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A terrestrial vacuum sampler for macroinvertebrates

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Macroinvertebrates (hereafter invertebrates) are a vital component in the diets of upland game birds (Kimmel and Samuel 1984, Healy 1985, Landers and Mueller 1986), providing a rich source of protein and calcium (Stiven 1961, Reichle et al. 1969, Pattee and Beasom 1981, Hurst and Poe 1985), which are needed for rapid bone and tissue growth in poults and egg production in hens. In the past, to better manage for upland game bird brood range, wildlife biologists have sampled fields and the forest floor to determine which habitats harbor abundant invertebrates (Blackburn et al. 1975, Martin and McGinnes 1975, Owen 1976, Healy 1985, Jackson et al. 1987, Knox 1994, Hollifield and Dimmick 1995, Peoples et al. 1996). These efforts have been particularly intensive in the eastern and southeastern United States, where biologists have managed for wild turkeys (*Meleagris gallopavo*), ruffed grouse (*Bonasa umbellus*), and bobwhite quail (*Colinus virginianus*).

A number of methods have been used in gathering data on invertebrates. Use of the "American" sweep" net (Beall 1935) is common, although it has many Emitations. First, abundance of many invertebrates, particularly those dwelling along the forest floor (e.g., snails, spiders, millipedes, centipedes) and those able to firmly grasp *vegetation, is underestimated when using a sweep net (Whittaker 1952, Hughes 1955). The position of an invertebrate on a plant poses another problem when sampling with a sweep net (DeLong 1932). Variations in temperature and wind velocity cause invertebrates to, be found either higher on vegetation or lower near the ground surface (Romney 1945, Hughes 19557. Thus, sweeping must be conducted at different heights during different conditions for comparable results. Additionally, extreme variation is encountered when 22 collectors sample with unequal intensity (Lockwood 1924, Whittaker 1952) and when sampling vegetation within certain habitats (e.g., old field with thick, waist-high grass and forbs vs. ankle-high clover patch), which prevents equal sweep intensity (Gray and Treloar 1933).

Although the sweep-net method provides qualitative data important in determining predominant and least prevalent species and indications of distribution (Whittaker 1952), accurate estimates of true density are not possible, because there is no measure of the area sampled. This precludes the comparison of different studies and sites, since few (if any) researchers use the same sized sweep net, the same number of sweeps per unit sampled, or the same sweep intensity. In addition, it is impossible to capture all, or even a definite proportion of, the invertebrates within a given area using a sweep net (DeLong 1932). These limitations also are present when sampling invertebrate populations using pitfall traps (Gist and Crossley 1975, Mader et al. 1990, Oliver and Beattie 1996) unless impassable borders (i.e., an enclosure) are constructed (Gist and Crossley 1973), and even then capture of flying invertebrates is limited.

Another commonly used device for sampling invertebrates is the D-Vac, named after E. J. Dietrich who described a gasoline-powered suction device in 1959 and a modified version in 1961 (Dietrich et al. 1959, Dietrich 1961). The D-Vac is a vacuum sampler which consists of a metal backpack frame with a 3-hp gasoline motor attached. The motor turns a fan that creates a vacuum through a 20-cm (8-inch)-diameter hose with a large plastic nozzle. An advantage to using a vacuum sampler is that density estimates can be

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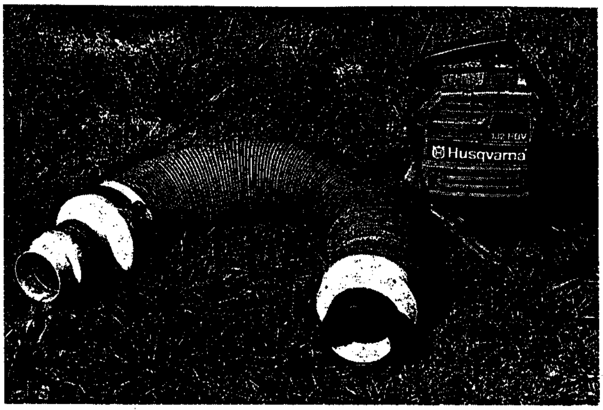


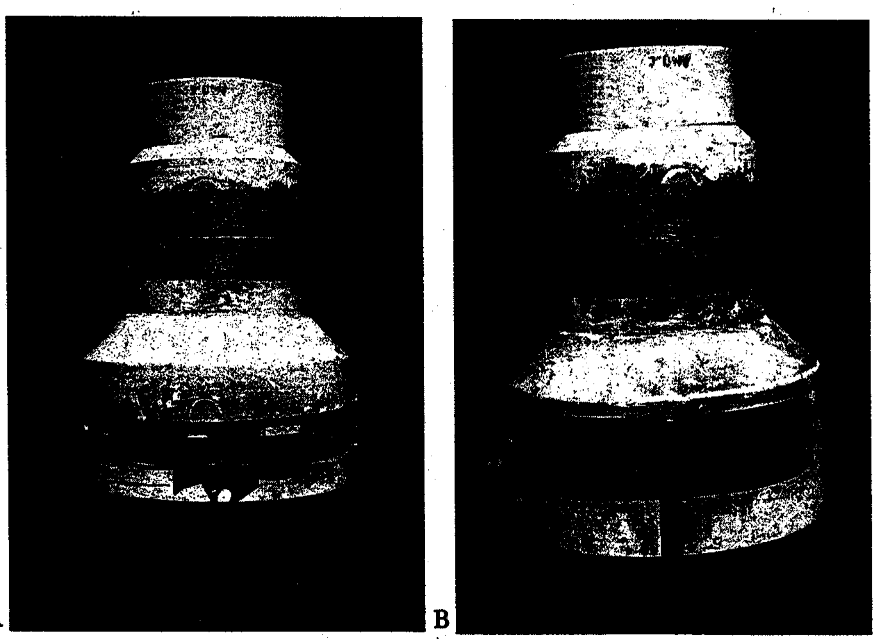
Fig. 1. Husqvarna model hand-held blower-vat 132 HBV shown with hose and nozzle for sampling of macroinvertebrates. Hose easily detaches from unit for increased portability.

obtained. Areas can be measured before sampling or a bottomless frame box of known size (e.g., 0.1 m^2) can be used, (Southwood and Cross 1969, Knox 1994). Callahan et al. (1966) found the D-Vac more efficient than the sweep-net method; sweeping required sampling an area 12 times larger than that of a D-Vac to obtain equal numbers of most invertebrates. Also, with the vacuum as opposed to the sweep net, they reported less damage to the invertebrates which later facilitated identification of species. The D-Vac, however, is heavy (>19 kg) and cumbersome. As a result, it is often mounted on a cart or hand-truck which limits the mobility of the researcher and may preclude sampling distant plots, steep terrain, and thick vegetation.

We designed a lightweight, portable vacuum sampler for working in forested habitats in the mountains of North Carolina. This vacuum sampler (Fig. 1) incorporated the largest hand-held blower-vat available, the Husqvarna model 132 HBV (Husqvarna Forest and Garden, Div. of White Consolidated Industries, Inc., 9006-J Perimeter Woods Dr., Charlotte, N.C.). With minor modifications, we converted this blower-vat into a vacuum sampler. The bottom of the unit had a detachable 10.2-cm (4-inch) PVC tube. We cut this detachment near the base and riveted on a 10.2- to 15.2-cm (4 to 6-inch) PVC bell reducer coupling. Next, we attached the coupling with duct tape to a 106-cm (3.5foot) length of Dayco's LU-10 Duravent urethane hose (15.2 cm diam; Atlanta Belting Co., Inc., 560 Edgewood Ave., N.E., Atlanta, GA 30312). This flexible hose is reinforced with wire and, thus, withstood rigorous fieldwork. To the other (front) end of the hose, we attached another 15.2- to 10.2-cm PVC bell reducer coupling, with a 10.2- to 7.6-cm (4 to 3-inch) PVC bell reducer coupling attached to it, forming a nozzle. We clamped the nozzle onto the hose by a draw latch (Fig. 2A) which was attached to the large end of the nozzle where a handle also was attached (Fig. 2B). We sewed sample-bags (25 cm diam x 89 cm long) out of cheesecloth with a canvas cotton neck, and removed the nozzle to insert the sample-bags into the hose (Fig. 3). Thus, all debris was captured in the sample-bag within the hose, thereby preventing anything from reaching the fan at the base of the unit. To further insure that no debris reaches the fan, wire mesh can be riveted to the inside of the detachment which connects the hose to the base of the unit (see Fig. 1). The hose and nozzle are easily installed and removed for walking to sampling sites and when inserting sample-bags. Weighing only 8.1 kg, this vacuum sampler can be carried into any habitat for sampling. A shoulder strap can be attached for ease of carrying and 'hands-free" efficiency when sampling (Fig. 3).

We used this vacuum sampler for 2 field seasons,

A



B

Fig. 2. (A) Close-up of nozzle and draw latch attachment; (B) Close-up of nozzle and handle attachment.

Fig. 3. Nozzle is easily removed for inserting sample-bags in hose. Note canvas neck & sample-bag is folded on outside of hose where nozzle locks it in place.

and it performed flawlessly. Its light weight and compact size facilitated sampling in dense habitats and on steep slopes. The 132-cc motor was capable of picking up rocks (some >270 g) the size' of the nozzle diameter (7.6 cm) and easily picked up litter and duff layers from the forest floor down to mineral soil. After a sample was collected, the sample-bag was removed, tied off, and another placed in the hose. On completion of sampling, sample-bags with contents were dried, leaf litter was sorted through sieves, and invertebrates were gleaned, identified, counted, and weighed.

This vacuum sampler can be used to sample along a transect or within a bottomless frame box (Fig. 4) because the nozzle and hose are compact when compared to the D-Vac. When sampling with a frame box, flying invertebrates are captured as soon as the lid is opened. As the nozzle of the sampler is inserted into the frame (as the lid is being opened), a downward vacuum is created within the box, which steers jumping or flying invertebrates into the nozzle. While sampling areas with dense grasses or forbs (e.g., food plots and seeded logging roads), vegetation can be clipped at ground level within a plot or frame box so that herbaceous material and all invertebrates are collected within an area of known size. Clipping vegetation within the frame box further insures that all invertebrates are captured, including those firmly attached to the vegetation. The size of frame box used can vary (e.g., 0.1 m^2 or $0.25 m^2$) among studies, and is usually determined by the distance to sampling sites, terrain, topography, etc.

The vacuum sampler also can be used for collecting other ecological data. Leaf litter and herbaceous plants can be sampled for weights and production estimates. Seeds can be gathered easily within plots of known area for mast-production estimates. Also, the vacuum sampler is an excellent tool for sampling terrestrial salamander populations (Harper and Guynn, In press) because all leaf litter and organic matter are collected down to the mineral soil. Salamanders hid-

Fig. 4. Shoulder strap allows for portability and efficiency of sampling. A $0.25\text{-}m^2$ frame box may be used in open habitats where accessibility is not a problem.

ing under leaf litter are sucked up with the debris. Any large rocks, sticks, or logs can be moved once a sampling area has been demarcated or a frame box has been put down. Salamanders are not harmed when sucked into a sample-bag, thus researchers can release the animals after counting and measuring. Indeed, this vacuum sampler is an excellent tool for collecting data to determine biological diversity along the forest floor.

The Husqvarna blower-vat and other parts needed can be purchased at a fraction of the cost of the bulky D-Vac (<$300 vs. $3,400). For those whose research includes sampling items from the forest floor or within fields, this vacuum sampler facilitates data collection.

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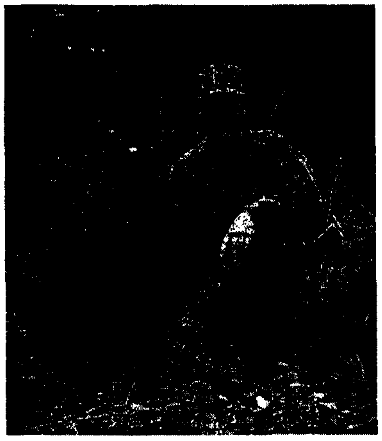

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