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A Practical Emergence Chamber for Collecting Coleoptera from Rotting Wood, with a Review of Emergence Chamber Designs to Collect Saproxylic Insects

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Abstract

A detailed and accurate survey of the insect fauna of rotting wood can be difficult due to the physical and mechanical properties of the habitat. Quarantining pieces or parts of dead wood in emergence chambers and collecting the insects that emerge is an effective survey method. Here we describe an inexpensive emergence chamber made from an 18-gallon (ca. 68-L) Sterilite® plastic tote box that was modified by adding a removable bottom collection jar and ventilation to the top and side. Ninety of these emergence chambers were three-fourths filled with dead wood (2.5–20 cm diameter) of various decay classes, and run for 24 months in Great Smoky Mountains National Park. A total of 5,692 adult Coleoptera specimens representing 50 families, 226 genera, and 275+ species were collected. Selected results are presented to illustrate the effectiveness of the design. Five fundamental axes of emergence chamber design are identified and discussed. We also compare this design to other published emergence chamber designs.

Key Words: coarse woody debris, photoeclector, Great Smoky Mountains National Park

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Dead wood is an opaque habitat. Even the experienced collector, tramping through a forest, is easily rebuffed by an impenetrable log. Subcortical faunae may be easy prey, but the mass of life teeming within the heartwood is perfectly safe from the would-be assassin, biasing short-term survey results. To gain an appreciation of the "life" of dead wood, we must step out of the day-collector's time scale. Only when we see months as if they were minutes, and years as if they were hours, can we truly see dead wood for the dynamic habitat that it really is.

A comprehensive study of the numerous organisms, particularly insects, that reside within dead wood is virtually impossible in real time due to the small size of most insects and the matrix within which they reside. To overcome this difficulty, researchers use emergence chambers to quarantine dead wood samples, and during the following weeks or months collect the organisms that emerge. Clever combinations of exposure or quarantine, substrate type, and time allow researchers to build a dynamic picture of the dead wood habitat.

Here we differentiate emergence from rearing. *Emergence* implies an attempt, with little or no intervention or addition of resources, to collect individuals from a given substrate, whereas *rearing* implies an attempt, often with intervention and addition of resources, to nurture organisms through life stages, for example from larva to adult, or through multiple generations. Emergence chambers are important tools in the study of the dead wood habitat because life cycles of most saproxylic insects involve emergence of adults after long periods of time inside the substrate.

Numerous emergence chamber designs have been used to collect saproxylic insects (Table 1). These designs vary greatly in size, ranging from the room of a house (Brues 1927) to much less than a cubic meter (Schauff 2001). They may enclose part of the wood (Derksen 1941) or all of it (Jonsell and Hansson 2007). Some designs may be placed within a closed building (Ulyshen *et al.* 2010), placed in an open building (Hedgren 2007), or left in the field (Hövenmeyer and Schauermann 2003). They may also require active external equipment (Ulyshen and Hanula 2009), or operate in a standalone fashion (Ferro *et al.* 2009). The specimen concentration method may be hand collection (Blackman and Stage 1924), photoeclection (Mecke *et al.* 2001), gravity (Hammond 1997) or a combination thereof. A photoeclector is a collecting device based on positive phototropism (Masner and García 2002). Additionally, several publications describe numerous insect collection techniques, including emergence chambers (Peterson 1953; Martin 1977; Southwood 1978; Schauff 2001; Aguilar Julio 2010).

To accommodate our specific research requirements, an emergence chamber was designed with the following attributes: 1) large enough to hold numerous pieces of dead wood, up to 20 cm diameter × 40 cm length; 2) robust enough to be left outdoors for several years; 3) easily defended against

Table 1. An annotated list of literature describing emergence chambers used to collect saproxylic insects. cut = wood death caused by humans; natural = wood death not caused by humans; CWD = coarse woody debris.

Publication	Country	Chamber type; size	Chamber location	Substrate type	Additional resources	Concentration method	Taxa, # specimens/ species collected
Grove *et al.* 2008	Australia	wrap around substrate; 3 linear meters each	field	cut CWD	none	gravity/photoeclection lower, photoeclection higher	Coleoptera 11,816/346
Lachat *et al.* 2006	Benin	independent, self supporting; 0.18 and 0.20 m^3	field	natural CWD limbs > 5cm	none	photoeclection	Coleoptera 7,474/469
Boulanger and Sirois 2007	Canada	wrap around suspended log; one sample per chamber	non-heated building	natural CWD produced by fire	building provided structure for chamber	gravity	Coleoptera 391/32
Hammond 1997	Canada	independent, self supporting; 1.5 m^3	laboratory	cut CWD logs and snags	none	gravity	Arthropoda 39,094 specimens, 13 orders, 113 families, 2,000+ species
Hammond *et al.* 2001	Canada	independent, self supporting; 1.0 m^3	laboratory	cut CWD snag, log, and stump	none	gravity, photoeclection	Coleoptera 1,049/49
Blackman and Stage 1918	USA	independent, self supporting	outdoors near laboratory	natural CWD snags, cut to size	water occasionally added	hand collection	Coleoptera ?/25; Diptera ?/4; Hymenoptera ?/15; Lepidoptera ?/1
Blackman and Stage 1924	USA	independent, self supporting; "cages" to "jars"	outdoors and inside insectary	natural CWD limbs and logs	none	hand collection	Coleoptera ?/105; Diptera ?/34+; Heteroptera ?/4; Hymenoptera ?/75; Lepidoptera ?/8; Thysanoptera ?/3
Brues 1927	USA	room of house where stove wood was stored	in building	cut CWD, seasoned (one year), split	climate control	photoeclection, hand collection	Coleoptera 385/34; Diptera 33/16; Heteroptera 5+/5; Hymenoptera 261/27; Psocoptera 12/4; Thysanoptera 3/2;
This study	USA	independent, self supporting; 0.12 m^3	field	natural CWD, 2.5–20 cm	none	gravity, photoeclection	Coleoptera 5,678/275+
Ferro *et al.* 2009	USA	independent, self supporting; 0.19 m^3	open air building	cut fine woody debris	none	gravity	Coleoptera 414/35
Ulyshen and Hanula 2009	USA	suspended bag; one sample per chamber	laboratory	cut CWD logs	ventilation with electric blower	gravity	Coleoptera 33,457/250+
Ulyshen *et al.* 2010	USA	suspended bag; one sample per chamber	laboratory	cut CWD logs	ventilation with electric blower	gravity	Coleoptera 3,457/80
Mecke *et al.* 2001	Brazil	independent, self supporting; 0.043 m^3	laboratory (presumed)	cut dead CWD and fine woody debris	moistened every 1–3 days	photoeclection	Coleoptera 5,787/35; Hymenoptera 64/5

Hövenmeyer and Schauermann 2003	Germany	independent, self supporting; one sample per chamber	field	natural CWD limbs	none	photoeclection	Diptera 11,616/163
Irmler *et al.* 1996	Germany	wrap supported by substrate; one sample per chamber (logs), partially surrounded substrate (stumps)	field	cut CWD logs and stumps	none	photoeclection	Diptera: Mycetophilidae 1,224/55; Sciaridae 5,894/38; Coleoptera 3,956/114
Økland 1996	Norway	wrap supported by substrate; partially surrounded substrate (75 cm linear distance)	field	natural CWD	none	gravity, photoeclection	Coleoptera 162/64
Gibb *et al.* 2006a, b, Hilszczański *et al.* 2005, and Stenbacka *et al.* 2010	Sweden	wrap supported by substrate; partially surrounded substrate (30 cm linear distance)	field	cut CWD logs and snags	none	photoeclection	Coleoptera 126,092/76; Hymenoptera: Ichneumonoidea 949/24
Hedgren 2007	Sweden	suspended bag; one sample per chamber	open air building, then greenhouse	cut CWD low and high stumps	climate control	gravity, hand collection	Coleoptera 10,357/25+; Hymenoptera 797/10+; Heteroptera 168/1+
Jonsell and Hansson 2007	Sweden	comparison of 1) independent, self supporting box; 2) suspended bag	both in laboratory	both cut fine woody debris	1) none 2) building provided structure for chamber	1) photoeclection; 2) gravity	Coleoptera 1) 433/92; 2) 1,055/109
Lindhe and Lindelöw 2004	Sweden	wrap supported by substrate; one sample per chamber	field	cut high stumps	none	photoeclection	Coleoptera 47,038/316
Weslien 1992	Sweden	suspended bag; 0.13 m^3 - moved from bag to paper carton	bag left in field; bolts lay unprotected in the field during winter then placed in carton in laboratory	cut CWD logs	none	bag, gravity; carton, photoeclection	Arachnida: Pseudoscorpionida 8/1; Insecta: Coleoptera 23,373/21; Diptera 831/7+; Hymenoptera 953/8
Wikars *et al.* 2005	Sweden	suspended bag; each sample had 0.5 m^2 bark area	field	natural CWD	none	gravity	Coleoptera 1,483/80
Scheigg 2001	Switzerland	wrap supported by substrate; partially surrounded substrate	field	natural CWD trunks and limbs	none	photoeclection	Diptera 30,095/426; Coleoptera 4,906/228

wild animals; 4) requiring no regular maintenance or active external equipment; 5) with a passive specimen concentration method; 6) mass producible; 7) and affordable to build in quantity. We herein describe our emergence chamber and present selected results to illustrate the effectiveness of the design.

Material and Methods

The main body of the emergence chamber is a grey Sterilite® 18-Gallon Tote Box model number 18158208. The external dimensions are 24.000 × 18.375 × 15.750 in (~61 × 47 × 40 cm). The volume is 18 gal (~68 L) and each tote box masses ~1.7 kg. The central portion of the bottom of the tote box is raised and flat. This creates a trough ~4 cm wide and ~1 cm deep around the perimeter of the tote box. There is one ~5-mm diameter hole in the center of the molded handle on each end of the tote box placed here by the manufacturer. The central portion of the lid, starting ~6 cm from the edge, is lowered by ~1 cm. The lid clips on but does not entirely seal.

Modifications to the tote box were made as follows (Fig. 1):

1. A ~6-cm diameter hole was drilled in the trough of the bottom of the tote box directly under the molded handle (the end of the tote box) (Fig. 2). A band that fits a Kerr® wide-mouth half-pint (8-oz, ~0.24 L) mason jar was secured around the hole using two wide-head screws (truss washer lath). The screws were positioned in the distal and proximal edges of the band, not lateral. A generous amount of Liquid Nails® brand Heavy Duty Construction Adhesive (LN-901) was used to seal and fill any gaps between the band and the tote box. When the completed emergence chamber was in use, a Kerr® wide-mouth half-pint (8 oz, ~0.24 L) mason jar was placed here as the collection container.

2. The front ventilation hole was made by drilling one ~3-cm diameter hole in the center of the front side wall of the tote box ~10 cm above the bottom and directly over the collection jar (Fig. 1). Three layers of Weedblock® landscape fabric were placed over the hole and the edges were secured in place with Heavy Duty Construction Adhesive. The adhesive was covered with masking tape to keep nested chambers from becoming glued together. The landscape fabric has a closed mesh, allows ventilation, prevents light from entering, and blocks insects from entering or exiting the chamber.

3. The top ventilation holes were made by drilling two ~3-cm diameter holes side by side in the raised perimeter of the lid in the center of the left side (Fig. 1). On the underside of the lid three layers of landscape fabric were placed over the holes and secured in place with Heavy Duty Construction Adhesive.

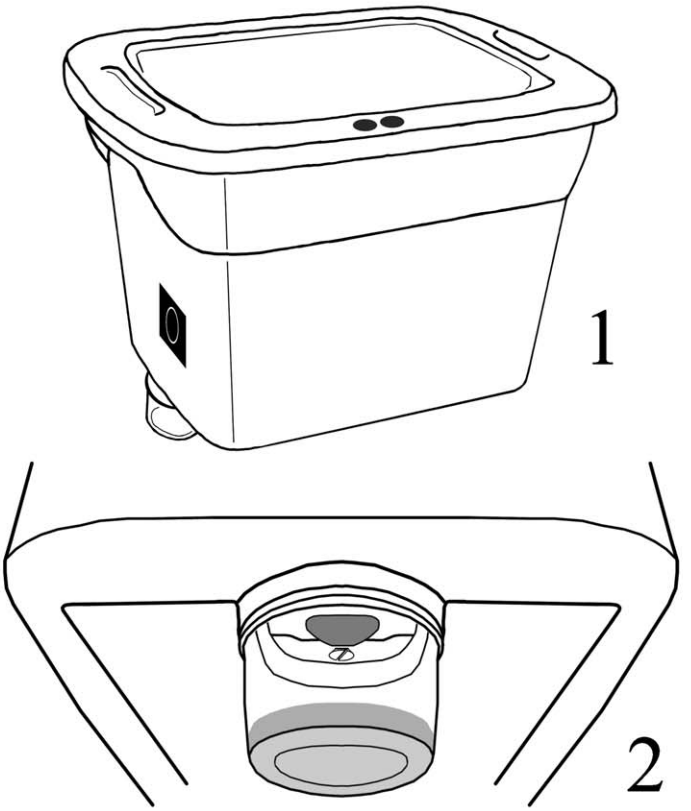
4. Each hole in the center of the molded handle was covered with tape on the inside of the tote box.

5. After substrate was added, the lid was sealed to the bottom portion of the tote box with Duck Tape® duct tape.

6. When deployed in the field, these emergence chambers could be safely stacked two high (Fig. 3). Landscaping timbers 3 × 4 in (~7.6 × 10 cm) were used to elevate and provide a stable platform for the lower chambers. The lower chambers were set side by side facing the same direction. A second chamber was placed on each lower chamber, facing the opposite direction and positioned so that its collection jar was just beyond the edge of the lid of the lower chamber. A 20-cm long piece of 2 × 2 in (~5 × 5 cm) lumber was placed on the lid of the lower chamber and against the back of the bottom of the upper chamber. Two 2.5-in (~6-cm) screws were used to secure the lumber to the lid of the lower chamber and one screw was used to secure it to the back of the upper chamber, thus fastening the two together. A single 1.25-in (~3-cm) screw placed in the right front corner of the lid of the lower chamber was used to securely fasten it in order to prevent the lid from popping open due to strain from the slightly cantilevered upper chamber. No such screw was needed in the upper chamber.

7. After the emergence chambers were secured in place, an appropriate amount of propylene glycol antifreeze (Prestone® Low Tox™ brand) was added to each collection jar as a preservative.

The above design was used as part of the Coleoptera component of the All Taxa Biodiversity Inventory at Great Smoky Mountains National Park, Tennessee/North Carolina (GSMNP) (Carlton and Bayless 2007; for a summary of publications resulting from that project see Ferro and Carlton 2010). A complete description of the research indicated below, with detailed results, is in preparation, and the following outline is provided to place the generalized results of the use of the described chambers in context. During April 2006, dead wood from mixed species of deciduous trees of various decay classes and sizes was gathered at remote sites in GSMNP and transported to a single locality within the park. Ninety emergence chambers were each three-fourths filled with dead wood (2.5–20 cm diameter) and placed in a shady, forested location near the Twin Creeks Science and Education Center in GSMNP. This approximated the environment from which the wood was collected and reduced the risk of overheating. The array was surrounded by a battery-powered electrified fence to protect against bears and feral hogs. Chambers were serviced six times during the spring, summer, and early fall of 2006, and three more times during spring, summer, and fall of 2007, otherwise the



Figs. 1–3. Emergence chambers. **1)** Completed emergence chamber with collection jar and front and top ventilation holes; **2)** Detail of collection jar attachment, only the distal screw is shown; **3)** Stacked chambers in the field (Great Smoky Mountains National Park).

chambers were left unattended. Servicing consisted of removal of specimens and old preservative, then addition of new preservative.

Results

Production. Each emergence chamber cost approximately US$7 in supplies and building 90 units took about 10 days. Because the main bodies of the chambers can be nested, only about 6.5 m^2 of floor space were needed for the entire manufacturing process. The emergence chambers were loaded on a small trailer and transported ~1,100 km from Baton Rouge, Louisiana to GSMNP.

Integrity of the Design. No chambers fell over in the first year of use. During 2007, a dead tree crushed two stacked chambers and disturbed two others. Collection jars, even when left unattended through the winter, did not fall off, leak, or break. No lids came open and the ventilation holes remained "sealed".

At the end of the collection period all chambers were opened and inspected for defects or wear and tear. None of the holes made by screws in the lid of the lower chamber and base of the upper chamber showed signs of allowing water movement or insect entrance or escape. No chambers had holes or punctures caused by boring insects, falling sticks, or other mechanical abrasions. In some cases the Heavy Duty Construction Adhesive used to seal the collection jar band to the chamber began to separate from the chamber but remained firmly pressed against it. This separation was only evident when lateral pressure was placed on the collection jar but the chamber was effectively sealed again when pressure was removed.

The duct tape used to seal the lids was frayed, dried, and weathered on the top of the lid where it was exposed to the sun. However, it was surprisingly fresh, flexible, and strong under the edge of the lid where it sealed against the chamber.

Several times collection jars nearly filled with water, diluting the preservative, but not harming the specimens. Presumably, the central depression of the lid filled with water from a rain storm and debris (leaves and sticks) that had settled on the lid wicked the water over to the top ventilation holes.

When the chambers were opened, the underside of the lid tended to be covered in condensation, while the bottom of the chamber was typically dry. Several chambers had pieces of wood that were apparently saturated with water, while other pieces in the same chamber were dry. Several chambers had wood with extensive recent fungal growth.

Performance. Identifications are ongoing for difficult taxa, and some are identified only to family or genus. Therefore, the true number of genera and species of specimens that emerged from the collected wood is expected to be higher than what is reported here.

Table 2. Coleoptera families and number of species collected from emergence chambers with dead wood collected in Great Smoky Mountains National Park. Scydmaenids are considered separately (as Staphylinidae: Scydmaeninae) because they were widely recognized as a family until recently (Grebennikov and Newton 2009).

Family	# spp.	Family	# spp.
Aderidae	1	Lucanidae	1
Anobiidae	9	Lycidae	1
Anthribidae	2	Lymexylidae	1
Buprestidae	2	Melandryidae	8
Carabidae	11	Melyridae	2
Cerambycidae	29	Monotomidae	1
Cerylonidae	5	Mordellidae	7
Chrysomelidae	2	Mycetophagidae	1
Ciidae	7	Nitidulidae	3
Cleridae	1	Oedemeridae	1
Colydiidae	2	Ptiliidae	3+
Corylophidae	1	Ptilodactylidae	1
Cryptophagidae	3	Pyrochroidae	3
Cucujidae	1	Salpingidae	1
Cupedidae	1	Scarabaeidae	1
Curculionidae	28	Scraptiidae	1
Elateridae	10	Silvanidae	3
Endomychidae	5	Staphylinidae	62+
Erotylidae	1	Scydmaeninae	7+
Eucinetidae	1	Stenotrachelidae	1
Eucnemidae	7	Synchroidae	1
Histeridae	4	Tenebrionidae	13
Hydrophilidae	1	Tetratomidae	1
Laemophloeidae	4	Throscidae	1
Lampyridae	1	Trogossitidae	2
Leiodidae	9	**Total spp.**	**275+**

A total of 5,678 adult beetle specimens were collected. These comprised 50 families, 226 genera, and 275 species (Table 2). During 2006, the six collection events resulted in 1,580 specimens in 44 families, 174 genera, and 197 species (Table 3). Of these, 13 families, 74 genera, and 97 species were collected exclusively during the first year. During the second year, three samples were taken that resulted in 4,098 specimens in 37 families, 155 genera, and 178 species. Of these, 6 families, 53 genera, and 77 species were collected exclusively during the second year.

Discussion

Emergence Chamber Described in this Paper. This emergence chamber design was low-cost, easy to manufacture, stable, resisted weathering and breakage, required no upkeep, and concentrated/preserved a wide variety of taxa. This is an excellent trap design for researchers with little indoor or laboratory space to devote to emergence chambers. Additionally, the design is robust enough to be left

Table 3. Total taxa and unique taxa collected by year from dead wood samples collected in Great Smoky Mountains National Park.

	2006 total	2006 only	2007 total	2007 only	
	# taxa (%)	# taxa (%)	# taxa (%)	# taxa (%)	Total
Specimens	1,583 (28%)		4,109 (72%)		5,692
Family	44 (88%)	13 (26%)	37 (74%)	6 (12%)	50
Genus	174 (77%)	74 (33%)	155 (69%)	53 (23%)	226
Species	197 (72%)	97 (35%)	178 (65%)	77 (28%)	275

unattended for many months. The diversity of taxa collected was impressive: 74 beetle families with possible saproxylic species occur in GSMNP and specimens from 50 (68%) of these were collected using the emergence chambers.

The number of specimens increased by 250% during the second year, indicating that at least some species may have undergone multiple generations in the emergence chambers. Twenty-eight percent of all species collected were only collected during the second year. This indicates that at the very least the chamber did not contain a design flaw that sterilized the contents (*e.g.* overheating) and species requiring more than one year to develop could do so within the environment of the chamber.

This study resulted in the fourth highest species richness of all saproxylic Coleoptera emergence studies reviewed and the second highest species richness of saproxylic Coleoptera emergence using a self-supporting chamber (Table 1). Meaningful comparisons across studies are difficult because each study looked at different faunas, used different volumes of substrate, and collected over differing amounts of time. However, standardization of studies of fauna in dead wood using emergence chambers would require an emergence chamber that is compatible with a wide variety of taxa.

Reviewed Emergence Chamber Designs. The reviewed emergence chamber designs (Table 1) differed on five major axes: 1) full or partial enclosure of dead wood; 2) self-supporting or supported by substrate; 3) final location of chamber and environmental control; 4) resource requirements for chamber operation; and 5) concentration method. These axes are not meant to represent every conceivable aspect of chamber design, only the most fundamental. Depending on the research question(s), other aspects may be as or more important (*e.g.* incorporation of data loggers and other sensor equipment), but those specific aspects will not be discussed in this general review.

1. Enclosure of dead wood. This axis has two states: fully enclosed or partially enclosed (not given in Table 1). The substrate is typically not fully enclosed in the following situations: the substrate is too large to fully enclose (snags, large logs); portions of the substrate are inaccessible (stumps); and/or the researcher wishes to leave a portion of the substrate open to colonization while another section is being surveyed. Full enclosure of the substrate in principle provides a better seal and reduces loss of enclosed organisms or contamination from outside organisms. Other axes are largely independent of this axis, except axis 3 where a decision to not fully enclose the substrate may reduce where and how the substrate may be stored.

2. Chamber self-supporting or supported by substrate. This axis represents a continuum of states ranging from a rigid chamber whose structure is independent of the substrate to a completely flaccid chamber that is fully supported by the substrate (Table 1: Chamber type). Where the substrate is small, not structurally sound, samples are intended to be stacked, and/or complete or partial climate control is desired (*e.g.* in a laboratory), a rigid chamber may be best. Rigid chambers provide an easily standardized volume and may be easier to monitor for damage or holes than some types of partially or fully flaccid chamber. However, a chamber (typically consisting of cloth-like material or netting) supported by the substrate may be best used in situations where the substrate is very large (lying or standing), when the study area is far from vehicular access and the substrate will be left in the field (thus rigid material would be heavy/cumbersome to transport to the site), or when portions of the substrate are to be left exposed. This axis is largely influenced by axis 3 (see below).

3. Final location of chamber and environmental control. This axis represents a continuum from the chamber being left in the field with no additional attempts to control the substrate's environment to the chamber removed to a laboratory where multiple aspects of the environment are strictly controlled actively or passively (Table 1: Chamber location). Any emergence chamber, regardless of design or material used, will alter the microclimate of the substrate, affecting, at the very least, the boundary layer of air surrounding the dead wood, which in turn will influence the temperature and humidity of the substrate. Presumably, chambers left at the study site or completely outdoors will experience

large environmental effects, such as daily temperature changes, similar to the undisturbed substrate. However, it should be expected that the rate or magnitude of these changes will be dampened by the increased boundary layer created by the chamber. As the chamber is further removed from the outside environment—placed in an open-sided building or a climate-controlled laboratory—the influence of the outside environment will necessarily decrease. Thus, the final location of the chamber and environmental control over the substrate are inseparably linked.

Environmental factors such as the possibility of the chamber flooding, overheating, destruction by animals (*e.g.* bears, rodents), vandalism, and accessibility should be taken into account when deciding the final location of the chamber and any environmental controls used. Chamber location influences axis 1 (see above) and axis 2 where transportation, stacking, or otherwise storing samples is affected by chamber size and shape. Location is influenced by axes 4 and 5 (see below).

4. Resource requirements for chamber operation. This axis takes into consideration the labor, energy, and materials used during the entire life of the chamber (Table 1: Additional resources, exclusive of servicing). Typically, resources are associated with environmental control, such as laboratory space for stacking or hanging chambers (axis 2), ventilation, and addition of water. Servicing a chamber (*e.g.* specimen removal) is a labor resource and should be taken into account when considering the final location of the chamber (axis 3), especially if there is a possibility that student workers or volunteers will be used. Resource requirements are also influenced by axis 5 (see below).

5. Concentration method. When an emergence chamber is sealed, specimens within the substrate have, in a sense, been collected. This axis involves methods to sequester specimens after they have emerged from the substrate (Table 1: Concentration method). Concentration methods can be active or passive. The most straightforward active concentration method is hand collection. This method has obvious benefits, including allowing for precise association of specimens with emergence holes and galleries, and association of parasitoids with hosts. However, hand collection may result in small specimens being overlooked, requires that chambers be very accessible (axis 3), and is labor intensive (axis 4). Most concentration methods are passive, based on the design of the chamber, and exploit specific aspects of insect behavior. Photoeclection (concentration of insects based on positive phototropism) is accomplished by constructing an opaque emergence chamber where the only light available is from a transparent collection container. Placement of such a collection container at the top of the chamber exploits the flying or upward crawling behavior of certain insects. However, not all insects associated with dead wood can fly or detect directionality of light, so these techniques may not be appropriate for some taxa. Many substrate-supported chambers have funnels leading to collection containers incorporated into their design. Here, collection is based on organisms actively moving around within the chamber and randomly falling into the collection container. Another passive collection method is the use of gravity, where a collection container is placed under the substrate to collect anything falling or moving downward. This is certainly an effective concentration method (see below) and does not rely on organisms actively moving around the chamber, but for maximum efficiency requires that the chamber have a funnel-shaped bottom. That requirement may limit final location of the chamber (axis 3) and may add to resource requirements (axis 4), *e.g.* laboratory space for hanging chambers.

Design Comparisons. Jonsell and Hansson (2007) compared three sampling methods for saproxylic beetles involving two different styles of emergence chambers. One chamber was a self-supporting box with a photoeclection concentration method. The collection vial was inserted in the side of the box several centimeters above the bottom. The other chamber was a suspended bag with a collecting vial at the bottom (gravity concentration). The suspended bag was "somewhat more efficient" than the box (Jonsell and Hansson 2007). Of 119 species collected, 55 were represented by five or fewer individuals. The box produced 60% fewer specimens and 15% fewer species. Thirty-eight species were exclusively collected using the bag, and 19 were exclusively collected from the box. Their comparison involved at least two variables (chamber support and concentration method), so which had the greater influence over chamber performance is difficult to determine.

The design described in this paper combines the two concentration methods of photoeclection and gravity. The chamber (including ventilation holes) is opaque; therefore, the transparent glass collection jar acts as a photoeclector. Additionally, by placing the collection jar in the trough at the bottom of the chamber, species that are wingless, blind, or otherwise indifferent to light are more likely to enter the collection jar. For example, two rarely collected wingless species, *Adranes lecontei* Brendel (Staphylinidae) and *Tohlezkus inexpectus* Vit (Eucinetidae), were both collected in very high numbers, 40 and 163 specimens respectively. Collecting specimens of those two species would have been unlikely using an elevated collection container such as the one used in Jonsell and Hansson (2007).

Certainly, more comparative studies are needed to show what, if any, systematic biases exist among emergence chamber designs. This pertains not only to concentration methods, but also the effects of microclimate (such as temperature and humidity) and substrate position (horizontal vs. vertical) on the diversity of catch. The level of appropriateness for various emergence chamber designs depends on how the five design axes relate to the specific study question and the resources available to the researcher. Due to the highly complex nature of any biological or ecological research, extreme care should be taken to ensure that the observations being made relate in a biologically significant manner to the questions being asked and are not simply based on an idealized statistical scenario.

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