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Survey of Arthropod Fauna on European Buckthorn, *Rhamnus cathartica*, in Minnesota

BY

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Abstract

The objective of this study was to carry out a comprehensive survey of all arthropod species associated with buckthorn, in various habitat types in Minnesota. This survey provides baseline information on the availability of feeding niches for potential control agents and threats by predators or parasitoids to agent establishment. A total of eight different buckthorn infestations were sampled for insect fauna in southeastern Minnesota. In two years of sampling, a total of 267 species representing 82 families and 13 orders were collected (excluding unidentified Diptera). The majority of the species collected are represented by only a few specimens. Most herbivores collected were generalists and will feed on a variety of plants. There was no substantial damage to foliage found at any of the sampled sites. In addition, there appear to be no insects that have a feeding niche specific to common buckthorn in Minnesota. We surmise that insect herbivores will not interfere with the establishment of an introduced biological control agent. However, a large diversity of generalist parasitoids and predators were collected which could be a source of biotic resistance, potentially affecting the selection and establishment of a biological control agent for common buckthorn.

Introduction

Common buckthorn or European buckthorn, *Rhamnus cathartica* L., is non-native tree capable of growing 30 feet tall (Godwin 1943). In North America, it was originally sold as hedging; however, buckthorn's competitive abilities have allowed it to out-compete many of North America's native forest species. Buckthorn can form dense under-stories in forest habitats out-competing native plants including tree seedlings such as oaks, maples, and birches (Archibold *et al.* 1997, Catling 1997). The presence of common buckthorn has a broad range of effects on the natural ecosystem ranging from changes in soil composition to increased predation on songbirds (Heneghan *et al.* 2002, Heneghan *et al.* 2004, Schmidt and Whelan 1999). The Minnesota Department of Agriculture has placed common buckthorn on the restricted noxious weed list, which regulates the possession, transport and sale of this plant.

Multiple methods of control are currently being used against buckthorn including cut stump treatments, foliar herbicide applications and burning (Archibold *et al.* 1997, Moriarty 2005). Such control efforts are expensive (labor and materials) and for the most part are only effective on a small scale. In an attempt to develop a long-term solution for managing buckthorn, the Minnesota Department of Natural Resources initiated research on the potential for classical biological control. The initial phase of this research is to survey for potential agents in the native range of common buckthorn. Working in collaboration with CABI Bioscience Center, Switzerland, research was initiated in Europe in 2001. The goal is to introduce host specific biological control agents from Europe that can reduce the growth and abundance of buckthorn.

Prior to the introduction of any biological control agent, researchers must understand what insect species are currently utilizing common buckthorn in North America and how this may affect their establishment and control success. Biological control establishment and control success may be limited due to feeding niches occupied by native or non-native insects. Another potential threat to successful establishment could occur if a closely related insect already exists in North America and if so, if the natural enemies (parasitoids, predators, pathogens) of this native insect can attack the candidate biological control agent. Our objective was to conduct a survey of all arthropod species associated with buckthorn, with a specific focus on various Minnesota habitats known to harbor large buckthorn infestations in Minnesota. This information will provide key information in understanding the availability of feeding niches for potential control agents and provide insights on threats to agent establishment in various site types in Minnesota.

Materials and Methods

Field sites:

Seven buckthorn infestations in 2004 and six buckthorn infestations in 2005 were selected in southeastern Minnesota, for studying insect fauna on buckthorn (Table 1). Because sampling protocol was changed between years, sampled sites varied between years. Three urban landscapes included: University of Minnesota St. Paul Campus, Ramsey County (2004 only); Tierney Wood's and Hyland Park in Three Rivers Park

District, Hennepin County. Two Mississippi river basin sites were Battle Creek Park, Ramsey County; and Frontenac State Park, Goodhue County. Agricultural landscapes, located south of the Twin Cities metro area were UMORE Park, University of Minnesota Outreach, Research- Experiment station, Dakota County; Courthouse Park, Waseca County (2004 only); and Sakata State Park, Le Sueur/Rice County (2005 only).

2004 Sampling protocol:

At each site, twelve common buckthorn plants were marked for repeated sampling, four in each of three size categories, small (<1m in height), medium (1-3m), and large (>3m). All branches or all reachable branches for large trees were visually surveyed every two weeks for insect fauna, following procedures developed by collaborators at CABI, Delemont, Switzerland. At each site, two transects were surveyed monthly during the growing season. The first transect consisted of 25 consecutive buckthorn trees growing parallel to path, roadway or other opening where buckthorn had full exposure to the sun. The second transect of another 25 consecutive buckthorn trees was laid out perpendicular to the first transect. The second transect included plants growing in the under-story where seedlings grew in shade or filtered sunlight

All trees selected were visually sampled for approximately one minute. Any insect found in that time were collected and identified. Immature insects were reared to adult in the laboratory for identification. Some insects experienced high mortality rates when confined to small rearing containers with buckthorn cuttings. In these cases a sleeve cage made of "no-see-um" netting was placed over the tree to exclude predators and to contain the insects of interest until the insects molted to the adult stage in the field. Once insects in the sleeve cages reached the adult stage, representatives are collected and identified. Soft bodied insects and any immature insects that failed to reach the adult stage during rearing were preserved in vials containing 70% ethanol. Records were maintained on each insect including the site, date collected, and individual tree number for comparison between sites and among sites and years.

2005 Sampling protocol:

At each site, 50 buckthorn trees were selected for sampling; 25 consecutive trees along a roadside or path which receives direct sunlight and 25 consecutive trees located in the shaded under-story which receives shade or filtered sunlight. Each buckthorn tree was sampled for approximately 2 minutes. Insects and eggs that were found were removed, returned to the laboratory and placed into Petri dishes to allow development to the adult stage. Records were maintained on each insect relating to the location and date collected. As adults emerge, insects were preserved and identified.

For each sampling site, a survey of site characteristics was conducted which will aid in comparing the diversity and abundance of insects collected in the insect fauna survey. At each site, 10 randomly selected 1m by 1m plots were sampled. Data collected in each plot included: percent shade coverage, diameter of surrounding trees within 1m radius of plot, diameter of buckthorn trees, percent buckthorn coverage, percent native vegetation coverage and native vegetation abundance/diversity.

Results

In 2004, surveys began 24 May and ended on 24 September. In 2005, surveys began 9 May and ended on 10 September. Identified species collected on buckthorn can be found in Table 2. A total of 497 and 1239 adult specimens were collected in 2004 and 2005, respectfully. The higher number of specimens collected may be explained by an earlier sampling start in 2005 in order to collect insects that are only present in early spring when foliage is expanding. Also, 2004 data may be underestimated because one species, *Metcalfa pruinosa,* was very abundant (over 100 specimens) and collection of this species stopped halfway through the 2004 sampling year.

At the time of this report, Diptera have yet to be sorted and identified. Results that follow do not include these unsorted specimens. There are 267 different species found in 82 families and 13 orders represented in the collection. Hemiptera/Homoptera (83 species) was the most abundant, followed by Hymenoptera (75 species), and Coleoptera (56 species). Several species were found in abundance in both 2004 and 2005, including: *Graphocephala coccinea* (Homoptera: Cicadellidae), *Metcalfa pruinosa* (Homoptera: Flatidae), *Lasius alienus* (Hymenoptera: Formicidae) and *Harmonia axyridis* (Coleoptera: Coccinellidae). The two Homopterans are herbivore generalists and are known to feed on many different plants. *Lasius alienus* (an ant species) was found in abundance tending aphid colonies on buckthorn and searching for food. *Harmonia axyridis* (multi colored Asian ladybeetle) is a predator that typically feeds on aphids and which is known to prefer arboreal habitats.

We had little success in rearing immature insects to adults. Table 3 is a list of immature insects that died in the rearing process. Immatures of five insect species were reared on buckthorn and the adults were identified as: *Acanalonia conica* (Homoptera: Acanoloniidae), *Metcalfa pruinosa* (Homoptera: Flatidae), *Neoxabea bipunctata* (Orthoptera: Gryllidae), Tortricidae spp. (Lepidoptera), and *Gyponana quebecesseus* (Homoptera: Cicadellidae). In a literature search of these five species, all are categorized as generalist herbivores that include Rhamnaceae.

Discussion

One main of this study was to identify major herbivores present on common buckthorn in Minnesota. Overall, there was an abundance of herbivores collected. Despite finding high densities of a few herbivore species, there was no substantial damage that could be considered sufficient to limit the growth and reproduction of buckthorn. For most of the insect species, only a few specimens were collected during the study. This research does not show any herbivore abundant or specific enough to buckthorn that would be affected by the removal of buckthorn from Minnesota. For most of the insect species, only a few specimens were collected during the study, suggesting that they are either transient or generalists that do not commonly utilize buckthorn.

A second objective of this study was to identify possible sources of biotic resistance, like parasitoids and predators that might interfere with establishment of an introduced biological control agent. The high number of parasitoids and predators

found on buckthorn in Minnesota are all considered generalists. These parasitoids and predators may interfere with establishment and expansion of a biological control agent if abundant prey is available. The most abundant generalist predator was the multi-colored Asian lady beetle, *H. axyridis*. This coccinellid is an abundant predator that could pose a threat to certain groups of insects like psyllids if selected as bio-control agents. This non-native coccinellid could be a source of biotic resistance with the establishment of a bio-control agent especially if a vulnerable life stage is present during times of *H. axyridis* high density. How much of an impediment *H. axyridis* may be needs further study and analysis.

In summary, although there is large insect guild associated with common buckthorn in Minnesota, availability of feeding niches seems likely due to the lack of insect specificity and lack of damage to buckthorn observed in the field. The large diversity of parasitoids and predators, may hinder establishment of potential biological control agent. More research, however, would be required to determine if biotic resistance could play a significant role is the success of biological control for common buckthorn.

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Table 1. Locations of common buckthorn infestations included in arthropod surveys.

Site	County	GPS location		Site type	Sampling years
Battle Creek Park	Ramsey Co.	44.93028°N	93.02241°W	River Basin	2004-2005
Courthouse Park	Waseca Co.	44.02383°N	93.52713°W	Agriculture	2004
Frontenac State Park	Goodhue Co.	44.50360°N	92.32187°W	River Basin	2004-2005
Hyland Lake Park	Hennepin Co.	44.83088°N	93.36778°W	Urban Forest	2004-2005
Saint Paul Campus	Ramsey Co.	44.98912°N	93.18786°W	Urban Forest	2004
Sakata State Park	Le Sueur Co.	44.21834°N	93.58220°W	Agriculture	2005
Tierney Woods Park	Hennepin Co.	44.85396°N	93.39247°W	Urban Forest	2004-2005
UMORE Park	Dakota Co.	44.70401°N	93.07005°W	Agriculture	2004-2005

Table 2. Insect species collected from *Rhamnus cathartica* in Minnesota.

		No. of Specimens		
Order	**Family *Genus species***	**2004**	**2005**	**Total**
Collembola		14	51	65
	Entomobryidae sp. a	1	5	6
	Entomobryidae sp. b	11	13	24
	Entomobryidae sp. c	1	0	1
	Isotomidae sp. a	0	1	1
	Isotomidae sp. b	1	0	1
	Sminthuridae sp. a	0	6	6
	Sminthuridae sp. b	0	25	25
	Sminthuridae sp. c	0	1	1
Orthoptera		18	15	33
	Acrididae *Melanoplus viridipes*	2	1	3
	Acrididae *Melanoplus walshii*	0	1	1
	Gryllidae *Neoxabea bipunctata*	10	5	15
	Gryllidae *Oecanthus fultoni*	3	1	4
	Gryllidae *Oecanthus niveus*	0	2	2
	Tettigoniidae *Amblycorypha oblongifolia*	0	2	2
	Tettigoniidae *Conocephalus fasciatus*	1	1	2
	Tettigoniidae *Orchelimum nigripes*	0	1	1
	Tettigoniidae *Scudderia furcata*	1	1	2
	Tettigoniidae *Scudderia* sp.	1	0	1
Phasmida		2	1	3
	Heteronemiidae *Diapheromera femorata*	2	1	3
Thysanoptera		0	1	1
	Phlaeothripidae	0	1	1
Psocoptera		41	62	103
	Psocoptera sp. a	5	5	10
	Psocoptera sp. b	5	2	7
	Psocoptera sp. c	1	0	1
	Psocoptera sp. d	23	29	52
	Psocoptera sp. e	5	15	20
	Psocoptera sp. f	0	2	2
	Psocoptera sp. g	1	0	1
	Psocoptera sp. h	1	0	1
	Psocoptera sp. i	0	9	9
Hemiptera / Homoptera		149	470	619
	Anthocoridae *Orius insidiosus*	0	2	2

Miridae *Agnocoris rubicundus*	1	0	1
Miridae *Ceratocapus fuscinus*	2	1	3
Miridae *Ceratocapus modesta*	2	1	3
Miridae *Diaphnocaris provancheri*	1	1	2
Miridae *Hyaliodes harti*	7	6	13
Miridae *Hyaliodes vitripennis*	3	2	5
Miridae *Lygocoris caryae*	1	0	1
Miridae *Lygocoris viburni*	0	1	1
Miridae *Metriorrhynchomiris dislocatus*	1	0	1
Miridae *Paraproba capitata*	6	8	14
Miridae *Phytocorus spicatus*	2	4	6
Miridae *Psallus morrisoni*	1	0	1
Miridae *Reuteria bifurcata*	2	0	2
Miridae *Reuteria fuscicornis*	0	1	1
Miridae *Reuteria querei*	0	1	1
Miridae *Taedia scrupeus*	1	0	1
Miridae *Taedia pallidulus*	1	0	1
Nabidae *Lasiomerus annulatus*	10	15	25
Pentatomidae *Acrosternum hilare*	1	1	2
Pentatomidae *Banasa calva*	0	1	1
Pentatomidae *Banasa dimidiata*	1	2	3
Pentatomidae *Euschistus tristigmus*	8	9	17
Pentatomidae *Holcostethus abbreviatus*	1	0	1
Pentatomidae *Podisus maculiventris*	0	1	1
Reduviidae *Zelus luridus*	0	1	1
Reduviidae *Acholla multispinosa*	1	0	1
Rhopalidae *Boisea trivittatis*	4	0	4
Saldidae *Saldula pallipes*	0	1	1
Tingidae *Corythuca pergandei*	0	5	5
Acanaloniidae *Acanalonia bivattis*	0	1	1
Acanaloniidae *Acanalonia conica*	9	11	20
Aphididae *Aphis glycines*	7	17	24
Aphididae *Aphis glycines / nasturtii*	0	39	39
Aphididae *Aphis nasturtii*	0	26	26
Aphididae sp. a	0	1	1
Aphididae sp. b	0	1	1
Aphididae sp. c	0	1	1
Aphididae sp. d	1	0	1
Aphididae sp. e	1	0	1
Aphididae sp. f	1	2	3
Aphididae sp. g	3	0	3
Aphididae sp. h	0	2	2
Aphididae sp. i	0	2	2
Aphididae sp. j	0	1	1
Aphididae sp. k	0	1	1
Cercopidae *Clastoptera obtusa*	0	7	7
Cercopidae *Philaenus spumarius*	2	8	10

	Cicadellidae *Agalliota quadripunctata*	1	2	3
	Cicadellidae *Conenus intricatus*	1	0	1
	Cicadellidae *Empoasca distracta*	0	3	3
	Cicadellidae *Empoasca fabae*	0	1	1
	Cicadellidae *Empoasca pergrada*	0	1	1
	Cicadellidae *Empoasca sp.* a	1	0	1
	Cicadellidae *Empoasca sp.* b	0	5	5
	Cicadellidae *Empoasca sp.* c	0	4	4
	Cicadellidae *Empoasca sp.* d	1	1	2
	Cicadellidae *Empoasca sp.* e	0	2	2
	Cicadellidae *Empoasca sp.* f	0	1	1
	Cicadellidae *Empoasca sp.* g	0	1	1
	Cicadellidae *Empoasca sp.* h	0	4	4
	Cicadellidae *Graphocephala coccinea*	21	64	85
	Cicadellidae *Gyponana quebecesseus*	4	9	13
	Cicadellidae *Idiocerus formosus*	2	0	2
	Cicadellidae *Idiocerus levis*	2	0	2
	Cicadellidae *Jakradia olitorius*	9	6	15
	Cicadellidae *Osbornellus auronitens*	0	1	1
	Cicadellidae *Penthimia americana*	1	2	3
	Cicadellidae *Ponana puncticollis*	2	0	2
	Cicadellidae *Scaphytopius acutus*	0	1	1
	Cicadellidae *Typhlocyba gillellei*	0	1	1
	Derbidae *Anotia kirkaldyi*	0	1	1
	Derbidae *Anotia robertsoni*	1	0	1
	Derbidae *Cedusa incisa*	8	2	10
	Derbidae *Otiocerus wolfii*	1	0	1
	Flatidae *Metcalfa pruinosa*	11	164	175
	Membracidae *Ceresa bubalus*	0	1	1
	Membracidae *Ceresa dicevos*	0	1	1
	Membracidae *Cyrtolobus pictus*	0	1	1
	Psyllidae *Cacopsylla negundinis*	0	4	4
	Psyllidae *Livia maculipennis*	0	1	1
	Psyllidae *Pachypsylla celtidus*	0	2	2
	Psyllidae *Psylla floccosa*	2	0	2
Neuroptera		3	3	6
	Chrysopidae *Chrysoperla plorabunda*	2	1	3
	Chrysopidae *Chrysoperla rufilabris*	0	1	1
	Hemerobiidae *Hemerobius humilinus*	1	1	2
Coleoptera		89	140	229
	Anobiidae *Protheca* sp.	1	0	1
	Apionidae *Apion* sp.	0	1	1
	Attelibadae *Eugnemptus angustatus*	0	1	1
	Buprestidae *Agrilus* sp.	1	0	1
	Cantharidae *Cantharis bilineatus*	1	0	1

Cantharidae *Podabrus punctulatus*	0	1	1
Cantharidae *Podabrus rugulosus*	5	0	5
Cantharidae *Polemius laticornis*	2	0	2
Cantharidae *Rhagonycha dichrous*	1	0	1
Carabidae *Lebia* nr. *pomula*	0	1	1
Cerambycidae *Molorchus bimaculata*	0	1	1
Cerambycidae *Strangalia luteic*	1	0	1
Chrysomelidae *Diabrotica longicornis*	1	5	6
Chrysomelidae *Altica chalygea*	1	2	3
Chrysomelidae *Chaetocnema pulicaria*	2	0	2
Coccinellidae *Chilocoris stigma*	1	1	2
Coccinellidae *Coccinella septempunctata*	2	0	2
Coccinellidae *Coleomegilla maculata*	3	2	5
Coccinellidae *Harmonia axyridis*	44	68	112
Coccinellidae *Hippudamia parenthesis*	0	1	1
Coccinellidae *Psyllobora vigintimaculata*	0	2	2
Coccinellidae *Scymnus kansanus*	2	2	4
Coccinellidae *Scymnus rubricandus*	0	1	1
Corylophidae *Corylophodes marginicollis*	1	1	2
Curculionidae *Anametis granulata*	0	1	1
Curculionidae *Conotrachelus* nr. *elegans*	1	0	1
Curculionidae Entiminae	0	1	1
Curculionidae Molytinae	0	1	1
Curculionidae *Polydrosus sericeus*	2	5	7
Curculionidae *Tachypterellus quadrigibbus*	1	1	2
Curculionidae *Thysandenemis fraxini*	1	2	3
Curculionidae *Tychius picirostris*	0	1	1
Curculionidae *Tychius stephensi*	1	0	1
Melyridae *Attalus confusus*	1	1	2
Elateridae *Melanotus similis*	1	0	1
Elateridae *Athos brightwelli*	0	1	1
Elateridae *Hemicrepidius hemipodis*	0	4	4
Eucnemidae *Deltometopus amoenicorins*	0	2	2
Lampyridae *Lucielota atra*	0	1	1
Lampyridae *Lucielota punctata*	1	1	2
Lampyridae *Photinus ignitus*	1	1	2
Lampyridae *Pyractonema borealis*	0	1	1
Lampyridae *Pyractonema lucifera*	1	0	1
Lathridiidae *Melanophthalma* sp.	1	14	15
Lathridiidae *Stephostethus* sp.	0	1	1
Melandryidae *Anaspis* sp.	0	1	1
Melandryidae *Canifa* sp.	0	1	1
Mordellidae *Tolidomordella discoidea*	0	1	1
Mycetophagidae *Litargus tetraspilotus*	1	0	1
Nitidulidae *Glischrochilus quadrisignatus*	1	0	1
Pedilidae *Pedius lugubris*	0	3	3
Pedilidae *Pedius impressus*	1	4	5
Phalacridae *Olibrus* sp.	1	0	1

	Phalacridae *Phalacruis* sp.	0	1	1
	Scarabaeidae *Dichelonyx subuittata*	1	0	1
	Staphylinidae *Atheta* sp.	3	0	3
Mecoptera		4	1	5
	Bittacidae *Bittacus strigosus*	3	0	3
	Panorpidae *Panorpa helena*	1	1	2
Tricoptera		2	0	2
	Leptoceridae *Trianades* sp.	2	0	2
Lepidoptera		16	36	52
	Arctiidae *Haploa lecontei*	1	0	1
	Arctiidae *Spilosoma virginica*	0	10	10
	Pterophoridae *Platyptilia carduidae*	1	0	1
	Lymantriidae *Orgyia leucostigma*	0	1	1
	Noctuidae *Eupsilia devia*	0	2	2
	Psychidae *Thyridopteryx ephemeraeformis*	0	4	4
	Torticidae *Acleris subnivana*	0	1	1
	Torticidae *Aethes promptana*	1	0	1
	Torticidae *Choristoneura rosaceana*	4	5	9
	Torticidae *Machimia tentoriferella*	2	3	5
	Torticidae *Pandemis lamprosana*	1	1	2
	Torticidae *Olethreutes appendicea*	0	1	1
	Pyralidae *Crambus agitatellus*	1	0	1
	Pyralidae *Parapoynx badiusalis*	1	0	1
	Argyresthiidae *Argyresthia oreasthia*	2	0	2
	Gracillariidae *Phyllonorycter caryaealbella*	2	6	8
	Geometridae *Ennomos subsignaria*	0	1	1
	Geometridae *Eupithecia miserulata*	0	1	1
Diptera*		47	123	170
	Anthomyidae	6 (3)*	0	6 (3)*
	Calliphoridae	1	0	1
	Cecidomyiidae	2 (2)*	0	2 (2)*
	Chironomidae	10 (6)*	46(22)*	56 (25)
	Chloropidae	13 (6)*	0	13 (6)*
	Dolichipodidae	2 (2)*	0	2 (2)*
	Empididae	6 (4)*	0	6 (4)*
	Otitidae	1	0	1
	Muscidae	0	2 (2)*	2 (2)*
	Sciaridae	1	0	1
	Syrphidae	0	2 (2)*	2 (2)*
	Tipulidae	5 (2)*	8 (4)*	13 (5)*
	Unknown	0	57 (40)*	57 (40)*
Hymenoptera		112	336	448

Braconidae *Aliolus* sp.	0	1	1
Braconidae *Apanteles* sp.	1	0	1
Braconidae *Austrozele uniformis*	1	0	1
Braconidae *Blacus* sp.	1	0	1
Braconidae *Bracon niger*	1	0	1
Braconidae *Dinotrema* sp.	0	1	1
Braconidae *Diolcogaster* sp.	0	1	1
Braconidae *Glyptocolastes* sp.	0	1	1
Braconidae *Heterospilus* sp. a	0	2	2
Braconidae *Heterospilus* sp. b	0	1	1
Braconidae *Meterorus hyphantriae*	1	0	1
Braconidae *Meterorus indagator*	0	1	1
Ceraphionidae *Ceraphron* sp.	1	0	1
Cynipidae *Diplopepsis* sp. a	0	9	9
Cynipidae *Diplopepsis* sp. b	0	1	1
Cynipidae *Liodora* sp. a	0	7	7
Cynipidae *Liodora* sp. b	0	1	1
Diapriidae *Monelata* sp.	0	1	1
Diapriidae *Oxylabis* sp.	0	1	1
Dryinidae *Crovettia* sp.	1	0	1
Encyrtidae *Encyrtus* sp.	1	1	2
Eulophidae *Aprostocetus* sp.	0	1	1
Eulophidae	0	1	1
Eupelmidae *Anastatus* sp.	1	0	1
Figitidae *Kleidotoma* sp.	0	1	1
Figitidae *Melanips* sp.	0	1	1
Formicidae *Camponotus nearcticus*	0	2	2
Formicidae *Camponotus noveboracensis*	1	1	2
Formicidae *Formica argentea*	3	7	10
Formicidae *Formica neogagates*	0	2	2
Formicidae *Formica nitidiventris*	0	2	2
Formicidae *Lasius alienus*	24	101	125
Formicidae *Lasius neoniger*	2	0	2
Formicidae *Leptothorax ambiguus*	1	13	14
Formicidae *Leptothorax longispinosis*	0	2	2
Formicidae *Myrmica emeryana*	0	3	3
Formicidae *Prenolepis imparis*	8	30	38
Ichneumonidae *Cratichneumon nigritarius*	0	1	1
Ichneumonidae *Cratichneumon paratus*	1	0	1
Ichneumonidae *Diaglyptidae* sp.	1	0	1
Ichneumonidae *Diplazon bradleyi*	0	1	1
Ichneumonidae *Endasys praerotundiceps*	0	2	2
Ichneumonidae *Exochus* sp.	0	1	1
Ichneumonidae *Gelis* sp. a	0	1	1
Ichneumonidae *Gelis* sp. b	0	3	3
Ichneumonidae *Gelis* sp. c	0	1	1
Ichneumonidae *Gelis* sp. d	0	1	1

Ichneumonidae *Phaeogenes* sp. a	0	1	1
Ichneumonidae *Phaeogenes* sp. b	0	1	1
Ichneumonidae *Itoplectis conquisitor*	1	0	1
Ichneumonidae *Lissonota* sp.	1	0	1
Ichneumonidae *Pimpla aequalis*	1	1	2
Ichneumonidae *Polyaulon* sp.	0	1	1
Ichneumonidae *Pristomerus* sp.	1	0	1
Ichneumonidae *Sinophorus* sp.	1	0	1
Ichneumonidae *Theronia atlantae*	0	1	1
Mymaridae	1	1	2
Platygasteridae *Leptacis* sp. a	0	1	1
Platygasteridae *Leptacis* sp. b	0	1	1
Platygasteridae *Leptacis* sp. c	0	8	8
Platygasteridae *Leptacis* sp. d	0	1	1
Platygasteridae *Leptacis* sp. e	0	1	1
Platygasteridae *Leptacis* sp. f	0	4	4
Platygasteridae *Leptacis* sp. g	0	1	1
Platygasteridae *Leptacis* sp. h	0	1	1
Platygasteridae *Platygaster* sp. a	0	2	2
Platygasteridae *Platygaster* sp. b	0	3	3
Platygasteridae *Trichacis* sp. a	0	2	2
Proctotrupidae *Phaneroserphus* sp.	0	1	1
Scelionidae *Idris* sp.	18	0	18
Scelionidae *Trissolcus* sp. a	37	39	76
Scelionidae *Trissolcus* sp. b	0	38	38
Sphecidae *Stigmus fraternus*	0	1	1
Tenthredinidae *Heterarthrinae fenusa*	0	19	19
Tiphiidae *Myrmosa unicolor*	1	0	1
Total	497	1239	1736

*We were unable to provide a species identification for a few specimens, these specimens were identified to family or genus and then assigned a letter to distinguish from other unidentified specimens (example Cicadellidae *Empoasca* sp. b = specimen is in the family Cicadellidae, genus *Empoasca*, species "b" or the second *Empoasca* in collection unable to determine to species.) Diptera are not identified to species, they are separated and counted as morpho-species. In the table, the number of different morpho-species are given as (#)* which can be found next to the number of specimens collected.

Table 3. List of the orders that contained immature insects collected from *Rhamnus cathartica* that died during rearing.

	Number of Specimens		
Order	2004	2005	Total
Orthoptera	43	37	80
Psocoptera	11	7	18
Hemiptera/Homoptera	99	127	226
Neuroptera	1	10	11
Coleoptera	0	5	5
Lepidoptera	98*	73*	171
Total	252	259	511

*Several caterpillars from collected egg masses.