

Basics of Terrestrial Invertebrate Husbandry



or

*"You want me to work with
BUGS?!"*

Chris Mooney



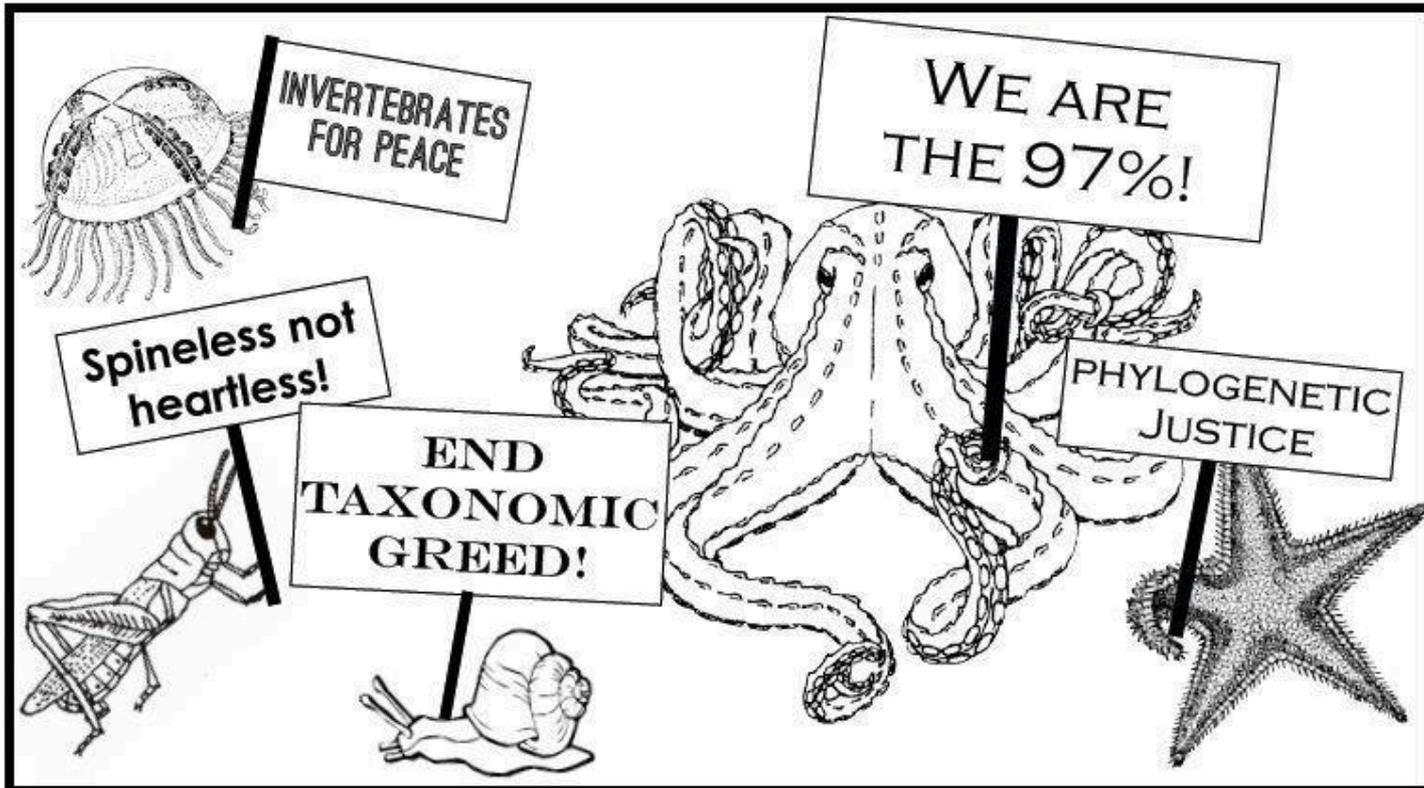
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Why Display Inverts?

- Invertebrates encompass 97% of all known animal species.
- Insects alone include over 1 million known species, with an estimated 6 - 10 million more awaiting discovery.
- In terrestrial areas, insects are EVERYWHERE.
- Yet of all the animals on the planet, insects are some of the most feared, reviled and misunderstood... and under-displayed!

OCTOPI WALL STREET



Invertebrates are 97% of animal diversity!

*Without them, there'd be
no us!*

- Invertebrates perform vital ecological roles, including primary consumption, pollination, decomposition, soil formation, aeration, and pest control.
- For every third bite of food you take, thank a honeybee!

Insects and their kin...

- ...are highlighted as the focal point of relatively few dedicated exhibits in North America.



- ...share a nearly universal misunderstanding and revulsion by American society.
- ...are the final frontier of zoological exhibitry!

Do people really want to see these things?



Absolutely!



I still haven't convinced you? Check this out...



So what are we talking about here?

- Phasmids (walking sticks)
- Roaches
- Beetles
- Millipedes
- Grasshoppers and katydids
- Mantids
- True bugs
- Arachnids
- Centipedes

What we're not gonna cover today:

- Hymenoptera (ants, wasps and bees)... I love 'em, but we just don't have the time.
- Aquatic insects. Ditto.
- Butterflies. Double ditto.
- Microinvertebrates
- Nematodes
- Mollusks
- Crustaceans
- Marine invertebrates



Some general considerations:

- USDA/APHIS PPQ permits
- Local and state regulations
- Safety

USDA/APHIS

- **United States Department of Agriculture's Animal and Plant Health Inspection Service.**
- **Why they matter to us:** responsible for controlling animals that have the potential to establish themselves as plant pests.
- **Allow individual facilities to maintain potential plant pest species by issuing Plant Pest Quarantine (PPQ) permits.**

The vast majority of the invertebrates displayed in zoos today are APHIS PPQ-permitted species!

**USDA/APHIS
Containment Facility
Authorized Personnel Only**

Basics of PPQ permitting:

- Each facility must list any and all restricted species it wishes to maintain and/or exhibit (if in doubt, include it).
- The APHIS/PPQ entomologist has full discretion to approve or deny any species at any facility.
- Each facility must be inspected and approved as a Containment Facility.

Containment Facility design (a very rough guide)



Double containment to prevent escape,
including for exhibits...

...screened ventilation and drainage...



...and trash sterilization via incineration, chemical treatment or freezing.



We freeze ours for 72 hours at -35°C .

Whereas USDA inspectors conduct inspections at zoological facilities to ensure that AWA standards are being met, it's PPQ inspectors who approve and make subsequent site inspections of invertebrate containment facilities... ensuring that containment standards are being met.

Local & State Regulations

You will need to investigate those on your own. Just know for now that many states require permits for collection, transport, display or release of any wild animals... including invertebrates.

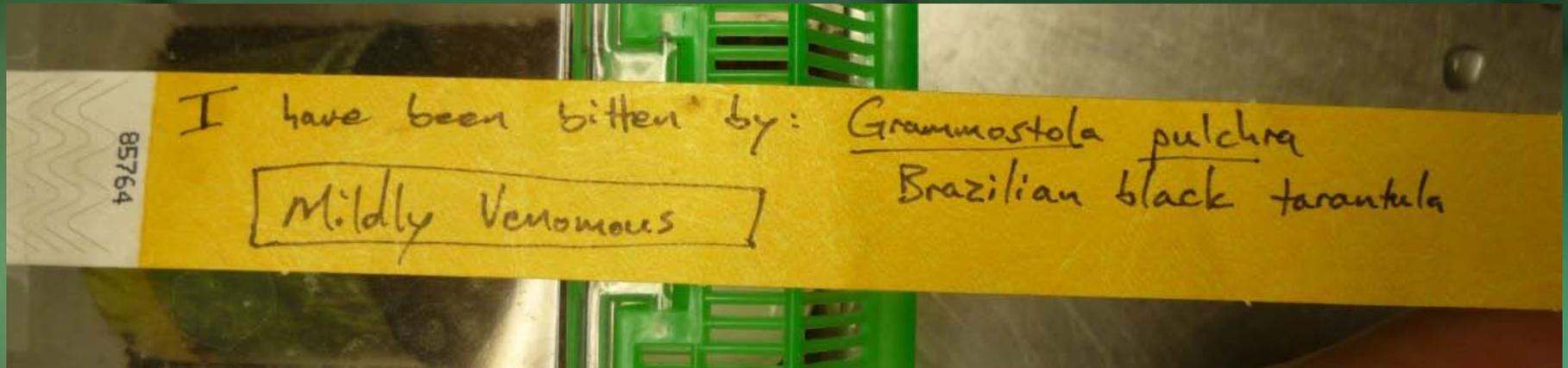
*General safety
considerations for working
with invertebrates*

- True bugs, bees and wasps, centipedes and most arachnids are venomous... some strongly so.
- Venom allergies can turn a normally mild bite, sting or spray into a medical emergency.
- All venomous animal enclosures should be clearly marked.
- Each venomous enclosure should carry a tag that can be removed by the victim in the event of a bite or sting, and kept on their body to let responders know what species is involved.
- And...

...all New World tarantulas have urticating hairs.



Venom bracelets at the San Diego Zoo



- Species names, scientific and common.
- Venom severity (written and color coded).
- Geographic origin.
- These are to go around the belt, never around the wrist.

Safety protocols

- Written and up-to-date standards for moving, handling, feeding, servicing enclosures, and recapturing animals in case of an escape.
- Should incorporate situationally appropriate equipment such as eye protection, protective gloves, long sleeves and forceps.
- More specifics as we cover various taxa.

Enclosures

- Invertebrate enclosures run the gamut from small plastic "jewel" boxes to large double-doored terraria with incorporated lighting and mist systems.
- Type and size depends mostly on the type, size and number of animals being housed.
- Depending on the species, you may need to install locks to prevent escape.

"Jewel" box



Kritter Keeper



ExoTerra-brand terrarium



40-gallon "breeder" tank





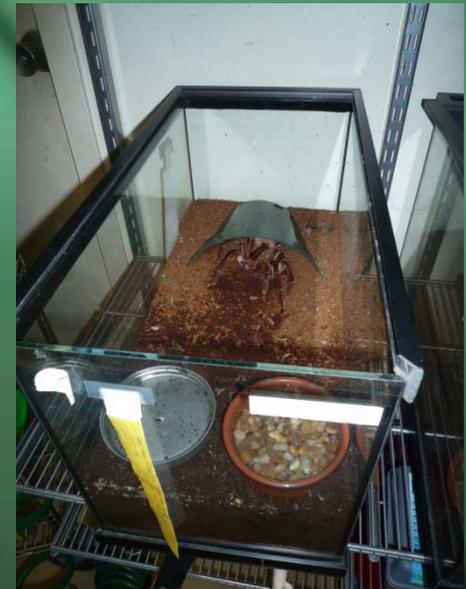
Plastic tubs of all sizes



Tall arboreal tanks



Standard size aquaria



Microhabitat

Each animal's enclosure and its contents form a microhabitat that can vary greatly from that in an enclosure sitting inches away. The conditions inside are what directly effect the animal. Those conditions can be tightly controlled, or can quickly get out of hand if ignored.



The characteristics of each microhabitat depends on:

- Ambient environment.
- Substrate... volume and composition.
- Ventilation... controlled by allowing more or less air to flow into the enclosure.
- Moisture... amount that is added through misting vs. the rate of evaporation.
- Lighting and photoperiod.

Ambient Environment

A good target for the ambient environment in the containment area is 80°F and 80% RH. We utilize Air-O-Swiss ultrasonic humidifiers, coupled with simple clip-on fans to prevent condensation. Space heaters are great for cold seasons.



A de-ionization system helps avoid mineralization of humidifiers and mineral staining of clear surfaces.



Substrate

- Depending on the species, could need a lot or almost none.
- Very moist, bone dry, or somewhere in the middle.
- Regardless of the volume, never let it become saturated or it can quickly become septic.
- Lots of materials to choose from...

Loamex



Coco Peat



Peat Moss



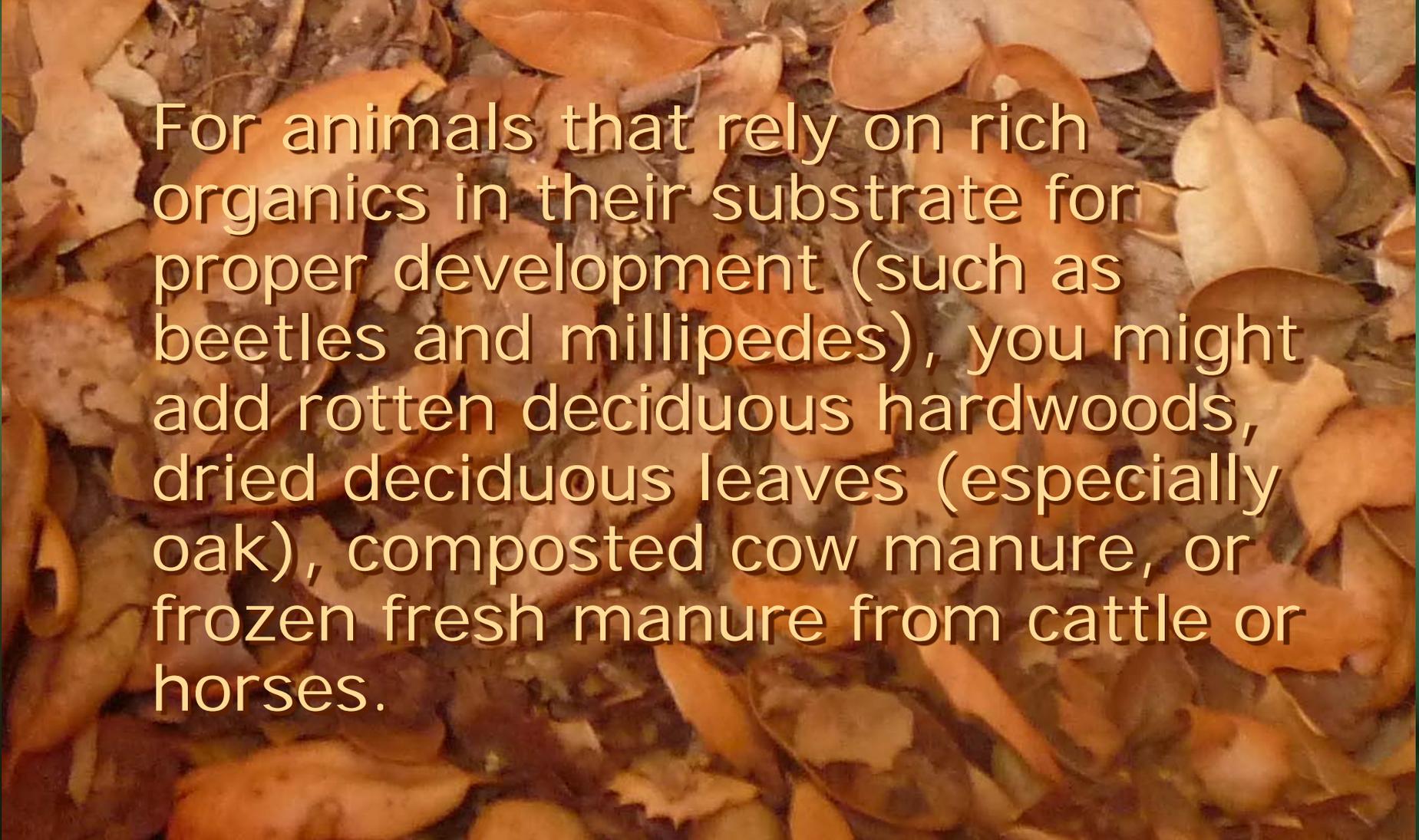
Sand



Gravel



Substrate Amendments



For animals that rely on rich organics in their substrate for proper development (such as beetles and millipedes), you might add rotten deciduous hardwoods, dried deciduous leaves (especially oak), composted cow manure, or frozen fresh manure from cattle or horses.

Ventilation

- Even for the most tropical and humidity loving species, air exchange is a good thing. Stagnant air can lead to issues such as mold and fungal growth.
- Too much air flow can lead to desiccation, even in the most arid of species.
- Some easy tricks for modifying ventilation are to cut more holes and then screen them (hot glue is an entomologist's best friend!), covering existing openings with plastic, or, in extreme cases, adding small mist systems or computer fans directly to an enclosure.

Screen top with adjustable cover



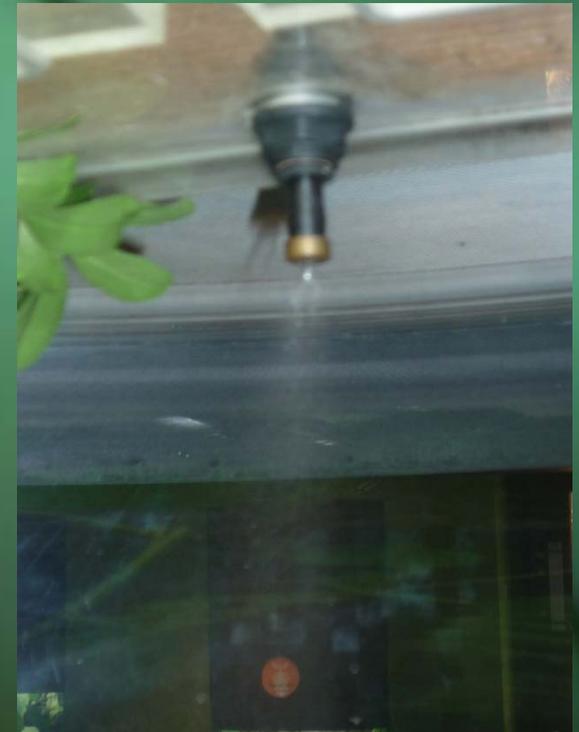
Computer fans mounted inside exhibit hood



Moisture via Misting

- Usually the first thing you do along with health checks, and the last thing you do before locking up for the night... and possibly several times in between.
- Most species benefit from some level of direct daily misting. For perching species that normally get water from dew on leaves, it is essential.
- Always be mindful of how much water is entering the substrate, and consider the needs of live plants in the enclosure.

Hand-held mist bottles with very fine setting adjustments offer the most precise control.



Mist systems can also be integrated into enclosures... just don't forget to turn it off or you'll have a mess on your hands!

Lighting and Photoperiod

- Lights can provide heat, various spectra (for instance, UVA is thought to stimulate appetite in some species), and a photoperiod.
- Even fossorial animals such as millipedes seem to benefit from a photoperiod. For certain species, such as some phasmids, it is critical for their wellbeing.
- For most species, full-spectrum daylight lamps are ideal.

Lighting types

Combo hood
(T8 florescent
tube & halogen)



Incandescent heat lamp



T5 florescent tubes in a daisy chain



Power compact florescent

*OK, so I told you all that
so that I can tell you this...*

Phasmids (walking sticks)

- Rely on camouflage for survival.
- Females lay eggs, which hatch out as tiny nymphs that grow by molting.
- Completely herbivorous.
- Live in tree foliage... some come down to lay eggs, other just drop their eggs to the soil.
- Can live in large groups.
- And...

...often exhibit extreme sexual dimorphism!



Heteropteryx dilatata

Host plants

Hibiscus



Boston fern



Acacia



Blackberry bramble

Host plants



Various species of ficus



Eucalyptus

Pyracantha



Storage in the containment area. If put in water promptly after cutting, some host plants can stay fresh and usable for two days. Filler plants (for décor and/or perching) can often last for a week if kept in clean water.



Spiny leaf insect (*Extatosoma tiaratum*)



- Thrive on eucalyptus, and can be sustained on pyracantha (fire thorn).
- For camouflage, they resemble a dried eucalyptus leaf.
- “Dance” like a fluttering leaf when disturbed.
- Subtropical... mist lightly but enough that they’ve got small droplets to drink off the leaves.
- Keep the substrate mostly dry.
- Coco peat is great, and can be kept very shallow (enough to pad eggs and collect frass).
- Sexually dimorphic (large unflighted females, small flighted males).
- Be careful with the nymphs... they blend in very well with the eucalyptus, and they’re fast!

Where's Waldo?

There's one nymph on the screen...
can you spot it?



Children's stick (*Tropidoderus childrenii*)

- Also thrive on eucalyptus.
- Also subtropical.
- Extreme sexual dimorphism.
- Dry substrate.
- Small eggs, fast nymphs!



Jungle nymph (*Heteropteryx dilatata*)

- Tropical... thrive in high humidity.
- Need deep, moist substrate so the females can bury their eggs.
- Sexually dimorphic. The unflighted



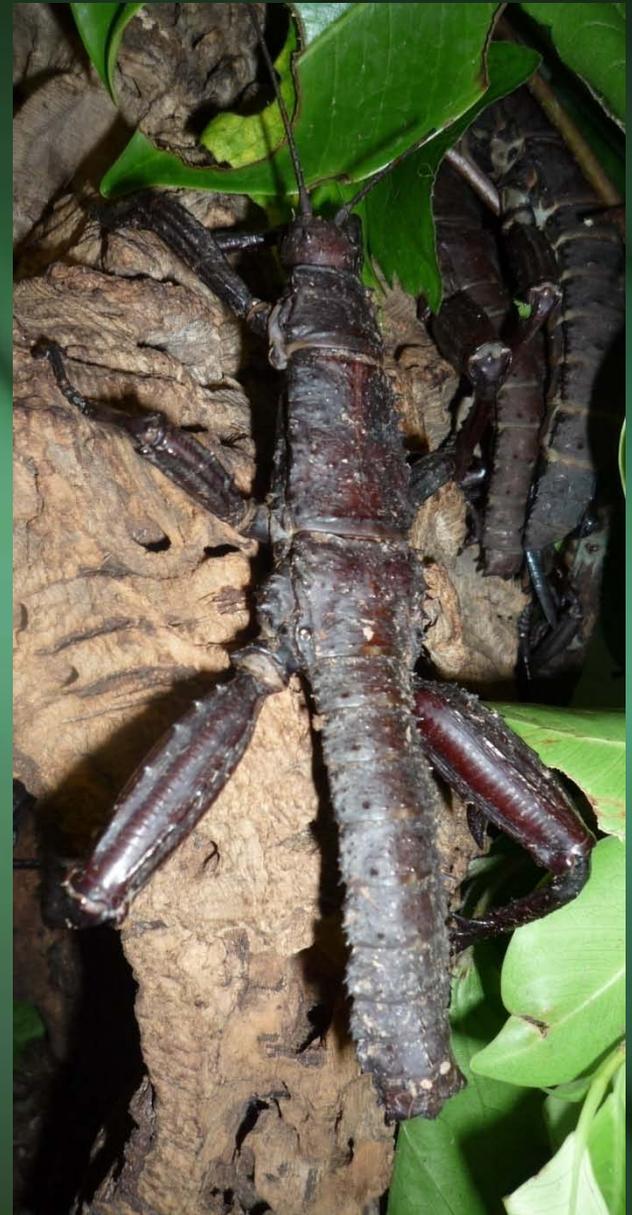
females are some of the heaviest insects on the planet.

- Females thrash violently with their hind legs when disturbed. A strong pinch can draw blood.
- Males are strong fliers.
- Some of their favorite host plants are blackberry bramble, pyracantha and hibiscus.
- Large eggs.
- Nymphs generally stay still to blend in.



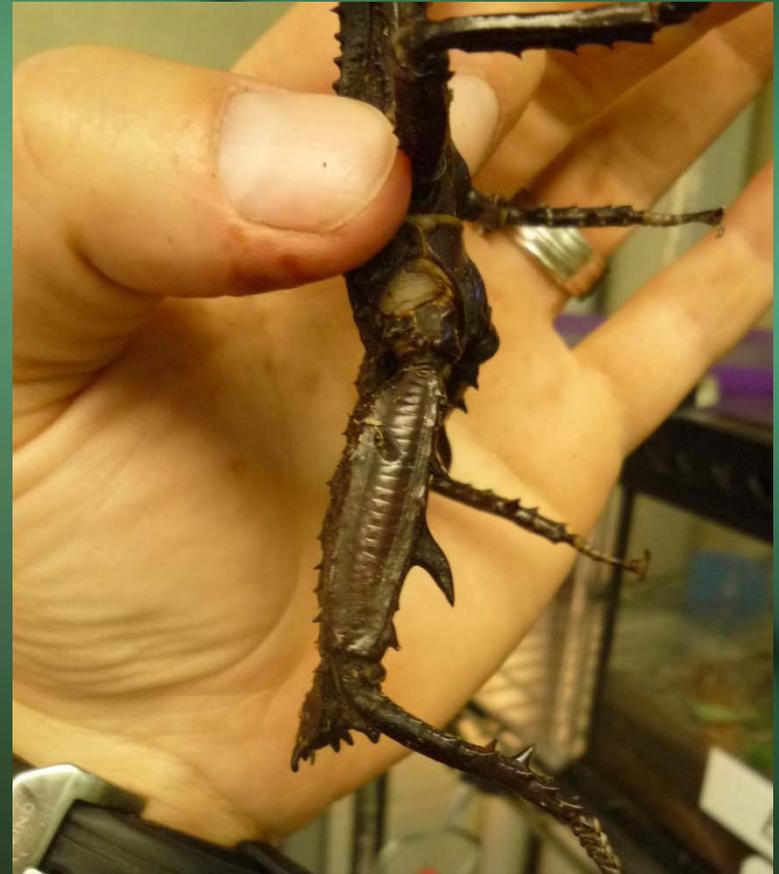
New Guinea spiny stick (*Eurycantha calcarata*)

- The “Mikey” of the phasmid world... seems like they’ll eat anything. Some favorites are blackberry, hibiscus and acacia.
- Tropical. They need high humidity and moist soil.
- Females bury their eggs.
- This species loves to hide behind cork bark or inside hollow logs.
- A heavy misting will trigger their appetite.
- The females are fantastic for educational programs. They are fairly relaxed on hand, have a weaker pinch than a jungle nymph, and are almost as large and impressive.
- Not very dimorphic, but...



...males have a large spine on the inside of each rear leg. Females do not. Males also emit a skunk-like musk when they're agitated. Females do not. Lesson? Only use females for programs, and know which gender you're

about to pick up! Hint: look for the long ovipositor at the end of the female's abdomen.



Giant leaf insect (*Phyllium celebicum*)

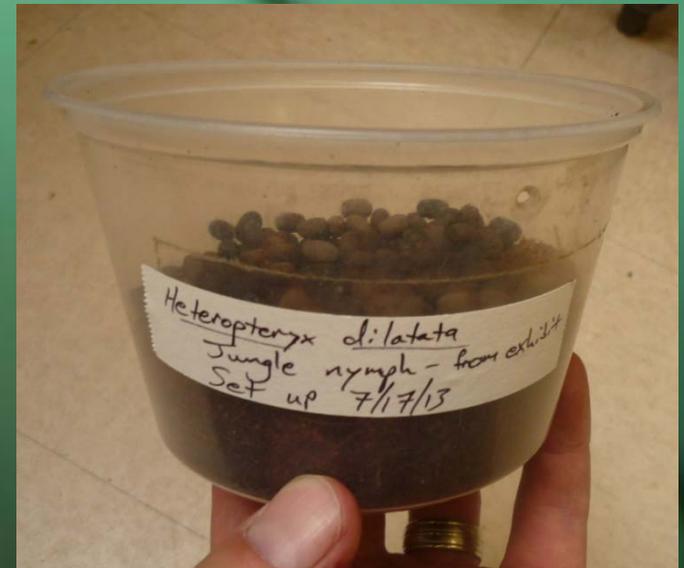
- Some of the best camouflage in the animal kingdom.
- Thrive on blackberry bramble.
- They do best with moist substrate and indirect misting.
- Females drop their eggs to the soil from above.
- Nymphs are not particularly fast, but blend in so well that they can be nearly impossible to spot.



Phasmid Egg Incubation

Phasmid eggs are easily collected and stored in deli cups in an incubator, such as this reptile model from Lyon Industries. Check daily for hatchlings, and mist deli cups as needed.

The eggs of some species can be viable for well over a year, so be sure to record the date of collection.



Roaches: the popular view



Roaches in the real world

- Flat, prolific omnivores that mainly eat decomposing organic matter.
- Can form huge groups.
- A very few number of roach species are pests... most never come near humans.
- They're super efficient decomposers, and are essential to the health of their ecosystems.
- Some make fantastic display animals that also do very well in a program setting.

Madagascan hissing roach (*Gromphadorhina portentosa*)



- A crowd favorite! These guys are big, loud, slow, and easy to care for... just keep a close eye on the babies, who are quick and can be tough to pick up.
- They thrive on any number of dry to slightly moist substrates. The key is to keep it clean. Remove dead roaches, shed exoskeletons and old food items on a regular basis.
- They devour almost all fresh cut produce, especially apple, sweet potato, corn, romaine, and cucumber.
- Fish flakes like TetraMin are a huge hit, and the high protein load keeps cannibalism to a minimum.
- The trick to kick start breeding is heat... under-tank heat pads and supplemental lighting can be used to push the surface temperature above 90°F.
- So how do they hiss?...

They quickly
expel air
from their
spiracles!



Can you tell the
boy from the
girl? Check out
the pronotum!

Giant cave roach (*Blaberus giganteum*)



- Another large roach that is very common in captive collections.
- Not as ideal for handling as hissing roaches because they are quicker and much more skittish, but display very well.
- An easy display option for this species is to put them in a tall tank with lots of vertical climbing surfaces.
- A prolific breeder that thrives on a broad range of produce. Also loves protein supplements like fish flake or dry cat food.
- Unlike hissing roaches, it's tough to tell the boys from the girls.

A housing tip for roaches:

If using a glass tank, apply a thin coating of petroleum jelly to the top 3" of the enclosure.



Beetles

- The largest slice of the insect pie, beetles represent well over 300,000 species!
- All beetles undergo a complete metamorphosis (egg to larva to pupa to adult)... like a butterfly.
- Their shiny, hardened outer pair of wings are called elytra, and they protect the inner flight wings.
- They have sharp grasping hooks, called tarsi, at the end of each leg.
- Beetles are vital to a healthy ecosystem and make for beautiful display animals.

Beetle rearin' ain't easy!



Atlas beetle

(Chalcosoma atlas)

- One of the largest beetle species, the males have 3 enormous horns with which they fight over food and females.
- Tropical (Southeast Asia) and love a humid enclosure with lots of rotting fruit.
- Love, love, love bananas topped with honey and bee pollen.
- Larvae grow to be the size of a hotdog.
- Larvae need to be reared in individual tubs with LOTS of rotting hardwood that is replenished often.
- Very strong with huge tarsi.





Jade-headed buffalo beetle (*Eudicella smithi*)

- Much smaller than an atlas beetle, but very beautiful.
- Can be reared in large numbers in a single tub.
- Adults love cut bananas with honey and pollen, while the larvae need rotten wood, dead leaves and rich soil.
- Larval soil can be fortified with cow or horse manure, but be sure to freeze it first.
- This species is very prolific... you'll probably end up culling larvae if you maintain any sizable group of adults.

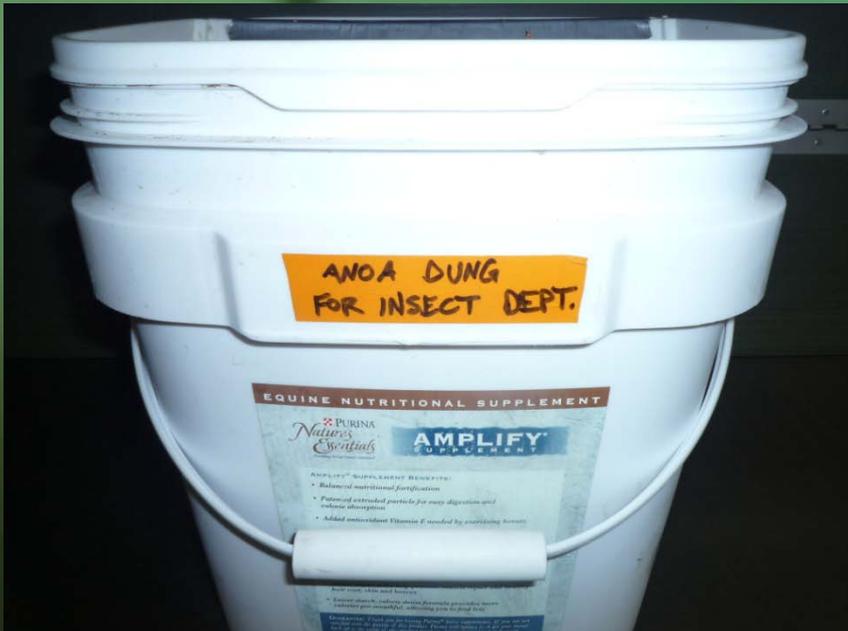


North American dung beetle (*Canthon pilularius*)



- These are a rolling dung beetle, and will stay active on the surface of the soil, as opposed to tunneling dung beetle species.
- We've experimented with the dung of several species, and they definitely prefer cattle dung. Our dung comes from the zoo's lowland anoa.
- The dung goes in the freezer for a week to kill earthworms and any parasites. We then remix it by [gloved] hand with water until it's the texture of wet cement... then serve!
- While they display well in large numbers, they are better at reproducing when housed as pairs.

Why I got into entomology in the first place...



Millipedes

- They are not insects; they are myriapods.
- “Millipede” means “1000 legs,” but at 2 pairs of legs per body segment, it’s usually no more than a few hundred legs per animal.
- All are decomposers, and are very beneficial to their ecosystems.
- They can excrete a mild cyanide solution from their exoskeleton if agitated. Gloves are recommended, as the secretions of some species can stain bare skin.

Giant African millipede (*Archispirostreptus gigas*)





- They need deep, moist substrate, and will climb if headroom and perching is available.
- Some favorite foods are romaine, cucumber, zucchini tomatoes, sweet potatoes, tomatoes and apples.
- They can suffer from cuticle issues, so we feed them powdered chitin sprinkled on their produce.
- The trick to getting offspring is to disturb the substrate as little and as infrequently as possible. If a partial soil change is needed, save as much of the old stuff as you can.

Grasshoppers and Katydid

- All can jump.
- Wide variety of diets.
- Some species make good display animals and feeders.
- Perching is essential.
- Some species have a powerful bite.

Rainbow lubber (*Romalea guttata*)

- From southeast US.
- Voracious eaters.
- Slow and hesitant to jump.
- Nymphs make good feeders for larger predators.



Long legged katydid (*Macrolyristes corporalis*)

- Largest in the world.
- Very long antennae.
- Hear with their knees!

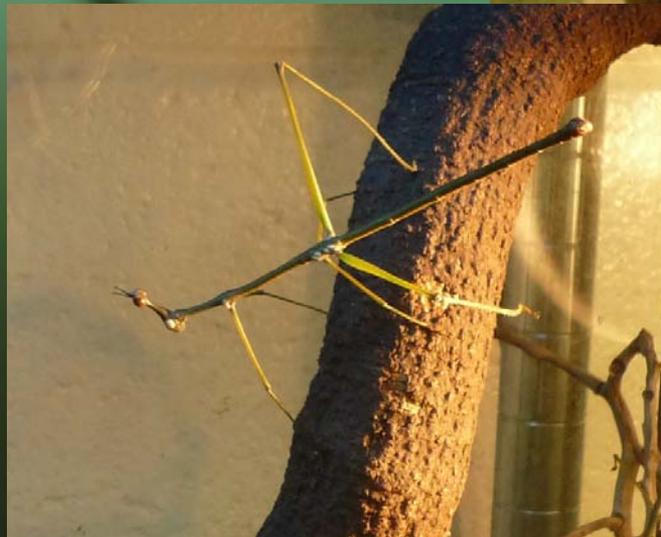


- Need lots of space.
- Eat a variety of cut produce.
- Fantastic program animals, but keep them inside as both sexes can fly.



Jumping stick (*Stiphra* sp.)

- Looks like a phasmid, but actually a grasshopper.
- Thrive on blackberry bramble.
- Need deep substrate for eggs, which look like bananas!
- They're quick, and can jump very far.



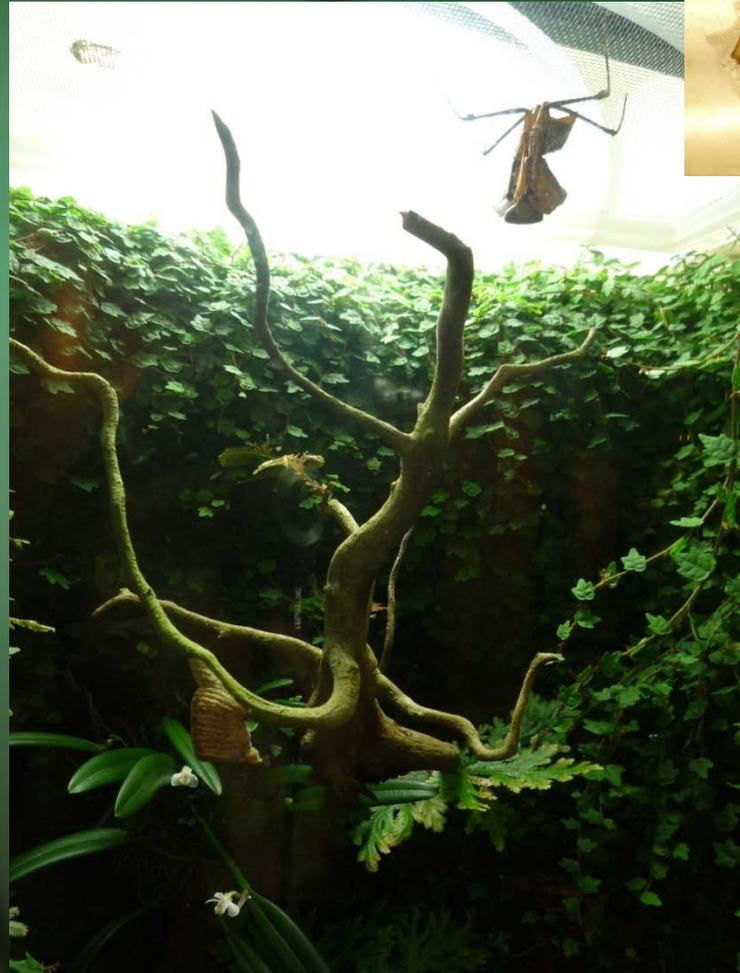
Mantids



- All are predators.
- Many have amazing camouflage.
- Require perching and live prey.
- Moveable head and amazing vision.
- Can be mated without the male meeting his end, but you've gotta keep an eye on them!

Dead leaf mantis (*Deroplatys dessicata*)

- Females have a large shield on the back of the thorax.
- Display very well and tolerate lots of disturbance.
- Will lay and guard an ootheca (egg case) even if she's never mated.



True Bugs

- An actual order of insects, true bugs are characterized by their piercing/sucking mouthparts.
- Ecologically, they can be extreme plant pests, though some species are predatory.
- They often sport aposomatic coloration, warning of a painful bite.

White-spotted assassin bug (*Platymeris biguttata*)

- They thrive in groups on dry substrate.
- Love live crickets.
- Their saliva contains a strong digestive enzyme which they use to kill and liquify their prey.
- They can also spray their saliva, so WEAR SAFETY GLASSES.
- They've got a painful bite, so WEAR GLOVES.



Arachnids

- Spiders, scorpions and their relatives.
- Found all over the world.
- Are vital for population control.
- Grow by molting.
- 8 legs, 2 main body parts – 100% fascinating!



Goliath bird eater (*Theraphosa blondi*)

- Largest known spider.
- Loves to burrow.
- This tarantula has been known to eat baby birds in the wild on the rare opportunity it gets a chance, but it's more likely to ambush its prey on the ground.
- A definite crowd pleaser on exhibit.



A trip to the hospital for some dermal glue.



Desert hairy scorpion (*Hadrurus arizonensis*)

- Largest scorpion in North America, but not the most venomous.
- Sting comparable to a bee sting.
- Keep their enclosure dry, but provide water.
- Brown sensory hairs help it capture prey.
- Spend their days hiding and their nights hunting.



Emperor scorpion (*Pandinus imperator*)

- One of the world's largest scorpions.
- Fairly weak venom.
- Native to central African rainforests.
- Rely on their enormous pincers more than their venom.
- Live under leaf litter, sometimes in large groups.
- The females are attentive mothers, which is rare among scorpions.



Centipedes

- Another type of myriapod.
- Means "100 legs." In reality, each individual has 1 pair of legs per body segment.
- All are predators.
- The most common to display are the largest members of the genus *Scolopendra*.
- Incredibly fast. Use extreme caution.\

Giant Sonoran centipede (*Scolopendra heros*)

- Ferocious predator.
- Fast, fast, FAST!
- House in a tall tank on dry substrate.
- Very strong.
- Prefers to hide under rocks or wood, but will often sit out in the open.



Use snake clips on lids.



Our facility



Containment Room



Exhibit Area





Polinator Garden



Exhibit Design





