

Ground Beetles and Conservation Biocontrol

**A Cautionary Tale From
Biodiversity and Natural History**



CAUTION

**James R. LaBonte
Oregon Dept. of Agriculture**

**April 8, 2017
Soil School, PCC Rock Creek Campus**



Conservation Biocontrol

“Free” Biocontrol!

Invertebrates

+

Weeds!

**“... a Beautiful
theory ...
killed by an
ugly fact.”**

(T.H. Huxley)

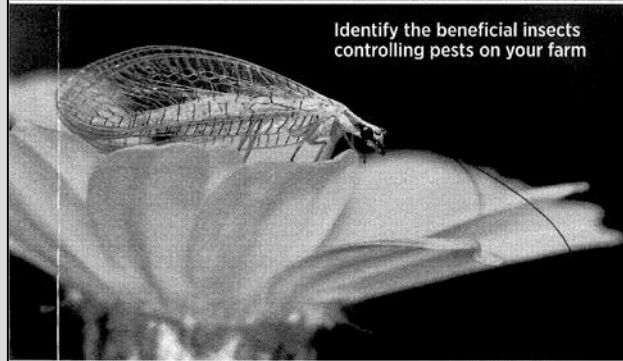
**Or, in this case,
Many “ugly” facts**



THE XERCES SOCIETY GUIDE

Farming *with* Native BENEFICIAL INSECTS

Ecological Pest Control Solutions



Identify the beneficial insects
controlling pests on your farm



Improve crop yields by
reducing pest damage



Provide habitat for beneficial insects
with hedgerows and buffer strips

Eliminate Pesticides, Restore Biodiversity

GROW BOUNTIFUL ORGANIC CROPS while improving the biodiversity of your farm by making your land a welcoming place for native beneficial insects. Mantids, stink bugs, beetles, flies, wasps, and many others prey upon crop pests, reducing or eliminating the need for chemical pesticides.

Your first step is learning to identify these important farm heroes: close-up photography and in-depth profiles familiarize you with more than 20 beneficial insects and their kin. After assessing your land, current practices, and goals, you'll find detailed instructions for a host of projects, from beetle banks to organic buffers, to improve habitat for your insect helpers.

**Maybe, but not
to pristine fauna**



PLANTING PROJECTS FOR PROVIDING HEALTHY HABITATS INCLUDE:

- Hedgerows
- Insectary strips
- Native plant field borders
- Cover crops
- Contour buffer strips
- Grassed waterways

Inundation by Exotic Species

- ~ 25,000 terrestrial invertebrate species in Oregon
- ~ 1,000 species of exotic terrestrial invertebrates in Oregon

Most of these are found in agricultural and residential settings!



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XXXX



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- Contour buffer strips
- Grassed waterways

Praying mantis

“They’d eat small children if they could!”

Unknown source



“Generalist”
(= “indiscriminate”)
predators eat beneficials
just as enthusiastically
as they eat pests!



Eliminate Pesticides, Restore Biodiversity

**Is increased general biodiversity
(via land use and other practices)
coupled with increased pest control?**

It COULD be, but NOT necessarily.

New Exotic Invertebrate Species Found Established in Oregon 2007 - 2016

**Exotic species
are part of
“Biodiversity”**

<u>Year</u>	<u>No. Species</u>
2007	13
2008	10
2009	8
2010	11
2011	5
2012	10
2013	5
2014	6
2015	21
2016	10

Significant Exotic Pests Detected 2007-2016

On average, **every year**
Oregon has had at
least one **SIGNIFICANT**
exotic pest detected...

Aculops cannabicola

Aleyrodes protella

Amphimallon majale

Amyntas gracilis

Arion hortensis

Brachyepplus basalis

Ceresa festina

Corythucha arcuata

Drepanothrips reuteri

Drosophila suzukii

Ferrisia gilli

Hylotrupes bajulus

Nematus lipovsyi

Neodiprion sertifer

Pandemis cerasana

Pityophthorus juglandis

Scolytus schevyrewi

Siphoninus phillyreae

Stephanitis pyrioides

Hemp russet mite

Cabbage whitefly

European chafer

Asian jumping worm

Garden slug

Honeybee hive sap beetle

3-cornered alfalfa hoppr

Oak lace bug

Grape thrips

Spotted wing Drosophila

Gill's mealybug

Old-house borer

Azalea sawfly

European pine sawfly

Barred fruit-tree tortrix

Walnut twig beetle

Banded elm bark beetle

Ash whitefly

Azalea lace bug

**New exotic pests
often lack either
natural enemies or
effective chemical
controls**

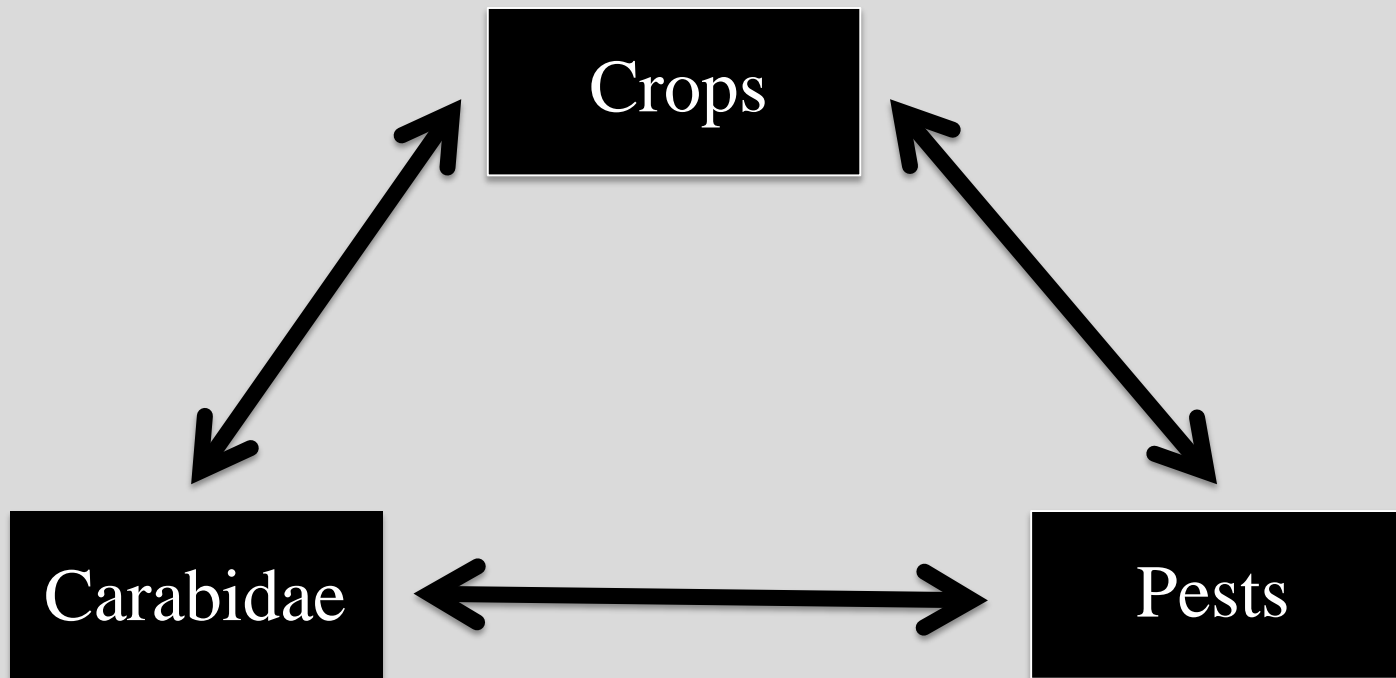
Azalea Lace Bug
Stephanitis
pyriodes



Carabid Beetles and Conservation Biocontrol

- **“Predaceous” “ground” beetles**
 - **many feed on plants, especially seeds**
 - **many are found primarily on foliage or flowers**
- **Targets of Conservation Biocontrol**
 - **“Generalist” predators of pests**
no such thing, polyphagous “opportunists” instead
 - **Common in agricultural and horticultural systems**

How Carabidae (= “ground beetles”) are Perceived and Promoted in Conservation Biocontrol



But... it isn't that simple!

**Weather,
Weather,
Weather!**

Annual
Perennial
Rotation

Damage Thresholds!

Crops

Agricultural Practices

Type
Timing
Frequency
Field Size

Carabidae

Pool of Species
Habitat Requirements
Phenology
Dispersal Capabilities
Abundance
Prey Range

Predators/parasites of Carabids

Pests

Pool of Species
Habitat Requirements
Phenology
Dispersal Capabilities
Abundance
Host Range

Susceptibility to Carabids Present



OREGON CARABIDAE

504 species of Carabidae in Oregon!

All (to varying degrees) with **different** biologies.

For instance:

- **504 different sizes**
- **504 different diets**
- **504 different life cycles**
- **504 different habitat parameters**
- **504 different dispersal capabilities**

THESE DIFFERENCES

MATTER!!!!

Pertinent Questions

- **Can the carabids present in your setting eat the pests you are concerned about? Prey capture capabilities.**

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- **Do the carabids present in your setting eat these pests?** Reality check.

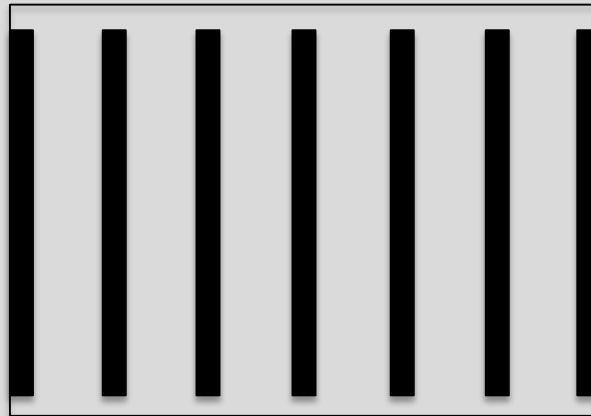
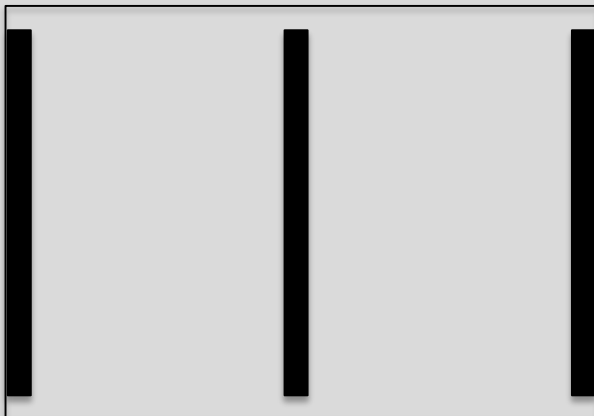


Where alternative prey were present, *Pterostichus melanarius* killed significantly fewer grey field slugs. Beetles with access to large numbers of alternative prey weighed the most, were the most fecund, and killed the fewest slugs.

Symondson et al. 2006. Biodiversity vs. biocontrol: positive and negative effects of alternative prey on control of slugs by carabid beetles. *Bulletin of Entomological Research* 96: 637-645.

Pertinent Questions

- **Can the carabids present in your setting eat the pests you are concerned about?** Prey capture capabilities.
- **Will the carabids present in your setting eat these pests?** Often based on lab studies.
- **Do the carabids present in your setting eat these pests?** Reality check.
- **Can the carabids present in your setting get to these pests?** (1) Dispersal capabilities (2) Pests on ground or on plants



VS



Pertinent Questions

- **Can the carabids present in your setting eat the pests you are concerned about?** Prey capture capabilities.
- **Will the carabids present in your setting eat these pests?**
Often based on lab studies.
- **Do the carabids present in your setting eat these pests?**
Reality check.
- **Can the carabids present in your setting get to these pests?** (1) Dispersal capabilities (2) Pests on ground or on plants
- **THE BIG QUESTION:**
Do the carabids present in your setting eat enough of these pests to provide a benefit justifying your expenditure of resources (time, money, work, land)?

Common Taxa of Carabidae in Oregon Agricultural Settings (* = at least some exotics)

Amara spp.*

Anisodactylus spp.*

Bembidion spp.*

Bradycellus spp.*

*Calathus fuscipes**

*Carabus nemoralis**

*Clivina fossor**

Harpalus spp.*

Loricera foveata

*Nebria brevicollis**

Omus audouini

Pterostichus algidus

*Pterostichus melanarius**

Scaphinotus marginatus

*Trechus obtusus**

**A Very Small Subset of Total OR Carabids!
14 of 88 genera, ~2 dozen of 504 species**

Agricultural Settings (as Carabid Habitats) are **NOT** Monolithic

wikipedia



stillmansfarm.woodpress.com



ces.ncsu.edu

Major Differences Within a Single Perennial Crop - Blueberry Fields

<u>Species</u>	<u>% Total N</u>	
	Benton Co.	Clackamas Co.
<i>Agonum muelleri</i> (Herbst)*		1.4
<i>Amara aenea</i> (DeGeer)*		4.5
<i>Amara apricaria</i> (Paykull)*		0.5
<i>Amara littoralis</i> Mannerheim	2.4	0.6
<i>Anisodactylus binotatus</i> (Fabricius)*		5.1
<i>Bembidion lampros</i> (Herbst)*		1.1
<i>Clivina fossor</i> (Linnaeus)*		1.5
<i>Harpalus affinis</i> (Schrank)*		6.1
<i>Loricera foveata</i> LeConte	3.3	
<i>Nebria brevicollis</i> (Fabricius)*	21.0	54.1
<i>Pterostichus algidus</i> LeConte	51.9	
<i>Pterostichus melanarius</i> (Illiger)*	15.7	21.8
<i>Trechus obtusus</i> (Erichson)*	2.4	
All other species < 1% each	7 spp., 3.3%	17 spp., 3.3%

* = Exotic species

2008 J.C. Lee study

Carabid Faunas of Two Perennial Crops

<u>Species</u>	<u>% Total N</u>	
	Christmas trees	Grapes
<i>Anisodactylus binotatus</i> (Fabricius)*	0.4	1.2
<i>Anisodactylus similis</i>		4.5
<i>Calathus fuscipes</i> (Goeze)	7.5	1.8
<i>Carabus nemoralis</i> Muller	2.1	1.1
<i>Metrius contractus</i> Eschscholtz	0.9	6.3
<i>Nebria brevicollis</i> (Fabricius)*	3.2	7.6
<i>Omus audouini</i> (Reiche)	4.7	6.2
<i>Pterostichus algidus</i> LeConte	73.0	54.2
<i>Pterostichus castanipes</i> (Menetries)	1.0	1.5
<i>Pterostichus melanarius</i> (Illiger)*	3.2	6.6
<i>Scaphinotus marginatus</i> Fischer	2.0	6.5
<i>Trechus obtusus</i> (Erichson)*		1.2

Those species in **orange** also found in blueberry fields

**How a carabid
beetle acquires
and
manipulates
food**

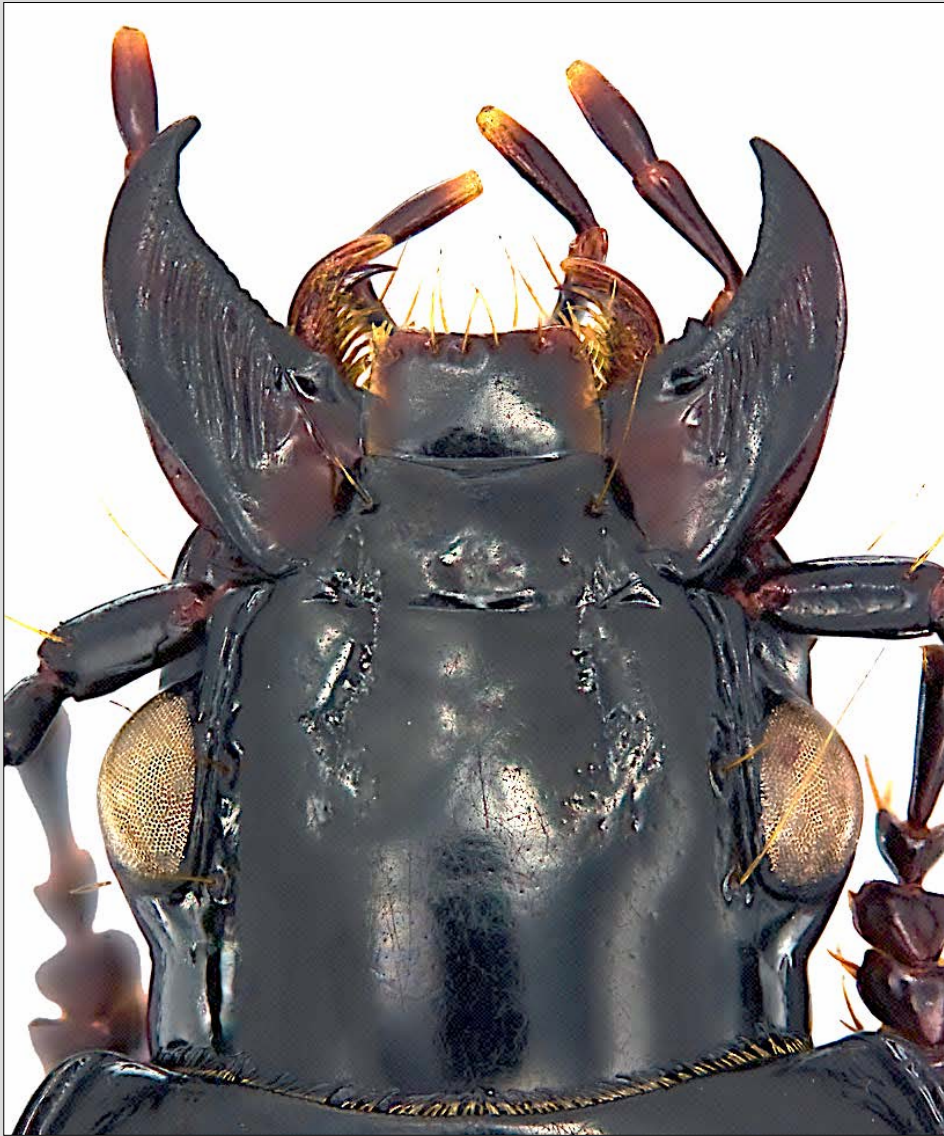
“Jaws” Theme





*Pterostichus
algidus*





*Pterostichus
melanarius*



“Generalists” are really “Opportunists”
= Double-edged swords in biocontrol



[ericjohnbaker.wordpress](http://ericjohnbaker.wordpress.com)

Unintended consequences (or, be careful what you wish for...)

Carabus auratus



Unintended consequences...

Harpalus rufipes

Strawberry seed beetle



Unintended consequences...

**Seedcorn
beetles**



*Clivina
impressifrons*



Stenolophus lecontei



Unintended consequences...

Zabrus tenebrioides

Cereal ground beetle



fao.org



www.eurocarabidae.de

(c) 2011 O. Bleich eMail: o.bleich@gmx.de

Timing IS All...

- Crop
- Cultivation
- Harvest
- Pesticide application
- Target pests
- *et cetera*

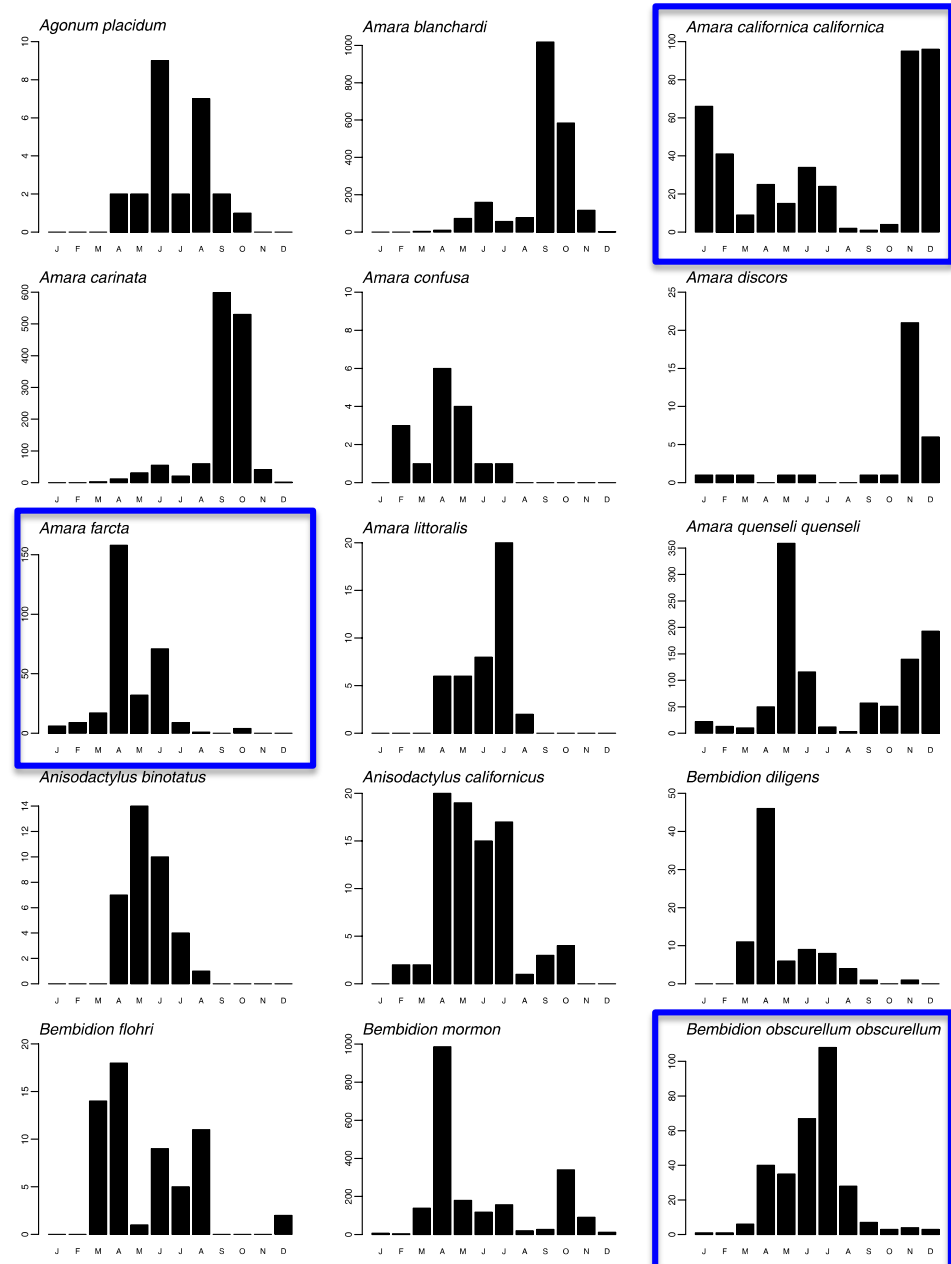


Figure 3. Bar graphs presenting total seasonal abundance for select pitfall-trapped carabid species. Y-axes indicate the total number captured per month, summed across all sites.

SIZE Matters!

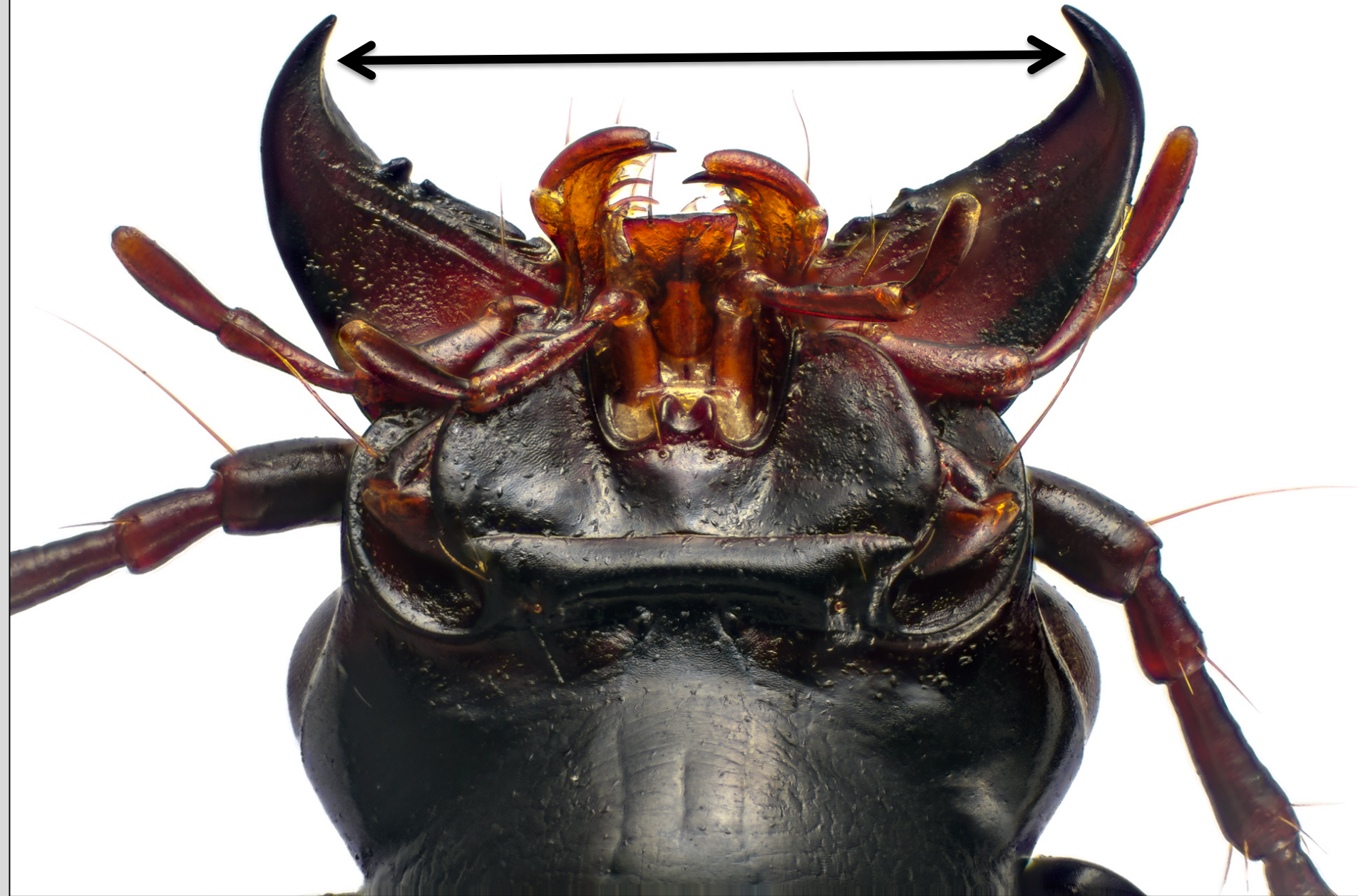


Harpalus caliginosus

Elaphropus parvulus



Especially as related to gape!



Wheater, C.P. 1988.
Predator-prey size
relationships in some
Pterostichini.
Coleopterists Bulletin
42 (3): 237-240.

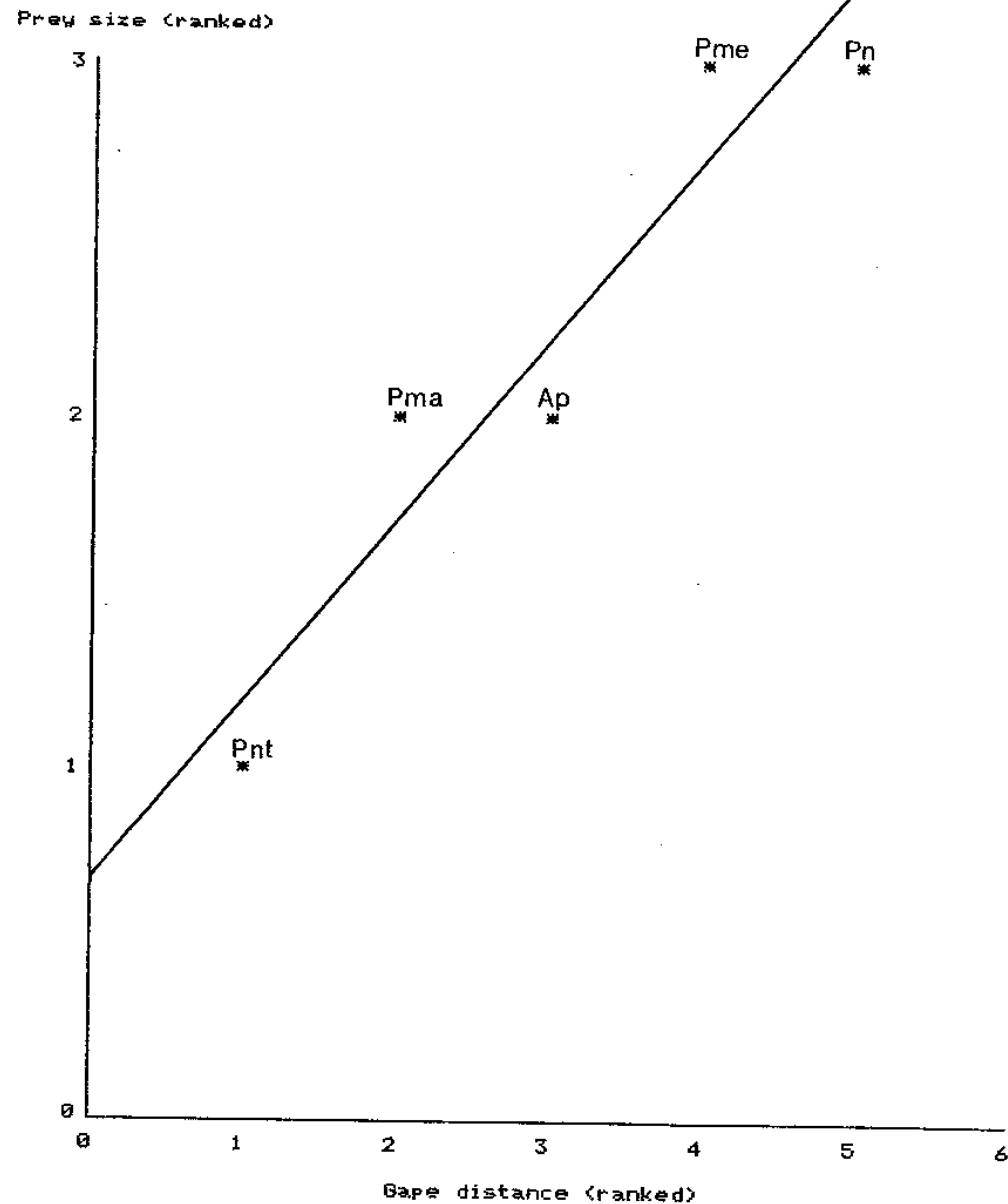


Fig. 1. Relationship between the distance between the mandibles at full gape in Pterostichini and the median sizes of prey attacked ($R_s = 0.95$, $t = 5.13$, $P = 0.014$). Pma = *Pterostichus madidus*; Pme = *Pterostichus melanarius*; Pn = *Pterostichus niger*; Pnt = *Pterostichus nigrita*; Ap = *Abax parallelepipedus*.

As does **STYLE!**

Omnivore



Predator





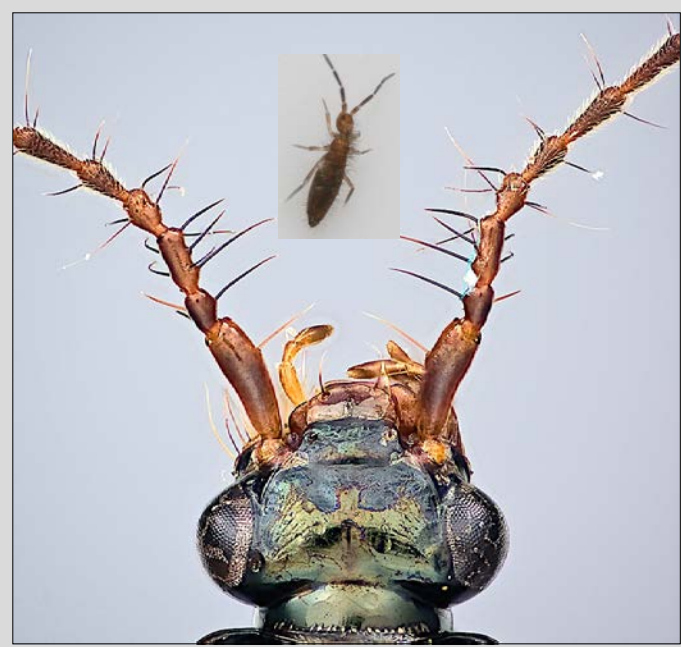
Omus cazieri



*Leistus
longipennis*

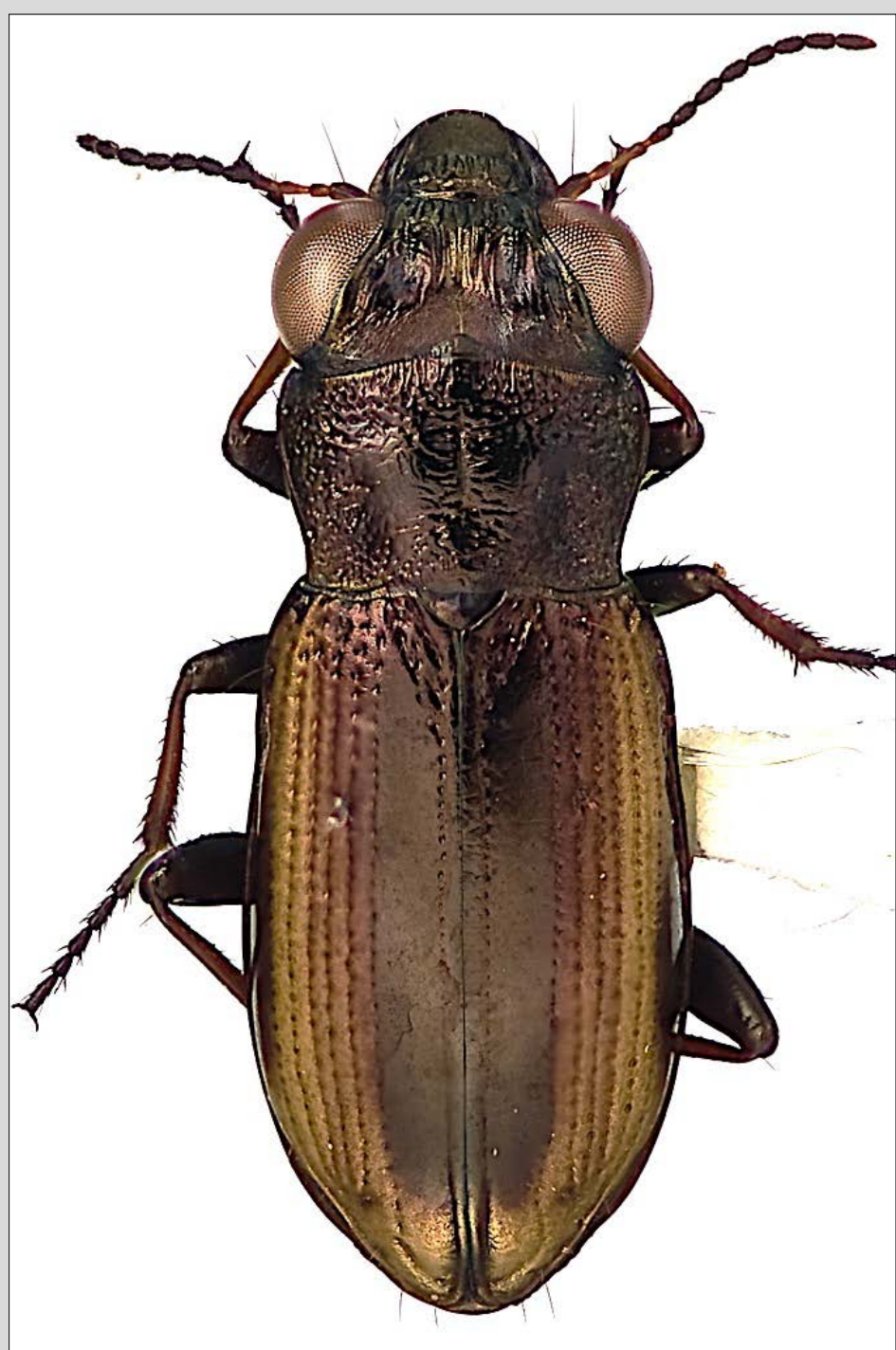


*Loricera
pilicornis*





*Notiophilus
sylvaticus*



Slugs



Arion ater

seebyseeing.net



eol.org

Derocerus reticulatum

Harpalus rufipes





Carabus nemoralis



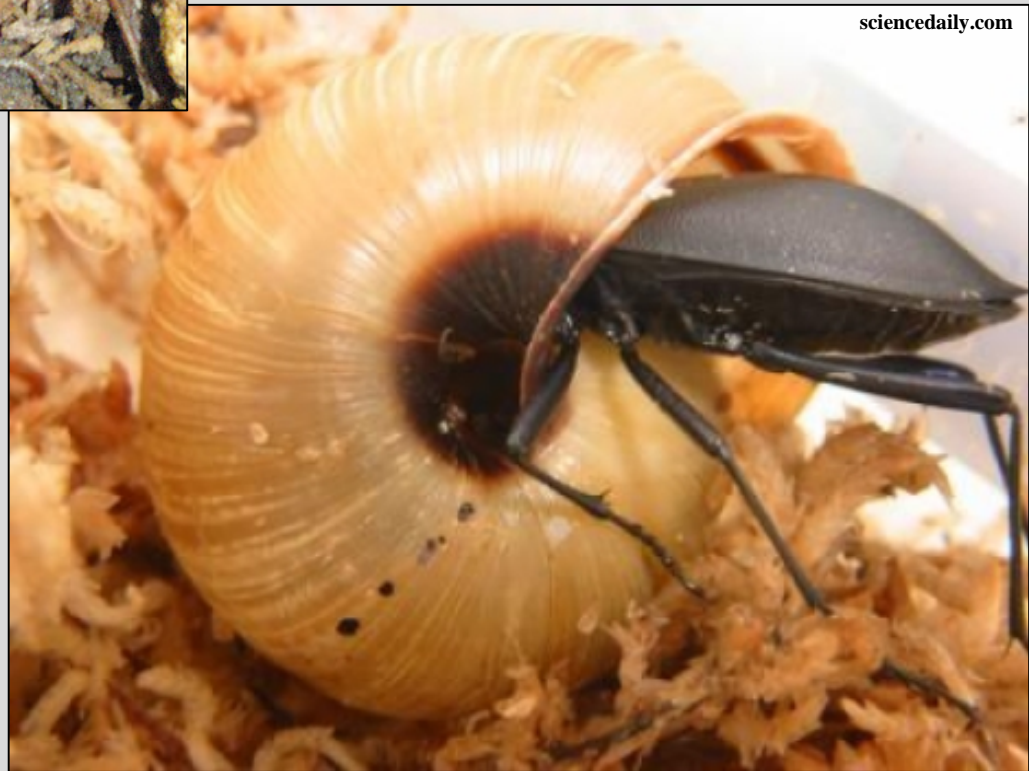
ARKive
www.arkive.org



© Emanuele Biggi



pbase.com



sciencedaily.com

*Cychrus
tuberculatus*



*Scaphinotus
(Neocychrus)
angulatus*



*Scaphinotus
marginatus*



Scaphinotus sp. larva



They really get into their work!



Chris Grinter

Once again, **SIZE** Matters!



“Mollusk-Munchers” in Blueberry Fields

<u>Species</u>	<u>% Total Individuals</u>	
	Benton Co.	Clackamas Co.
<i>Agonum muelleri</i> (Herbst)*		1.4
<i>Amara aenea</i> (DeGeer)*		4.5
<i>Amara apricaria</i> (Paykull)*		0.5
<i>Amara littoralis</i> Mannerheim	2.4	0.6
<i>Anisodactylus binotatus</i> (Fabricius)*		5.1
<i>Bembidion lampros</i> (Herbst)*		1.1
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* = Exotic species

2008 J.C. Lee study

“Mollusk-Munchers” in Two Perennial Crops

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Harpalus caliginosus



Harpalus rufipes eating weed seeds



Different Habitat Requirements

Mollusk-munchers



Weed seed



eaters

Oregon Agricultural Settings and Their Carabid Fauna

wikipedia



stillmansfarm.woodpress.com



ces.ncsu.edu

Pterostichus algidus in Blueberry Fields

<u>Species</u>	<u>% Total N</u>	
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Pterostichus algidus in Christmas trees and grapes

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*Pterostichus
algidus*



Pterostichus algidus hard at work

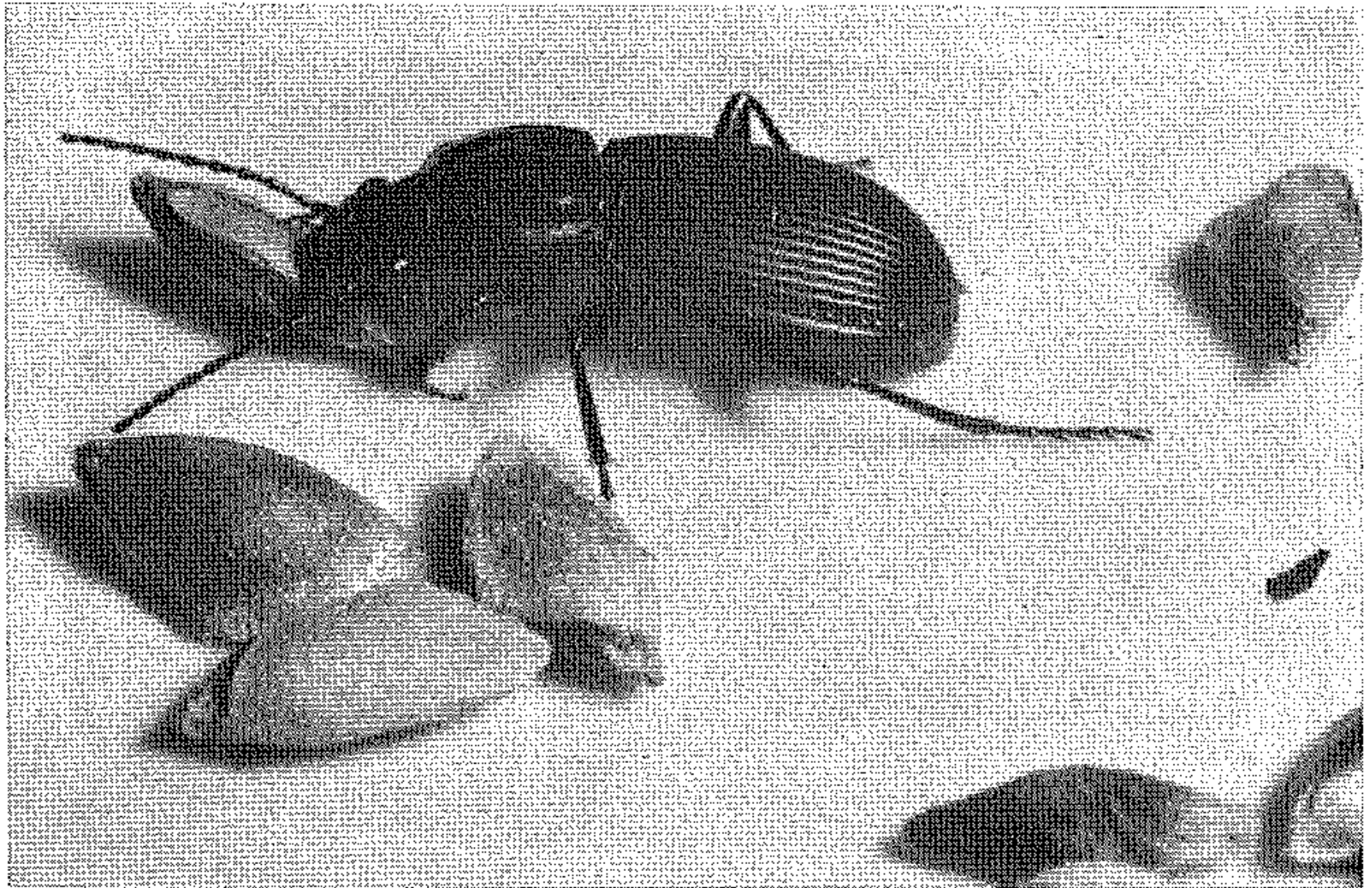


FIG. 2.—*Pterostichus algidus* carries off a Douglas-fir seed.

Carabidae Exotic to North America: 67 species

35 spp. in PNW (BC 29, ID 11, OR 24, WA 26)

<i>Abax parallelepipedus</i> (Piller and Mitterpacher)	<i>Bembidion tetracolum tetracolum</i> Say	<i>Metacolpodes buchanani</i> (Hope)
<i>Acupalpus meridianus</i> (Linnaeus)	<i>Blemus discus</i> (Fabricius)	<i>Mochtherus tetraspilotus</i> (MacLeay)
<i>Agonum muelleri</i> (Herbst)	<i>Bradycellus harpalinus</i> (Audinet-Serville)	<i>Nebria brevicollis</i> (Fabricius)
<i>Amara aenea</i> (DeGeer)	<i>Brosicus cephalotes cephalotes</i> (Linnaeus)	<i>Notiophilus biguttatus</i> (Fabricius)
<i>Amara anthobia</i> A. Villa and G.B. Villa	<i>Calathus fuscipes</i> (Goeze)	<i>Notiophilus palustris</i> (Duftschmid)
<i>Amara apricaria</i> (Paykull)	<i>Calosoma sycophanta</i> (Linnaeus)	<i>Ophonus puncticeps</i> Stephens
<i>Amara aulica</i> (Panzer)	<i>Carabus auratus auratus</i> Linnaeus	<i>Ophonus rufibarbis</i> (Fabricius)
<i>Amara bifrons</i> (Gyllenhal)	<i>Carabus granulatus granulatus</i> Linnaeus	<i>Paranchus albipes</i> (Fabricius)
<i>Amara communis</i> (Panzer)	<i>Carabus nemoralis nemoralis</i> O.F. Müller	<i>Perigona nigriceps</i> (Dejean)
<i>Amara eurynota</i> (Panzer)	<i>Clivina collaris</i> (Herbst)	<i>Philorhizus melanocephalus</i> (Dejean)
<i>Amara familiaris</i> (Duftschmid)	<i>Clivina fossor</i> (Linnaeus)	<i>Plochionus pallens</i> (Fabricius)
<i>Amara fulva</i> (O.F. Müller)	<i>Clivina vespertina</i> Putzeys	<i>Porotachys bisulcatus</i> (Nicolai)
<i>Amara ovata</i> (Fabricius)	<i>Dicheirotichus placidus</i> (Gyllenhal)	<i>Pterostichus melanarius melanarius</i> (Illiger)
<i>Anisodactylus binotatus</i> (Fabricius)	<i>Dromius fenestratus</i> Fabricius	<i>Pterostichus strenuus</i> (Panzer)
<i>Anisodactylus nemorivagus</i> Duftschmid	<i>Dyschirius globosus</i> (Herbst)	<i>Pterostichus vernalis</i> (Panzer)
<i>Asaphidion curtum curtum</i> (Heyden)	<i>Elaphropus parvulus</i> (Dejean)	<i>Somotrichus unifasciatus</i> (Dejean)
<i>Bembidion bruxellense</i> Wesmael	<i>Harpalus affinis</i> (Schrank)	<i>Stomis pumicatus</i> (Panzer)
<i>Bembidion femoratum femoratum</i> Sturm	<i>Harpalus rubripes</i> (Duftschmid)	<i>Tetragonoderus laevigatus</i> Chaudoir
<i>Bembidion lampros</i> (Herbst)	<i>Harpalus rufipes</i> (DeGeer)	<i>Trechoblemus westcotti</i> Barr
<i>Bembidion nigropiceum</i> (Marsham)	<i>Laemostenus complanatus</i> (Dejean)	<i>Trechus obtusus</i> Erichson
<i>Bembidion obtusum</i> Audinet-Serville	<i>Laemostenus terricola terricola</i> (Herbst)	<i>Trechus quadristriatus</i> (Schrank)
<i>Bembidion properans</i> (Stephens)	<i>Leistus ferrugineus</i> (Linnaeus)	<i>Trechus rubens</i> (Fabricius)
<i>Bembidion stephensii</i> Crotch		

Most exotic carabids are considered ecologically benign:

- Specialists that fill empty niches, human-derived (“anthropogenic”) habitats**
- Native carabid species are often much less diverse and abundant in anthropogenic habitats**
- Thus, exotic carabids provide ecosystem services, such as invertebrate and weed pest control, in habitats where native carabids can not**

Anthropogenic Habitats



Vacant lots



Roadsides



Agricultural Lands



Lawns & Gardens

Carabids of Anthropogenic Habitats

Agonum muelleri



Amara apricaria



Anisodactylus binotatus



Bradycellus harpalinus



Calathus fuscipes



Carabus granulatus



Carabus nemoralis



Laemostenus complanatus



Pterostichus melanarius



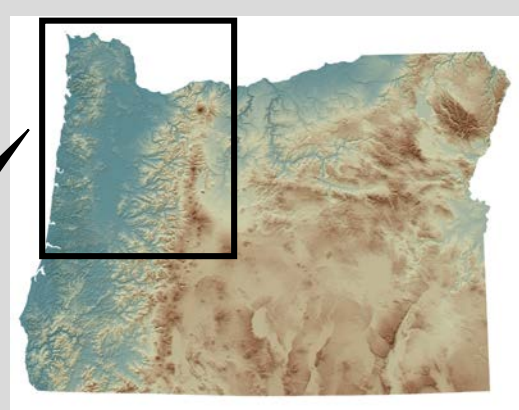
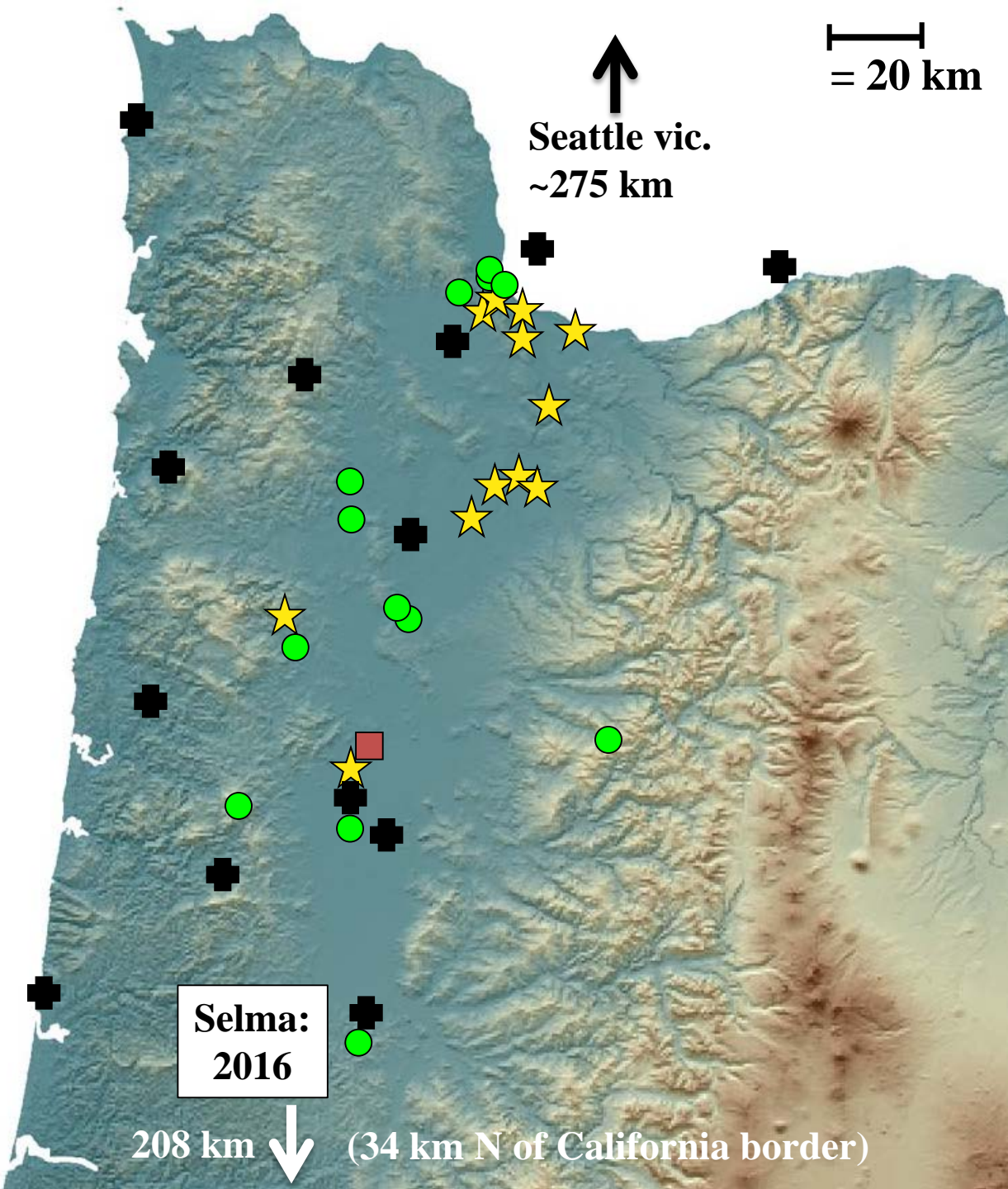
Trechus obtusus



The Supreme Invader

Nebria brevicollis
(Fabricius)





- = 2007
- ★ = 2008
- = 2009
- ⊠ = 2010





Truck stop



Blueberry field



Garden



Second growth mixed forest

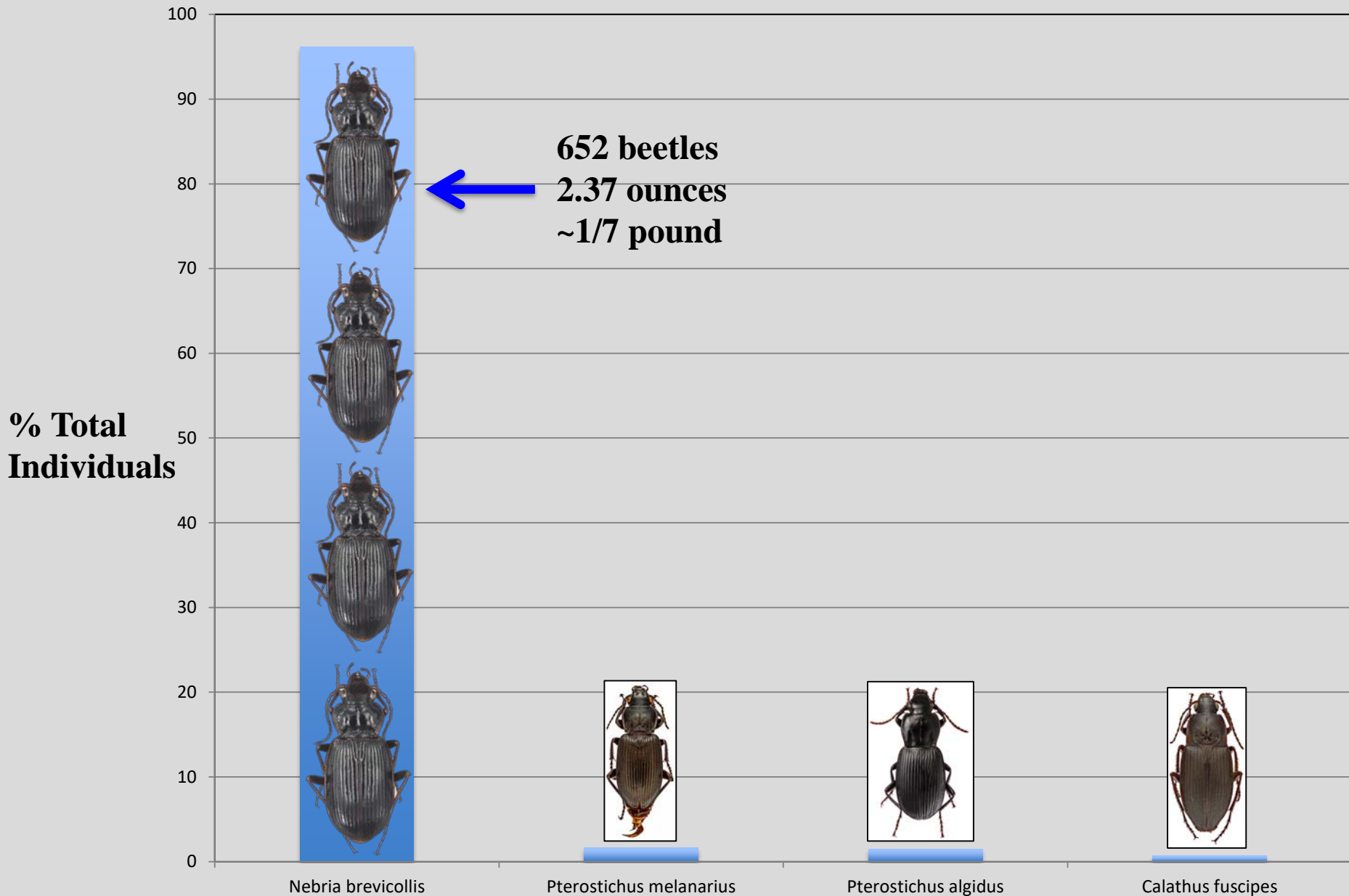
Nebria brevicollis in Blueberry Fields

<u>Species</u>	<u>% Total N</u>	
	Benton Co.	Clackamas Co.
<i>Agonum muelleri</i> (Herbst)*		1.4
<i>Amara aenea</i> (DeGeer)*		4.5
<i>Amara apricaria</i> (Paykull)*		0.5
<i>Amara littoralis</i> Mannerheim	2.4	0.6
<i>Anisodactylus binotatus</i> (Fabricius)*		5.1
<i>Bembidion lampros</i> (Herbst)*		1.1
<i>Clivina fossor</i> (Linnaeus)*		1.5
<i>Harpalus affinis</i> (Schrank)*		6.1
<i>Loricera foveata</i> LeConte	3.3	
<i>Nebria brevicollis</i> (Fabricius)*	21.0	54.1
<i>Pterostichus algidus</i> LeConte	51.9	
<i>Pterostichus melanarius</i> (Illiger)*	15.7	21.8
<i>Trechus obtusus</i> (Erichson)*	2.4	
All other species < 1% each	7 spp., 3.3%	17 spp., 3.3%

* = Exotic species

2008 J.C. Lee study

Numerical Dominance of *Nebria brevicollis* at St. Paul, OR



Possible impacts of *N. brevicollis*

Competitive or predatory impacts on agricultural or horticultural carabid “services” (on both indigenous and exotic species)

Weed biocontrol

Herbivore biocontrol




Pitfalls of Pitfalls

A large white tray filled with hundreds of dark beetles, likely collected from pitfall traps. The beetles are densely packed and cover the entire surface of the tray. The tray is placed on a wooden surface.


**~Non-selective:
one pitfall trap: two weeks**

BIG
problem:
Can't
take at
face value!





**Oh, nooooo!
I'm falling!**



**Oh oh, better
watch my step!**

Once again, size matters...

North Cascades (WA)

Total non-necrophagous
beetles captured: **10%**



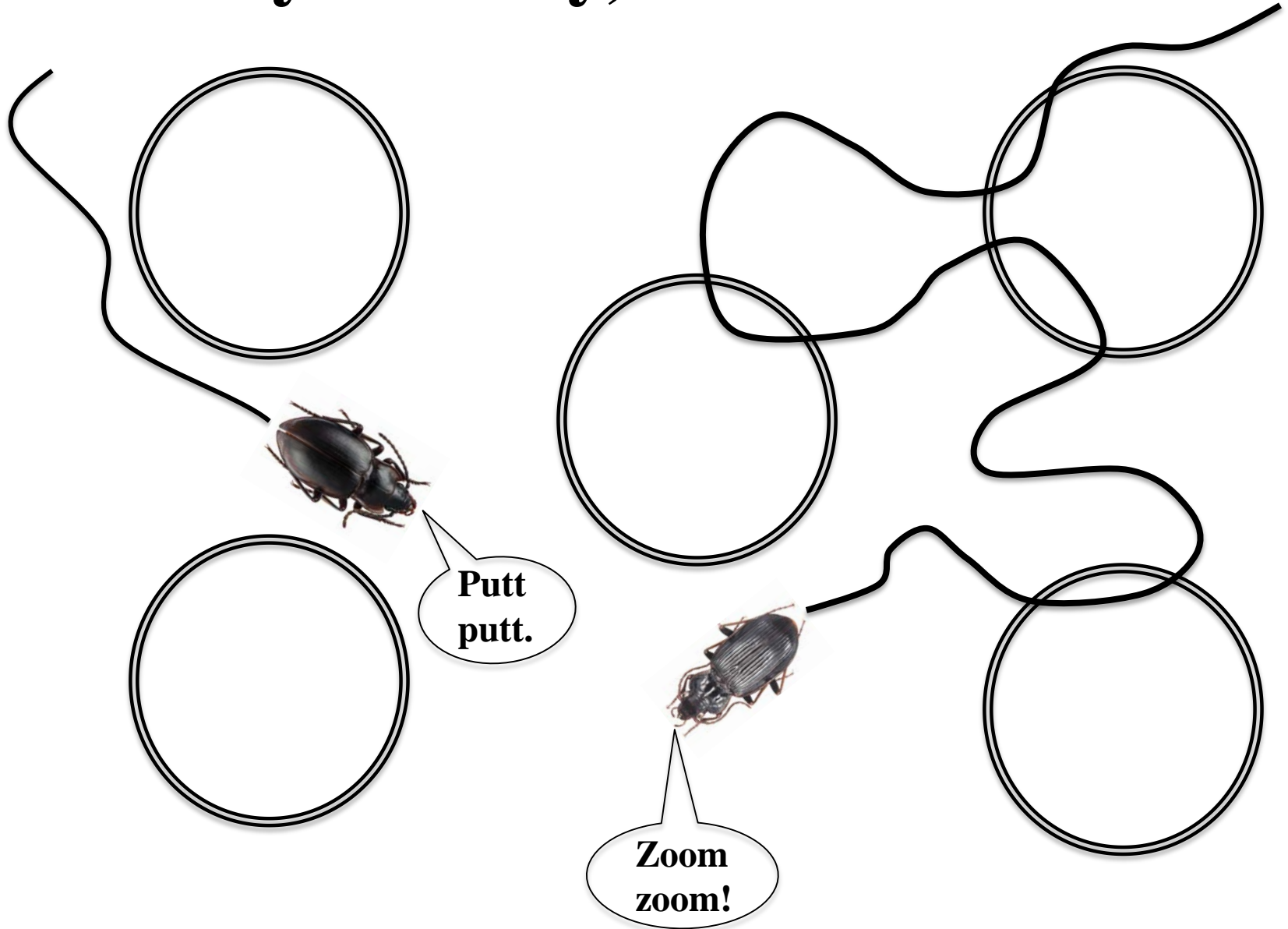
Gravel Bar Small Carabids

	Pitfalls	Hand*
Spp.	6	25
No.	53	35-40/m ²

Over-representation
large carabids,
Under-representation
small carabids!

*D. Hering 1998

Activity-Density, NOT Abundance!



Natural Enemies of Pests

- **Not a “silver bullet”**
 - **Constraints on prey range**
 - **Constraints on dispersal capabilities**
 - **Recruiting from limited local species pool**
- **No “one size fits all” approach**
 - **natural enemies have differing habitat requirements**
good habitat for one is poor for another
- **New exotic pests may have no local natural enemies or none that are effective**
- **Indiscriminate natural enemies***
- **Limited or misinformation****

Indiscriminate Natural Enemies

PREDATORY INSECTS

Assassin Bugs, Ambush Bugs

ORDER: Hemiptera

FAMILY: Reduviidae SUBFAMILY: Phymatidae



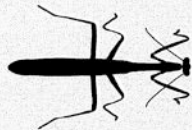
0.2 TO 1.4 INCH
(5 TO 36 MM) LONG

PREDATORY INSECTS

Mantids

ORDER: Mantodea

FAMILY: Mantidae



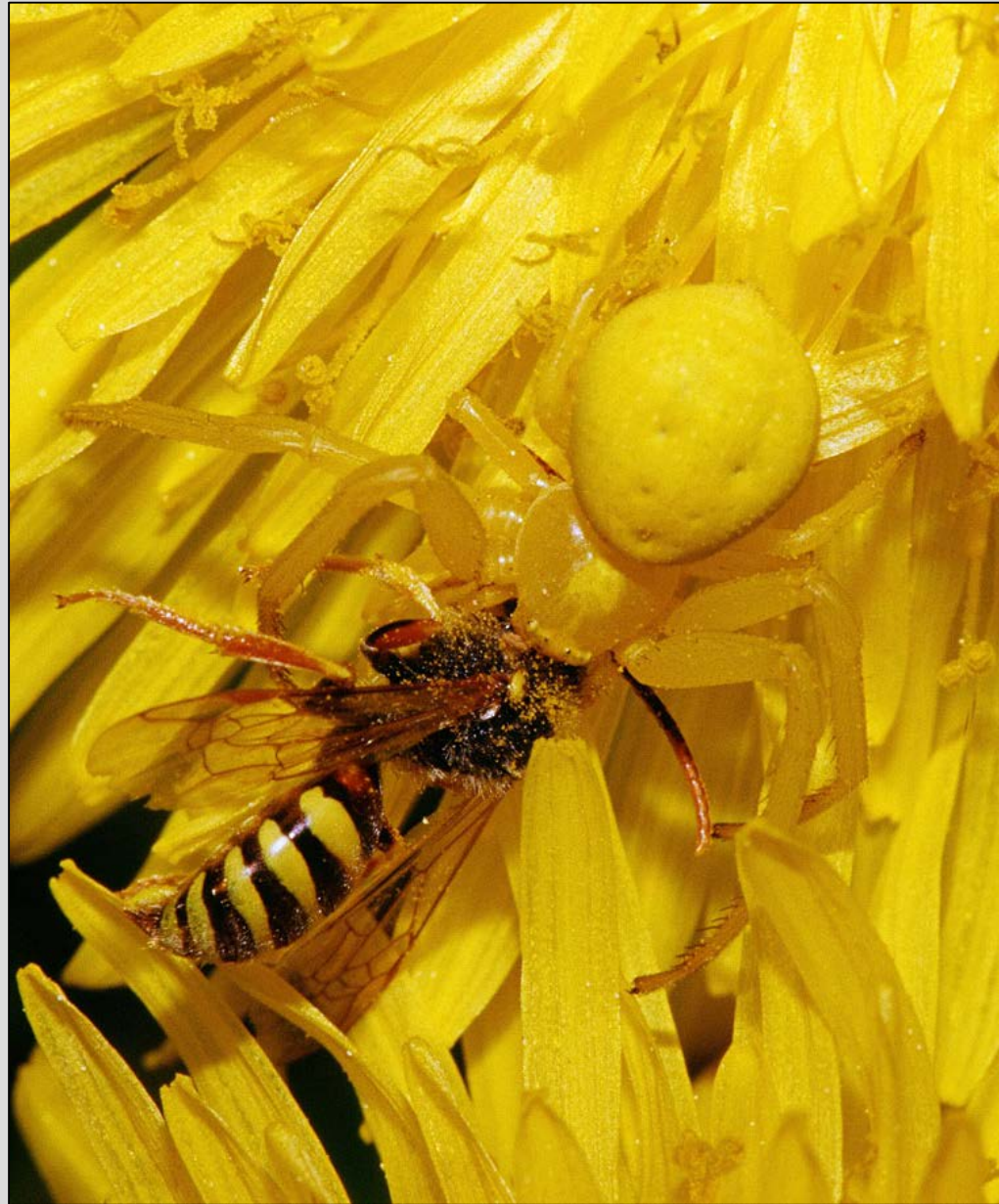
0.5 TO 4 INCHES
(12-200 MM) LONG

NONINSECT BENEFICIAL PREDATORS

Jumping Spiders, Wolf Spiders, Orb Weaver Spiders, Sheet-Weaving Spiders

ORDER: Araneae

FAMILY: Lycosidae, Salticidae, Araneidae, Linyphiidae



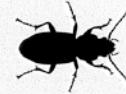
Indiscriminate + Rarely Abundant

PREDATORY INSECTS

Tiger Beetles

ORDER: Coleoptera

FAMILY: Carabidae SUBFAMILY: Cicindelinae



0.27 TO 2.75 INCHES
(7 TO 70 MM) LONG



Punctured Tiger Beetle adult

TIGER BEETLE LARVAE anchor their grublike bodies within their burrows and conceal their large jaws under their flat heads while waiting for prey to wander near the burrow. Adult tiger beetles may be grayish brown, metallic bronze, or iridescent blue or green, sometimes with white markings on their wing covers. Adults have long, thin legs used for running swiftly in short bursts. As visual hunters, adult tiger beetles also have prominent eyes, with heads that are wider than the more slender thorax. Large sickle-shaped jaws are used to capture and chew prey.

COMMON PREY: Caterpillars, grasshoppers, beetles, flies, and other insects. Closely related to ground beetles, tiger beetles are less common in many agricultural fields, but may still contribute to pest management. Both larvae and adults are carnivorous. Tiger beetle larvae typically hunt from cylindrical burrows in the soil, grabbing prey that wander by. Adult tiger beetles hunt on the surface of the ground, and are extremely fast-moving. Adult tiger beetles typically hunt during the day, though some are active at dusk or are nocturnal.

SPECIES IN NORTH AMERICA: Approximately 109

DEVELOPMENT TIME: One year or more, with adults living two to three years

GENERATIONS PER YEAR: One

EGG-LAYING SITES: Tiger beetle eggs are laid individually in burrows in damp, well-drained soil.

OVERWINTERING: Larvae or adults within burrows in the soil

ADDITIONAL HABITAT: Tiger beetles favor open ground in grasslands and forests, and can also be found along roadsides or in sandy areas like lake or stream edges and dunes.

CONSERVATION STRATEGIES: Create permanent plantings, like beetle banks or field borders, near crops to support tiger beetles. Maintain open, sandy areas for tiger beetle hunting and nesting; protect stream or lake edges, and reduce tillage.



Six-Spotted Tiger Beetle adult



Tiger Beetle with prey

Too “Discriminate”

Checkered Beetles

ORDER: Coleoptera

FAMILY: Cleridae



0.1 TO 1 INCH
(3 TO 24 MM) LONG

ADULT CHECKERED BEETLES are frequently brightly colored, with contrasting color patterns on their wing covers. They have elongated, narrow bodies and are covered with soft, short hairs.

COMMON PREY: Most species are predators as both adults and larvae. Some are common on flowers and foliage, feeding on grasshopper eggs, aphids, or other small insects, while many other species are associated with woody plants, feeding on wood-boring beetles or other pests of trees.

SPECIES IN NORTH AMERICA: Approximately 270

DEVELOPMENT TIME: From five weeks to one year or more, depending upon prey availability

GENERATIONS PER YEAR: One to two, depending on species, and prey availability

EGG-LAYING SITES: Under tree bark or in soil

OVERWINTERING: Larvae, pupae, or adults overwinter in soil or under bark

ADDITIONAL FOOD SOURCES: Pollen

ADDITIONAL HABITAT: Adults can be found on bark or flowers. Pupae are found in soil.

CONSERVATION STRATEGIES: Field borders, insectary plantings, hedgerows, and brush piles provide shelter, alternate prey, pollen, and overwintering habitat for checkered beetles.



Checkered Beetle adult



Checkered Beetle adult



Checkered Beetle adult

Although some larvae feed on grasshopper eggs, most feed on the provisions, eggs, and larvae of solitary bees!

**Specialist on wood boring insects.
Only on tree trunks and under bark**

**Specialist on ladybird beetles.
Aposematic coloration!**

**The Bottom Line For
Non-Crop Set-asides:**

**Consider CAREFULLY
Your Goals**

Increased Biodiversity

- **Very likely achievable**
 - **consider limited local pool of species**
- **Be careful for what you wish**
 - **> Exotics**
 - **> Pests**

For example:

Heavy mulching often 



Conservation Biocontrol

Have Realistic Expectations!

TANSTAAFL

(Robert A. Heinlein)

**There Ain't No Such Thing
As A Free Lunch**

My Appreciation To:

- **My ODA Colleagues, Thomas Shahan, Steve Valley, and Josh Vlach, for image acquisition.**
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- **Melville H. Hatch and Carl H. Lindroth for providing the taxonomic foundations enabling our excellent knowledge of the Carabidae of Oregon.**
- **You, the audience, for your attention and consideration.**

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