Standard insect collecting techniques were employed (Southwood 1978). These included day hand-collecting and night hand-collecting using a headlamp, aerial and sweep nets, ultraviolet and mercury-vapor light systems, pitfall traps and Malaise traps. Voucher specimens are held in the collections of K.Will, F.Purrington or the F.T. Stone Laboratory (Put-In-Bay, Ohio) collection.

Additional data were gathered from collections at The Ohio State University, F.T. Stone Laboratory and the Ashland County Historical Museum, Ashland, Ohio. Many specimens were collected by students, instructors and researchers at F.T. Stone Laboratory. Lindroth (1961-69) reported many species from the "north shore of Lake Erie"; however, only records specifically listed as Point Pelee or Pelee Island are reported here.

We compared wing length data for macropters vs. brachypters from the Erie islands with data from two mainland studies: The Wilderness Center, Stark County, Ohio (Purrington et. al. 1989) and Manistee National Forest,

Table 1. Islands in the western Basin of lake Erie considered for testing assumptions of island biogeography.

Island	# Species (current)	Area (h^2)	# of dates collected	Distance to mainland (km)
Green I.	32	8	146	6.0
Kelleys I.	62	1132	31	5.1
Middle Bass I.	21	329	10	9.5
North Bass I.	25	285	8	13.3
Pelee I.	51	4270	4	13.5
Rattlesnake I.	11	26	1	9.5
South Bass I. + Gibraltar I.	112	637	128	4.5
Starve I.	2	1	1	4.0
West Sister I.	36	31	1	13.4

Michigan (Liebherr & Mahar 1979). Like our survey, these studies employed pitfall traps and other collecting techniques designed to capture ground beetles not commonly collected in pitfall traps.

In order to properly compare these three studies only species collected during 1981–93 were used for the island data and species considered to have questionable flight capabilities were omitted. Species were omitted based on the following criteria: 1. species with atrophied wing muscles (Lindroth 1961–69), 2. species with reduced wings (but not fully brachypterous), 3. species that are wing-dimorphic or polymorphic. Shore species (five species, all macropters) found in the Lake Erie islands are omitted in order to control for an increase in macroptery related to the extensive shore habitat not found in the mainland sites. Wing length information is from Lindroth (1961–69), Liebherr & Mahar (1979), Erwin (1970), Purrington et. al.(1989) or from our inspection of specimens collected on the Lake Erie islands. Using these data, morphotypes were tallied and comparison of similarity was done using chi-squared analysis.

With data from 10 of these islands the assumptions of the island biogeography species-area and species-distance from the mainland paradigms (McArthur & Wilson 1967) are tested using simple and multiple regression analysis (Klinkenberg 1988). Variables considered were area, distance from the mainland and collecting effort. Islands considered in this study are listed in Table 1. Distances to the mainland were taken from King (1988) or measured using topographic maps. Measurements of area were taken from Herdendorf and Monaco (1988). Collecting effort is measured as number of unique collecting dates and pitfall trap-days.

Gibraltar Island is sheltered by Put-In-Bay harbor and less than 400m from South Bass Island. The mercury-vapor security lights on Gibraltar Island were constantly "sampling" beetles from South Bass Island. Students at Stone Laboratory frequently collected samples from these lights. For these reasons all variables for Gibraltar Island are included in the South Bass Island totals. East Sister Island and Sugar Island were not systematically collected during the current period (1981–93) and so are not used in this analysis. Mouse Island is less than 500m from the mainland and cannot be considered separate from it. Species used are those collected during the 1981–93 period.

Correlation analysis was done to establish the relationships among species number, area, distance to the mainland and collecting effort. The species number-area relationship and species number-collecting effort relationships were analyzed using simple regression of log transformed data. Analysis was also done using multiple regression for species number-area + collecting effort (number of collecting dates recorded) using log transformed data.

RESULTS AND DISCUSSION

Species are recorded for 13 of the 22 islands and 24 adjacent mainland sites. A total of 241 species was collected or recorded. Of these, 160 have most recently been collected during the "current" period (1981–93), 49 from the "recent" period (1950–1980), 26 known only from the "historic" period (pre-1950) and six are undated. Records prior to 1981 account for 43 of the 50 species found only on the mainland. Of the species reported here 46 are exclusively from Lindroth (1961–69). Lindroth's collections were made primarily in the mid-1950s when conditions existed that caused stratification of western Lake Erie (Britt 1955a). These conditions may have contributed to influxes noted by Lindroth. Most of the species reported by Lindroth were taken in beach drift. All species are listed in table 2.

Overall, flight-wing lengths of the 241 species from the Lake Erie islands were 84.6% (204) macropterous, 10.0% (24) brachypterous, 4.1% (10) dimorphic or polymorphic and 1.2% (3) remain uncharacterized.

Using the criteria above results of the χ^2 analysis were as follows: Lake Erie islands, 90.3% (132) macropters, 9.7% (13) brachypters; Stark County, Ohio, 74.1% (43) macropters, 25.9% (15) brachypters; Manistee National Forest, Michigan, 67.7% (23) macropters, 32.4% (11) brachypters. The mainland sites did not differ significantly from each other (χ^2 = 0.45) and are significantly different from the Lake Erie islands (χ^2 =26.63, df=1, p=0.001). The islands have a higher occurrence of macropterous species than these mainland sites. This supports the hypothesis that macroptery is favored in the Great Lakes islands because of the increased importance of vagility for ground beetle colonization of these islands.

Ås (1984) found that brachypterous ground beetle species in the Stockholm archipelago, Baltic Sea, were more common than the adjacent mainland. Conclusions made by Ås (1984) are not comparable to those of the current analysis. The limnetic, atmospheric and epigaeic conditions of the Baltic Islands are sufficiently different so that analysis of those islands, and perhaps all other oceanic islands, may result in a different wing type compositions than those found on land-bridge, fresh water islands. In the Erie Islands differential success in re-colonization may maintain the high proportion of long-winged species on the islands. The dynamics involved in the colonization and re-colonization of islands in the Great Lakes maintains a relatively high number of macropterous species. This insular effect may only be found in fresh water islands and probably can not be applied broadly to all islands.

Results of correlation analysis show a significant relationship between species number and area (Pearson correlation coefficient = 0.85) and species number and collecting dates (Pearson correlation coefficient = 0.63). No significant correlation between species number and distance from the mainland was found (Pearson correlation coefficient = 0.17).

Simple regression of species-area shows a significant positive relationship (r^2 = 0.72, p = 0.003). Regression analysis of species number and collecting dates fell below the level of significance (r^2 = 0.41, p = 0.06). Multiple regression done using both collecting effort and area showed a positive relationship (r^2 = 0.77, F = 10.33, Significance F = 0.01). The multiple regression model does not add to the predictive ability of the model but explains variation to a greater extent as shown by the slight increase in the r^2 value. The relationship

Table 2. An annotated list of the ground beetles from the islands of western Lake Erie and adjacent mainland . Key to Sections of Table 2:

SPECIES: Nomenclature follows Bousquet & Larochelle (1993), listed alphabetically. Superscipt numbers refer to notes at the end of the table. * = introduced into North America (Bousquet 1992).

LOCATIONS: Two-letter codes are used for islands and mainland counties, **GI**-Gibraltar I., Ottawa Co., **GR**-Green I., Ottawa Co., **KE**-Kelleys I., Erie Co., **MB**-Middle Bass I., Ottawa Co., **MC**-Mainland Canada, Point Pelee, Ontario, **ME**-Mainland, Erie Co., **MO**-Mainland, Ottawa Co., **NB**-North Bass I., Ottawa Co., **PE**-Pelee I., Ontario, Canada, **RS**-Rattlesnake I., Ottawa Co., **SB**-South Bass I., Ottawa Co., **WS**-West Sister I., Ottawa Co.

PERIOD COLLECTED: H-Historical, refers to collections prior to 1950, R-Recent refers to collections made from 1950 through 1980, C-Current refers to collections made after 1980, ?-Period inferred by collector's period of activity, no date given. [-]-Date information not available

FREQUENCY COLLECTED: This refers to collections *only* during the 1991,92,93 seasons and *only* in the study area. [-]-not collected during study, *i.e.* records from literature or specimen examined from a collection, **o**-only collected once and usually only one specimen, **r**-rarely collected, usually temporally or habitat restricted, **u**-uncommon, collected only in low numbers though often widespread, **c**-common, found abundantly in all suitable habitats, in good numbers.

COLLECTION METHOD: **a**-aspirator, **b**-beating sheet, **h**-hand collected (typically diurnal collecting), **l**-headlamp (nocturnal collecting), **mv**-mercury-vapor light, **n**-aerial net, **p**-pitfall, **s**-sweep net, **t**-treading, **uv**-ultraviolet light, [-]-no information available

WING: **M**-macropterous, flight observed, **m**-macropterous, specimens checked, **(m)**-macropterous, literature referenced, **(m)**B_1-macropterous, literature reference;dissection done and flight muscles atrophied, **b**-brachypterous, specimens checked, **(b)**-brachypterous, literature referenced, **d**-dimorphic, specimens checked and found to be dimorphic, **(d)B**-dimorphic, literature reference; specimens checked and all found to be brachypterous, **(d)m**-dimorphic, literature reference; specimens checked and all found to be macropterous, **(d)**-dimorphic, literature referenced, **(p)**-polymorphic, literature referenced, [-]-No information available

SPECIES	GI	GR	KE	MB	MC	ME	MO	NB	PE	RS	SB	WS	Period	Freq	Method	Wing
Acupalpus nanellus Casey[1]					+								R	–	–	(m)
A. partiarius (Say)[1]					+				+				R	–	–	(m)
A. pauperculus Dejean					+						+		RC	r	mv uv	m
A. pumilus Lindroth[1]					+								R	–	–	(m)
A. rectangulus Chaudoir[1]					+								HR	–	–	(m)
A. testaceus Dejean			+		+								RC	r	a	(m)
Agonum aeruginosum Dejean			+						+				C	r	ht	m
A. albicrus Dejean[1]					+								R	–	–	(m)
A. crenistriatum (LeConte)[1,4]					+				+		+		HR?	–	–	(m)
A. cupripenne (Say)								+					C	o	–	m
A. decorum (Say)[6]		+	+	+				+	+		+		RC	u	h	(m)
A. extensicolle (Say)[7]	+		+	+	+	+	+		+		+		HRC	c	h	(d)m
A. ferreum Haldeman										+			C	o	h	(m)
A. galvestonicum (Casey)[1]					+								R	–	–	(m)
A. harrisii LeConte									+				C	o	h	(m)
A. melanarium Dejean			+	+					+		+	+	HRC	c	hp	m
A. moerens Dejean					+				+		+		HC	r	h	(m)
A. nutans (Say)[4]						+							H	–	–	(m)
A. palustre Goulet												+	C	o	h	(m)
A. placidum (Say)	+					+	+				+	+	HRC	c	h uv	m
A. punctiforme (Say)			+								+	+	HRC	c	hu	(m)
A. rufipes Dejean[1]					+								R	–	–	(m)

Table 2. Continued.

SPECIES	GI	GR	KE	MB	MC	ME	MO	NB	PE	RS	SB	WS	Period	Freq	Method	Wing
A. striatopunctatum Dejean[1]					+								R	–	–	(m)
A. tenue (LeConte)											+		C	o	–	m
A. thoreyi Dejean												+	C	o	mv	(m)
A. trigeminum Lindroth												+	C	o	h	(m)
Amara angustata (Say)[8]			+		+	+					+		HRC	r	hs	(m)
A. apricaria (Paykull)*						+					+		C	r	mv h	(m)
A. convexa LeConte[1]					+								R	–	–	(m)
A. cupreolata Putzeys	+				+				+		+		RC	r	s mv	m
A. exarata Dejean		+			+								RC	o	p	m
A. familiaris (Duftschmid)*								+				+	C	r	–	(m)
A. littoralis Mannerheim[9]											+		C	r	h p mv	m
A. pallipes Kirby	+												C	r	mv	m
A. quenseli (Schönherr)[1]					+				+				HR	–	–	(p)
A. rubrica Haldeman			+										C	o	–	(m)
Amphasia interstitialis (Say)											+		HC	o	–	m
A. sericea (T.W. Harris)	+										+		C	u	mv uv	m
Anisodactylus agricola (Say)[10]		+	+								+		C	u	hlp	(m)B_1
A. caenus (Say)											+		C	o	mv	m
A. carbonarius (Say)[1,4]					+		+						HR	–	–	(m)
A. discoideus Dejean							+				+		HRC	r	–	(m)
A. harrisii LeConte											+		C	o	h	m
A. kirbyi Lindroth									+				C	r	h	(m)
A. melanopus (Haldeman)					+						+		RC	o	–	(m)
A. ovularis (Casey)[1]					+								R	–	–	(m)
A. rusticus (Say)[4]							+						H	–	–	(m)
A. sanctaecrucis (Fabricius)			+			+		+					C	r	–	(m)
A. verticalis (LeConte)[1]					+								R	–	–	(m)
Apenes sinuatus (Say)					+								R	–	–	(m)
Apristus latens (LeConte)[1]					+								HR	–	–	(m)
A. subsulcatus (Dejean)[11]			+						+				C	r	ha	(m)
Badister grandiceps Casey[1]					+								R	–	–	(m)
B. ocularis Casey[1]					+								R	–	–	(m)
B. reflexus LeConte			+										C	o	h	(m)
B. transversus Casey											+		C	r	uv	(m)
Bembidion affine Say	+	+	+				+		+		+	+	C	c	uv mv t	M
B. americanum Dejean			+								+		HRC	c	h	(m)
B. bifossulatum (LeConte)	+												C	o	mv	m
B. confusum Hayward[3]			+										R	–	–	(m)
B. cordatum (LeConte)							&						C	r	h	m
B. frontale (LeConte)			+				+						C	r	a	(m)

B. impotens Casey			+			+	+				+		C	c	t uv mv	m
B. lacunarium (Zimmermann)[12]									+		+		C	r	h	b
B. obscurellum (Motschultzsky)			+										C	o	–	m
B. patruele Dejean	+		+			+	+		+		+	+	HC	c	hat	m
B. planum (Haldeman)[13]	+		+	+			+		+		+		C	c	h	(m)
B. punctatostriatum Say			+										C	r	–	m
B. quadrimaculatum (Linne')[14]												+	C	o	a	(m)
B. rapidum (LeConte)	+	+	+	+		+	+	+	+		+		C	c	a uv mv	(m)
B. rolandi Fall				+									C	o	h	(m)
B. rupicola (Kirby)		+	+								+		C	r	uv	m
Brachinus alternans Dejean[5]									+				H	–	–	(m)
B. americanus (LeConte)[2]							+						–	–	–	(b)
B. cordicollis Dejean[2]											+		–	–	–	(m)
B. cyanochroaticus Erwin[15]					+				+				C	r	h	m
B. fumans (Fabricius)[4]											+		H	–	–	m
B. janthinipennis (Dejean)[2]					+	+							–	–	–	(d)
B. kavanaughi Erwin[2]											+		–	–	–	(m)
B. tenuicollis LeConte[2]					+								–	–	–	(m)
Bradycellus congener (LeConte)									+		+		C	u	h uv mv	(m)
B. nigriceps LeConte			+				+				+		C	o	uv	m
B. rupestris (Say)			+								+		HC	r	ah	(m)
B. tantillus (Dejean)			+								+		C	u	mv h	(m)
Calathus gregarius (Say)[16]		+							+		+		RC	c	hlp	d
C. opaculus LeConte[4]											+		H	–	–	m
Calleida punctata LeConte				+	+	+	+	+			+		HRC	r	–	(m)
Calosoma externum (Say)[1]					+								R	–	–	(m)
C. scrutator (Fabricius)[3,4]					+	+					+		HR	–	–	(m)
C. wilcoxi LeConte[1]					+								H	–	–	(m)
Carabus goryi Dejean[1]					+								H	–	–	(b)
C. maeander F. von Waldheim[4,17]						+							H	–	–	(b)
C. serratus Say[4]									+				H	–	–	(d)B
Chlaenius aestivus Say[18]			+		+	+	+	+	+		+		HRC	c	phl	(d)B
C. brevilabris LeConte											+		C	o	h	(m)
C. cordicollis Kirby[19]			+	+				+	+		+		HRC	u	h	m
C. emarginatus Say				+	+						+	+	HRC	r	h	(m)
C. impunctifrons Say		+		+			+		+				HC	u	hp	(m)
C. laticollis Say						+							H	–	–	(m)
C. lithophilus Say			+										C	o	h	(m)
C. nemoralis Say					+				+				HRC	o	–	(m)
C. pennsylvanicus Say[20]		+	+			+			+	+	+		HRC	u	–	(m)
C. pusillus Say[1]					+								R	–	–	(m)
C. sericeus (Forester)[4]							+		+		+		H	–	–	(m)

Table 2. Continued.

SPECIES	GI	GR	KE	MB	MC	ME	MO	NB	PE	RS	SB	WS	Period	Freq	Method	Wing
C. tricolor Dejean[21]	+	+	+	+				+	+		+	+	HC	c	p mv uv	m
Cicindela formosa Say[3,4,22]						+			+				H	–	–	(m)
C. hirticollis Say			+			+	+		+				HC	r	n	m
C. punctulata Olivier							+		+		+		HRC	r	n	M
C. repanda Dejean[23]			+	+			+		+				HRC	c	n	M
C. scutellaris LeConte[4,24]						+					+		H	–	–	(m)
C. sexguttata Fabricius[3,4]						+	+						H	–	–	(m)
Clivina americana Dejean[25]					+		+				+	+	RC	u	t	(m)
C. bipustulata (Fabricius)		+				+	+				+		HRC	c	h uv mv	M
C. impressefrons LeConte		+	+		+						+		C	c	h uv mv	M
Colliuris pensylvanica (Linne')									+				C	o	–	(m)
Cratacanthus dubius (Beauvois)[26]								+					C	o	h	(d)B
Cyclotrachelus freitagi Bousquet												+	C	r	l	b
C. sodalis (LeConte)							+			+	+		HRC	u	hl	b
Cymindis limbatus (Dejean)[1]					+								R	–	–	(m)
C. pilosus Say[1]					+								–	–	–	(d)
C. platicollis (Say)[1]					+								R	–	–	(m)
Dicaelus ambiguus La.-Sen.[3,4,27]											+		HR	–	–	(b)
D. elongatus Bonelli[1,4]									+				H	–	–	(b)
D. purpuratus Bonelli[1]									+				H	–	–	(b)
D. sculptilis Say[28]							+	+	+		+	+	HRC	c	hlp	b
D. teter Bonelli[4]											+		H	–	–	(b)
Diplocheila assimilis (LeConte)[4]						+							H	–	–	(m)
D. impressicollis (Dejean)			+		+		+		+		+		RC	r	h	m
D. major (LeConte)					+				+		+		RC	r	h	m
D. obtusa (LeConte)[1]					+								R	–	–	(m)
D. striatopunctata (LeConte)		+							+		+		C	r	hp	m
Discoderus parallelus (Haldeman)[1]					+								R	–	–	(m)
Dyschirius erythrocerus LeConte											+		C	o	mv	(m)
D. haemorrhoidalis (Dejean)[4]						+							H	–	–	–
D. integer LeConte											+		C	o	mv	(m)
Dyschirius sp[29]		+	+								+		C	r	–	b
Elaphropus anceps (LeConte)[30]				+									C	o	a	m
E. ferrugineus (Dejean)		+	+										C	r	–	b
E. saturatus (Casey)												+	C	o	–	m
E. vivax (LeConte)			+										C	o	a	m
E. xanthopus (Dejean)[1]					+								R	–	–	–
Elaphrus californicus Mannerheim							+	+			+		RC	o	h	(m)
Galerita janus (Fabricius)[3,4]			+								+		HR	–	–	(m)
Geopinus incrassatus (Dejean)	+						+				+		HC	o	–	(m)

Harpalus affinis (Schrank)*	+						+		+	+		C	u	uv	m
H. caliginosus (Fabricius)		+			+					+	+	HRC	r	mv	m
H. compar (LeConte)	+	+				+	+	+	+	+		HRC	c	uv mv	(m)
H. eraticus Say[3,4]					+	+						H	–	–	(m)
H. erythropus Dejean	+					+		+		+	+	HC	u	–	(m)
H. faunus Say			+							+		HC	o	–	(m)
H. fulgens Csiki				+						+	+	RC	r	–	(m)
H. longicollis LeConte								+		+	+	C	r	l	(m)
H. pensylvanicus DeGeer	+	+			+	+	+		+	+	+	HRC	c	mv uv l	(m)
H. providens Casey	+	+						+		+		RC	u	lh	(m)
H. puncticeps (Stephens)*	+						+		+	+	+	C	c	mv uv	M
H. somnulentus Dejean[1]				+								R	–	–	(m)
Lachnocrepis parallela (Say)[1]				+								R	–	–	(m)
Lebia analis Dejean		+								+		C	u	b	(m)
L. atriventris Say										+		C	o	uv	(m)
L. fuscata Dejean			+				+					RC	r	–	(m)
L. grandis Hentz		+										C	o	uv	(m)
L. lobulata LeConte[1]				+								R	–	–	(m)
L. pumila Dejean[31]			+									C	o	a	m
L. solea Hentz[4]						+						R	–	–	(m)
L. tricolor Say[4]										+		H	–	–	(m)
L. viridipennis Dejean		+			+							HC	o	–	(m)
L. viridis Say	+				+		+			+		HRC	c	uv mv b	(m)
Leptotrachelus dorsalis (Fabricius)					+					+		C	r	uv mv	(m)
Lophoglossus scrutator LeConte								+				C	r	h	m
Loricera pilicornis (Fabricius)[32]	+											C	o	h	m
Loxandrus minor (Chaudoir)[1]				+								R	–	–	(m)
L. velocipes Casey				+		+						RC	r	h	m
Loxandrus sp A[33]								+				C	o	h	m
Loxandrus sp B[34]						+						C	o	h	m
Microlestes brevilobus Lindroth[35]		+	+	+								RC	r	h	(m)
M. linearis (LeConte)[1]				+								R	–	–	(b)
Mioptachys flavicauda (Say)		+						+				C	r	–	(m)
Myas coracinus (Say)[1]				+								R	–	–	(b)
Nebria lacustris Casey[36]			+									C	r	lh	m
Notiobia nitidipennis (LeConte)[37]	+			+								RC	o	uv	m
N. sayi (Blatchley)										+		C	o	–	(m)
N. terminata (Say)	+				+					+		C	u	uv	m
Omophron americanum Dejean			+		+	+		+				HC	u	uv	(m)
O. robustum Horn[3]						+						H	–	–	(m)
O. tessellatum Say[3]			+									R	–	–	(m)
Oodes amaroides Dejean[1]			+	+								R	–	–	(m)
O. americanus Dejean[38]			+	+				+				RC	u	h mv	M
O. brevis Lindroth[1]				+								R	–	–	(m)

Table 2. Continued.

SPECIES	GI	GR	KE	MB	MC	ME	MO	NB	PE	RS	SB	WS	Period	Freq	Method	Wing
Panagaeus fasciatus Say[1]					+								R	–	–	(m)
Paratachys oblitus (Casey)							+				+		C	r	–	m
P. proximus (Say)[39]		+									+		C	u	uv	M
Patrobus longicornis (Say)[40]			+	+				+	+		+	+	HR?C	u	hl	d
Perigona nigriceps (Dejean)*											+		C	o	mv	(m)
Platynus cincticollis (Say)		+			+		+	+			+		HRC	u	–	(m)
P. decentis (Say)[4]									+				H	–	–	(m)
P. hypolithos (Say)[4]	+												R	–	–	(b)
P. tenuicollis (LeConte)					+						+		RC	r	h	(b)
Plochionus timidus Haldeman											+		C	o	–	(m)
Poecilus chalcites (Say)	+		+		+		+				+		RC	c	uv mv l	m
P. lucublandus (Say)							+				+	+	HC	c	uv h p	m
Pterostichus adoxus (Say)											+		C	u	h	(b)
P. atratus (Newman)[41]			+	+			+		+		+		HRC	c	hlp	b
P. caudicalis (Say)									+		+		RC	r	–	(m)
P. commutabilis (Motschultsky)					+				+				RC	o	h	(m)
P. corvinus (Dejean)				+									C	o	h	(m)
P. ebeninus (Dejean)			+		+								RC	o	–	(m)
P. femoralis (Kirby)					+				+				H	–	–	(d)
P. luctuosus (Dejean)			+	+		+			+				HC	u	h	(m)
P. melanarius (Illiger)[42]*	+	+	+				+	+		+	+	+	C	c	hp	d
P. mutus (Say)		+								+	+	+	RC	u	h	(m)
P. novus Straneo[1]									+				R	–	–	(b)
P. stygicus (Say)	+		+	+		+	+	+	+		+	+	RC	c	hlp	b
P. tristis (Dejean)											+		C	u	h	b
Scaphinotus elevatus(Fabricius)[3,43]						+							H	–	–	(b)
Scarites quadriceps Chaudoir	+		+		+		+				+		HR?C	u	h	m
S. subterraneus Fabricius[44]	+		+	+	+	+			+	+	+	+	HR?C	u	h	m
Schizogenius ferrugineus Putzeys[1]					+								HRC	–	–	(b)
S. lineolatus (Say)								+					C	o	–	m
S. sulcifrons Putzeys[1]					+								R	–	–	–
Selenophorus ellipticus Dejean[1]					+								R	–	–	(m)
S. hylacis (Say)					+							+	RC	o	uv	m
S. opalinus (LeConte)			+								+		C	r	–	m
S. pedicularis Dejean	+				+								RC	o	mv	(m)
S. planipennis LeConte[1]					+								H	–	–	(m)
Sphaeroderus shaumii Chaudoir[45]											+		HRC	r	lp	b
Stenolophus carbonarius (Dejean)[1]					+								R	–	–	(m)
S. comma (Fabricius)	+	+	+			+	+				+	+	RC	c	h uv mv	m
S. conjunctus (Say)					+				+				RC	o	–	m
S. lecontei (Chaudoir)	+	+	+	+		+	+	+	+		+	+	RC	c	h uv mv	m
S. lineola (Fabricius)		+			+	+					+		RC	r	–	(m)
S. megacephalus Lindroth[1]					+								R	–	–	(m)

S. rotundatus LeConte		+	+					RC	o	–	m
S. rotundicollis Haldeman		+	+					RC	o	–	(m)
Stenolophus sp.[46]		+				+	+	C	u	mv	b
Tachyta nana (Gyllenhal)[47]	+	+						C	u	h	(m)
Tetragonoderus fasciatus (Hald.)[48]		+	+					C	c	h	(m)
Trichotichnus autumnalis (Say)			+		+			HR	–	–	(m)
T. dichrous (Dejean)[1]			+					R	–	–	(m)
T. vulpeculus (Say)					+	+		RC	r	h l uv	(m)
Zuphium americanum Dejean[1]			+					R	–	–	(m)

Additional Records: East Sister I.-Current period, *Chlaenius tricolor, Pterostichus melanarius*; Mouse I.-Current period, *Trichotichnus vulpeculus, Nebria lacustris, Chlaenius tricolor, Agonum placidum*; Sugar I.-Historic period, *Pterostichus atratus, Amphasia interstitialis*; Starve I.-Current period, *Stenolophus lecontei*, Historic period, *Chlaenius cordicollis*; Mainland Sandusky Co. USA-Historic Period, *Cicindela repanda, Dicaelus elongatus, Pterostichus stygicus*

[1]Lindroth (1961–69); [2]Erwin (1970); [3]F.T. Stone Laboratory collection; [4]The Ohio State University Collection; [5]Ashland County Historical Museum Collection; [6]Found with *Brachinus cyanochroaticus* and *Diplocheila major*.; [7]Lindroth (1961–69) reports short-winged examples (not from our study area), eight individuals from various islands were examined, all have fully reflexed wings.; [8]Collected in fallow vineyard by sweeping forbs.; [9]Found in weedy and disturbed areas.; [10]Lindroth (1961–69) regards wings as too small to be functional. Dissections of several individuals from Green I. revealed wings reflexed at the tip and flight muscles atrophied. Flight is not possible.; [11]On sand mixed with organic material on Kelleys I. and Pelee I. beaches; [12]In Lindroth (1961–69) in "damp moss and leaves in shady places", all specimens collected during our survey were on the lake shore (in gravel on South Bass I. and in coarse sand on Pelee I.; [13]Lindroth (1961–69) gives habitat as near " rivers and brooks". Found among the dolomitic gravel at the edge of the wave splash. Difficult to collect as they move rapidly in the interstitial spaces. Probably occurs on gravel beaches throughout the island region. [14]Subspecies *oppositum* Say; [15]Found with *Agonum decorum*; [16]Lindroth (1961–69) reports a single long-winged specimen from Nova Scotia. One hundred individuals were inspected for wing development and only one macropter (female) was found.; [17]Author-Fischer von Waldheim; [18]Lindroth (1961–69) notes as found near running water and in flood plains. In the islands this species was found well away from open water but in moist habitats. Found at night climbing the trunks of small trees up to one meter off the ground. Lindroth (1961–69) notes this is a wing dimorphic species (polymorphic). Fifty specimens were examined and all found to be true brachypters.; [19]Found abundantly under limestone slabs on the shore of Pelee and Kelleys islands. Larvae were numerous in the early summer. Both adult and larvae were very active, foraging among the rocks.; [20]One specimen reared from a larva found in the sand on Kelleys I. beach.; [21]Found feeding on slugs.; [22]Subspecies *generosa* Dejean.; [23]Observed probing moist sand and capturing larval Diptera on Middle Bass I.; [24]Subspecies *lecontei* Haldeman; [25]Adults found alive, burrowing in the substrate under decaying flotsam.; [26]Lindroth (1961–69) records the short-winged form from Tex. & N.Mex and the long-winged form from S.C. & N.B. The single example from our study was brachypterous.; [27]Author is LaFerté-Sénectère; [28]Subspecies *intricatus* LeConte. This species occurs in areas of moderate perturbation. Often found among myrtle (*Vinca minor*). Observed at night climbing tree trunks to one meter high. Found feeding on worms.; [29]Specimens key to *D. globulosus* Say in Lindroth (1961–69), Bousquet (1988) however, does not differentiate between *D. globulosus* and D. *longulus* LeConte.; [30]Collected among the

Table 2. Continued.

duckweed on mud edge of a stagnant pool of water.; [31]Collected alive from drift material on Kelleys I.; [32]Collected alive among decaying eel grass on the gravel beach.; [33]Single female is part of a species complex (Allen 1972). The known range *L. extendus* is the only species in the complex near the study area.; [34]Single female either *L. vitiosus* Allen or *L. duryi* Wright; [35]Collected live from drift.; [36]Found on moss covered rocks at the edge of the wave splash zone.; [37]Lindroth (1961-69) reports this species as "appearing in great numbers among drift". That may have represented a rare event. Only taken once in our survey and no other records were found for the island region.; [38]Subspecies *fluvialis* LeConte.; [39]All specimens on Green I. came to uv light during a very short period a just after dusk.; [40]Checked 7 for wing length; 5 short 2 long. One long-winged specimen from South Bass I. and one from West Sister I. Lindroth (1961-69) reports that the macropterous form is "rare".; [41]Several found feeding on fresh hickory nut meat from nut scraps left by feeding squirrels.; [42]Introduced to North America from Europe via ship ballast (Lindroth 1957, Spence 1990) and first recorded in Nova Scotia in 1926 (Lindroth 1961-69). Lindroth (1961-69) notes this species in southern Ontario (no date given) and Western Ontario (Fort William 1948). The exact period of introduction into the islands cannot be deduced, however, it is probably more recent than 1948. Long-wing predominance is reported to be a sign of recent introduction and subsequent extension of the species' range (Lindroth 1961-69). In stable, established populations the short-winged form is more common (Lindroth 1949,1961-69). The islands have an extremely high number of long-winged individuals. Of the 388 individuals 95.5% (370) were macropters. The high percentage of macropters in the island population could be evidence that the introduction of *P. melanarius* to the islands was relatively recent. Trap studies in Alberta, Canada (Niemela & Spence 1991) showed proportions of macropters varying from 15% to 75% in all sites where more than two individuals were collected. The high rate at which the long-winged form has been observed to occur in the islands seems to support a recent introduction hypothesis. However, populations found on the islands may be subject to constant influxes of long-winged colonizers which maintain the skewed proportion.; [43]Subspecies *flammeus* Haldeman. The only data on this specimen, "Castalia Marsh" is very dubious.; [44]Lindroth (1961-69) reports this from the shore of Lake Erie but during our survey this species was found only in mesic woods and fields.; [45]Lindroth (1961-69) states "true" *S. nitidicollis* Chev. is restricted to Newfoundland, "form" *brevoorti* LeConte. is found in the northern mainland and subspecies *schaumi* Chaudoir is found in Ohio, Michigan and Virginia. Bousquet & Larochelle (1993) report the correct spelling as *schaumii*, author Chaudoir and the author of *nitidicollis* is Guérin-Mêneville. The population on the islands is *Sphaeroderus shaumii shaumii*; [46]Two males from West Sister I., one female from South Bass I., and a teneral female from Kelleys I. seem to have external characteristics that lie between *S. conjunctus* and *S. rotundicollis*. Genitalia of the males do not appear to conform to the descriptions of any of the species in Lindroth (1961-69). Wing is a small scale. This may represent a "sunk" species which is in fact distinct or a new species.; [47]Subspecies *inornata* (Say); [48]Author is Haldeman.

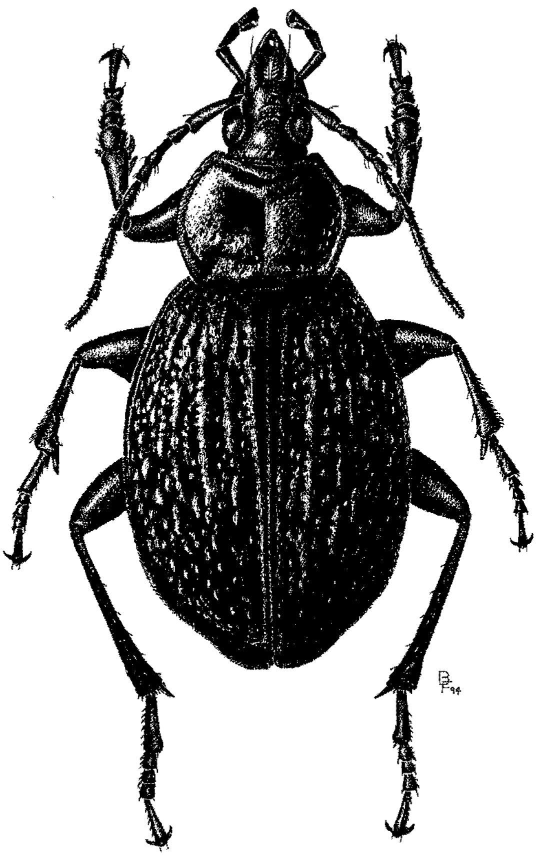

Figure 2. *Sphaeroderus shaumii shaumii* Chaudoir.

of collecting effort to species number accounts for some variation in the data which is an artifact of non-uniform sampling.

Ground beetle species number does show a significant positive relationship to area as predicted by the island biogeographical theory and no negative relationship exists between distance from the mainland and species number. This is consistent with the predicted species supersaturation (sensu King 1988) of land-bridge islands, but is not conclusive and must be considered in light of human activity on the islands. Extensive disruption has occurred and virtually no portion of the islands can be said to have been undisturbed. Supersaturation prior to human settlement of the islands no doubt existed with a different species composition. Human disturbance of habitats may cause differential extirpation. Ground beetle colonizers arriving with humans either constitute a small enough number as not to alter the equilibrium or their ability to disperse to all islands equally, creates an equilibrium simulating supersaturation.

The snail-eating ground beetle, *Sphaeroderus schaumii schaumii* Chaudoir (Fig. 2), is represented by more than a dozen specimens collected on South Bass Island prior to 1935. Scattered records from outside the study area exist for Ohio and Michigan but none more recent than 1962. Other putative subspecies are found in the southern Appalachians. During our survey we rediscovered a population on South Bass Island. Four males were collected and one female caught and released. The site where all specimens were found is upland maple-hackberry woods (Boerner 1984). A single large oak tree and a prominent dolomite ridge, exposed above the surface, suggests that up to the present the immediate area has escaped development. Similar areas on South Bass Island were simultaneously sampled but no *S. s. schaumii* were found. The collection site is extremely small and threatened by development. The great paucity of recent records indicates that the habitat and this species are threatened in Ohio. A lack of recent systematic publications on the Cychrini in eastern North America leaves the taxonomic delineation of *Sphaeroderus* species and subspecies unclear. Preservation of the habitat where this ground beetle is found is an immediate necessity. Further surveys of mainland areas in the recorded range of *S. s. schaumii* for extant populations are needed.

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LITERATURE CITED

Allen, R.T. 1972. A revision of the genus *Loxandrus* LeConte (Coleoptera:Carabidae) in North America. Entomol. Am. 46:1–184.

Ås, S. 1984. To fly or not to fly? Colonization of Baltic islands by winged and wingless carabid beetles. Journal of Biogeography. 11:413–426.

Beatty, J.A. 1988. Spiders of the Lake Erie islands. pp. 95–105. *In*:J.F. Downhower (ed.), The biogeography of the island region of western Lake Erie. The Ohio State University Press, Columbus, OH.

Boerner, R.E.J. 1984. Forest composition on the Lake Erie islands. Am. Midl. Nat. 111:173–184.

Bousquet, Y. 1988. *Dyschirius* of America north of Mexico: description of new species with keys to species groups and species (Coleoptera:Carabidae). Can. Entomol. 120:361-387.

______. 1992. *Bembidion femoratum* Strurm and *Amara communis* (Panzer) (Coleoptera: Carabidae) new to North America. J. New York Entomol. Soc. 100:503-509.

Bousquet, Y & A. Larochelle. 1993. Catalogue of the Geadephaga (Coleoptera: Trachypachidae, Rhysodidae, Carabidae including Cicindelini) of America North of Mexico. Entomol. Soc. Can. Memoirs.167:1-397.

Britt, N.W. 1955a. Stratification in western Lake Erie in summer 1953: effects on the *Hexagenia* (Ephemeroptera) population. Ecology. 36:239-244.

Courter, E.W. 1974. Crystal cave: A celestite prodigy. Lapidary J. July.

Dexter, R.W.,W.F. Hahnert, & J.A.Beatty, 1988. Distribution of the terrestrial Isopoda on the islands of western Lake Erie. pp. 95-105. *In*:J.F. Downhower (ed.), The biogeography of the island region of western Lake Erie. The Ohio State University Press, Columbus, OH.

Duncan, T. & R.L. Stuckey. 1970. Changes in the vascular flora of seven small islands in western Lake Erie. Mich. Bot. 9:174-199.

Erwin, T.l. 1970. A reclassification of bombardier beetles and a taxonomic revision of the North and Middle American species (Carabidae:Brachinida). Quaest. Entomol. 6:4-215.

Forsyth, J.L. 1988. The geological setting of the Lake Erie islands. pp. 11-23. *In*:J.F. Downhower (ed.), The biogeography of the island region of western Lake Erie. The Ohio State University Press, Columbus, OH.

Hamilton, E.S. & J.L. Forsyth. 1972. Forest communities of South Bass I. Island, Ohio. Ohio J. Sci. 72:190-210.

Herdendorf, C.E. & M.E.Manoca. 1988a. Physical and chemical limnology of the island region of Lake Erie. pp. 30-46. *In*: J.F. Downhower (ed.), The biogeography of the island region of western Lake Erie. The Ohio State University Press, Columbus, OH.

Herdendorf, C.E. & M.E.Manoca. 1988b. Biological and ecological limnology of the island region of Lake Erie, pp. 30-46. *In*: J.F. Downhower (ed.), The biogeography of the island region of western Lake Erie. The Ohio State University Press, Columbus, OH.

King R.B. 1988. Biogeography of reptiles on islands in Lake Erie, pp125-133. *In*: The Biogeography of the Island region of western Lake Erie. J.F. Downhower (Ed). The Ohio State University Press, Columbus.

Klinkenberg, B. 1988. The theory of island biogeography applied to the vascular flora of the Erie islands, pp. 95-105. *In*: The Biogeography of the Island region of western Lake Erie. J.F. Downhower (ed). The Ohio State University Press, Columbus.

Liebherr, J.K. & J. Mahar. 1979. The carabid fauna of the upland forest in Michigan: survey and analysis. Coleop. Bull. 32:183-197.

Lindroth, C.H. 1949. Ground Beetles (Carabidae) of Fennoscandia, a zoogeographic study, Part III. English translation 1992. J. Adis.(ed.) & T.L. Erwin.(Scientific Coordinator) Smithsonian Institution Libraries.

______. 1957. The faunal connection between Europe and North America. Wiley, New York.

______. 1961-69. The Ground-Beetles (Carabidae, excl. Cicindelinae) of Canada and Alaska, Parts 1-6. Opuscula Entomol. XX, XXIV, XXIX, XXXIII, XXXIV, XXXV. (suppl.)

MacArthur, R.H. & E.O. Wilson. 1967. The theory of island biogeography. Monographs in Population Biology 1, Princeton University Press, Princeton.

McCormick, J. 1968. Vegetation of fallow vineyards, South Bass Island, Ohio. Ohio J. Sci. 68:1-10.

Mohr, E.B. 1931. The Geology of the Bass islands. M.S. Thesis. The Ohio State Univ. Columbus.

Musgrave, D.K. & G.D. Derringer. 1985. Soil Survey of Ottawa County, Ohio. U.S. Dept. Agri., Soil Conservation Service.

Nault, B.A., R.W. Rings & D.J. Horn. 1989. Lepidoptera recorded from the islands of western Lake Erie, with a brief account of geology and flora. Great Lakes Entomol. 22:111–119.

Niemela, J. & J.R. Spence. 1991. Distribution and abundance of an exotic ground-beetle (Carabidae): a test of community impact. Oikos 62:351–359.

Purrington, F.F., J.E. Bater, M.G. Paoletti & B.R. Stinner. 1989. Ground beetles from a remnant oak-maple-beech forest and its surroundings in northeastern Ohio (Coleoptera:Carabidae). Great Lakes Entomol. 22:105–110.

Spence, J.R. 1990. Success of European carabid species in western Canada: preadaption for synanthropy?-pp. 129–141. *In*: The role of Ground beetles in ecological and environmental studies. Intercept, Andover.

Southwood, T.R.E. 1978. Ecological Methods, with particular reference to the study of insect populations. 2ed. Chapman & Hall.