# Can Townes type Malaise traps be improved? Some recent developments

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**Malaise traps, Schacht trap, collectors, new designs, Hymenoptera, Diptera, Coleoptera**

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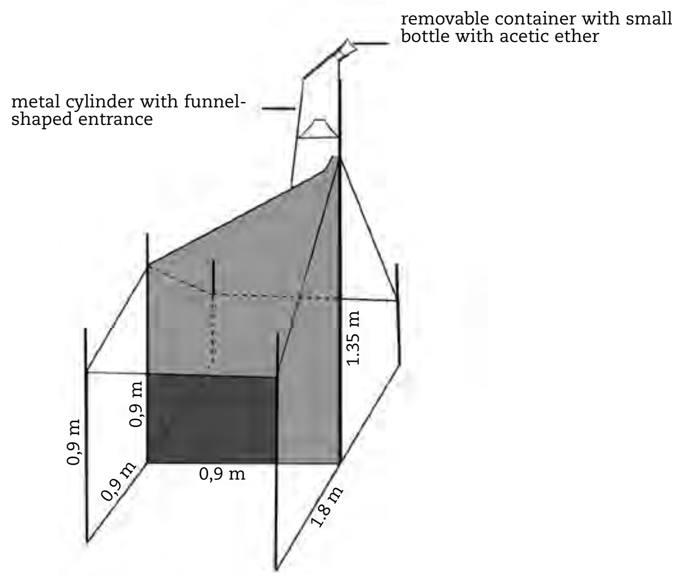
**Malaise traps are the most widely used flight inception traps. Since the introduction of the Townes design in 1962 little has been changed; only recently several new designs and new traps have been proposed. In this paper another new design is shown, together with the design for a cheap and almost indestructible collector. Other recent developments are mentioned and some shorts notes on proper placement of the traps are added.**

## Introduction

The Malaise traps are among the most important instruments for collecting day-flying (and in moonlit nights to some degree also night-flying species) of Hymenoptera and Diptera. Also other groups are collected, but in general less efficiently depending on the flying and searching activities of the species involved. Malaise traps are a special kind of flight interception trap for collecting insects with positive phototropism into the collection bottle of the collector. Nevertheless, Malaise traps are among the first choice for an extended survey like an ATBI (All Taxa Biodiversity Inventory) of a wide range of taxa. Large numbers of specimens may be collected and if properly placed for several weeks or months in the right season it gives a good sampling of the present flying insects. Depending on the size of the trap, usually from near-ground level up to 0.8 m height, there is a good sampling of the micro-habitat. Usually the traps are situated in a corridor between emerging vegetation, but they can be used in nearly every habitat. The designs are generally fairly weather resistant except for winter conditions with heavy (melting) snow loads on the roof of the trap. The traps are fairly portable and one person can set up a trap. Disadvantages are the cost (€ 100-400 per trap, depending on the design, place of manufacture and quality of the material), the visibility of the trap (rather large objects difficult to hide from humans, monkeys, cattle, etc.), the time needed to find promising places and the total weight if more than a few traps are used. Part of the disadvantages could be diminished by using thick thermo-sealed transparent Nylar film and not polyethylene plastic film, because it will deteriorate too fast in sunlight (Marston 1965). The collector could be made of a simple wire frame, covered with a bag and a second bag with alcohol taped to it.




**1.** First design of a bilateral trap with a central diaphragm and a lateral collector by Malaise (1937).
**1.** Eerste ontwerp van een tweezijdige tentval met een middendstuk en een zijdelingse verzamelpot door Malaise (1937).

## The first trap designs by Malaise

The trap is named after the Swedish Hymenopterist and art collector Dr René Edmond Malaise (1892-1978) who had the first traps made in Burma in 1934 for his expedition to the northern part of this country. He discovered the design when he was camping in Sweden because of an opening in his tent where a considerable number of insects gathered (Malaise 1937). The first design was a unilateral trap (i.e., with only one side open) with a central diaphragm and a complicated lateral funnel collector. He used acetic ether to kill the insects and to prevent damage. The trap had to be emptied on a daily basis. In 1937 he proposed three types: the original unilateral trap, a bilateral type with a lateral collector and one with a central collector. He suggested already the use of a framework to hang a bilateral trap in the canopy. The bilateral type with lateral collector (figure 1) was used for the Townes design, but with the length of the diaphragm twice the depth of the lateral opening; a modification already suggested by Malaise (1937). It lasted 25 years before the first improved designs were published: the small light-weighted Townes design (figure 2) and the comparatively heavy large Gressitt design (figure 3). At the moment the Townes design is the generally used design, only recently several modifications have been published on internet (e.g., http://bugdorm.megaview.com) and are commercially available.

Box 1

## Preparation of Hymenoptera from alcohol

Most groups of unprepared Hymenoptera are usually stored in alcohol 70%. This is a safe method, but there are some hazards; subsequent dilution of the alcohol should be avoided, otherwise a precipitate may form on the specimens. The specimens should be transferred to fresh alcohol 70% (be sure that it is 70%!) after collecting. Never put vials containing specimens in alcohol in sunlight (UV-radiation, temperature!) and store samples in alcohol as cool as possible, to put them in the freezer is no problem. Dried out alcohol samples should not be discarded (Van Cleave & Ross 1947); with a 0.25-0.50 % aqueous solution of a commercial grade of trisodium phosphate specimens are restored in a few hours (at 35° C in about one hour)!

The preparation of insects stored for a considerable time in alcohol 70% can be done well by two methods:

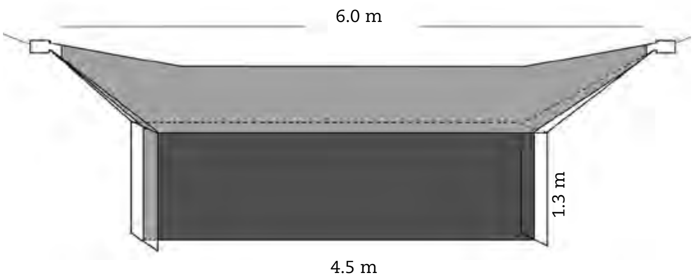
1. The more elaborate and more costly critical point drying method (CPD; described method as used by Mrs Josephine Cardale, CSIRO, Canberra, who kindly supplied the details): The wasps are transferred to 100% ethanol (70%, 95%, and two lots of 100%, 10 minutes each). The alcohol is taken off and the contents of each vial are transferred to a 'basket' - a small numbered mesh container. The label is dried and the basket number is written on the label (one basket for each small vial of insects; thus one label, one basket but if two baskets are used, the two numbers are written on that label). Put the basket into the critical point dryer. The main principle depends on the alcohol being rinsed from the insects, then the temperature and pressure being raised to the critical point so the liquid rinser (e.g., carbon dioxide) converts to gas and the insects are dry. The alcohol is rinsed off 'manually'- bleed $CO_2$ slowly from the chamber, shake it occasionally to aid rinsing, then bleed off more until it is sure the ethanol has gone. The dryer is cooled/heated by a water-jacket so a connection to the tap is necessary; in summer you may have to run iced water through or the $CO_2$ turns to gas and only part of the chamber is filled with liquid $CO_2$ - it has to be filled or the rinsing is not full. When the baskets are rinsed, warm water is run through (to 40°C and aim for a pressure of 1500 pounds per square inch – it is a closed system, so putting up the temperature increases the pressure). The high pressure gas is allowed to go out very slowly to avoid blasting the wasps to pieces. When the pressure reaches zero the chamber of the dryer can be opened, and the baskets can be pulled out. The insects are dry, separate easily from each other with enough flexibility to keep their antennae and legs on, and can be glued to points easily, for several months afterwards. The results for e.g. eulophids are much better than air drying as the heads don't collapse (as with the following method). A main benefit is the possibility to dry a large batch in one basket, without the individual handling needed for air drying. Freeze drying is a similar method.
2. The Alcohol/Xylene-Amyl acetate-method (AXA); a less expensive and less time-consuming method than critical point or freeze drying and the results are usually comparable. It is also suitable for large Hymenoptera and large quantities can be treated at once. It is based on the alcohol-ethyl acetate method used for the preparation of Syrphidae in the Canadian National Collection of Insects at Ottawa (Vockeroth 1966). The ethyl acetate was replaced by amyl acetate by the late Dr W.R.M. Mason (working at the same institute) for the preparation of Braconidae from 70% alcohol. The modified version, explained below, was used successfully by me over 30 years for preparing Braconidae and other Hymenoptera for the collection of the National Museum of Natural History (Naturalis) at Leiden. The alcohol is poured off (careful to avoid loosing specimens) and the vial is filled with a mixture of 40% xylene and 60% alcohol 96% (this mixture is made before and can be stored for a long time). After 1-3 days this mixture is poured off again and replaced by amyl acetate; do not use a kind of plastic vials etc. which are solvable in amyl acetate and avoid inhalation or contact with skin with the chemicals! The insects can be prepared after 1-2 days (or longer) in the amyl acetate. With a spring steel pair of pincers the specimens are taken from the fluid and with the wings stretched out laid on absorbing paper (e.g., waste-book paper). If the wings are not well stretched out, the procedure should be repeated or a drop of fluid is added with the tip of the pair of pincers. After about 15 minutes the specimens are ready to be pinned or glued. Pinning should be done not later than 25 minutes after taking out of the amyl acetate to avoid loosing legs or its head during pinning. An alternative is to put a limited number of specimens in a little of amyl acetate and let it evaporate.

### The Townes design

The major break-through came by the simplified design of Dr Henry Keith Townes, Jr. (1913-1990) published by him in 1962. The Townes type Malaise trap (figure 2) is open at two sides, with a diaphragm in the middle as barrier and with one lateral collector at the summit. The colour is either black with a white roof or completely black; the impact of having the trap white, black or bicoloured is a matter of debate. I did not notice negative differences when using all white traps compared to all black traps; for some groups like sawflies and Syrphidae the catches were on average even higher in white coloured traps. A white object (reflecting all colours) may attract insects usually attracted to flowers because of their colours. Most flying insects hitting a barrier will have a positive phototropic reaction and try to escape upwards to a light opening. Especially many beetles have a negative phototropic reaction and try to escape downwards. They can be traced by placing pan traps filled with water and some detergent below the diaphragm; adding insecticide to the diaphragm improves the catches. All together it will double about the collecting by the Malaise trap according to Campos *et al.* (2000).

Important for the quality of the collected material and for having long intervals possible between changing the collecting bottle is the used killing agent and conservative. Working frequently in the tropics I prefer by far using alcohol 70% as a long lasting conservative and killing agent in the collecting bottle (not alcohol 96% because it makes the specimens too brittle). Alcohol is relatively harmless and widely available. Other fluids as salt water, water with detergent, oil or antifreeze are alternatives if alcohol is problematic. Dry collecting is possible but more dangerous, the trap has to be emptied more frequently (preferably daily) and the specimens are contaminated by moth

**2.** Townes design of the Malaise trap. Photo: C. van Achterberg
**2.** Townes ontwerp van de Malaiseval.



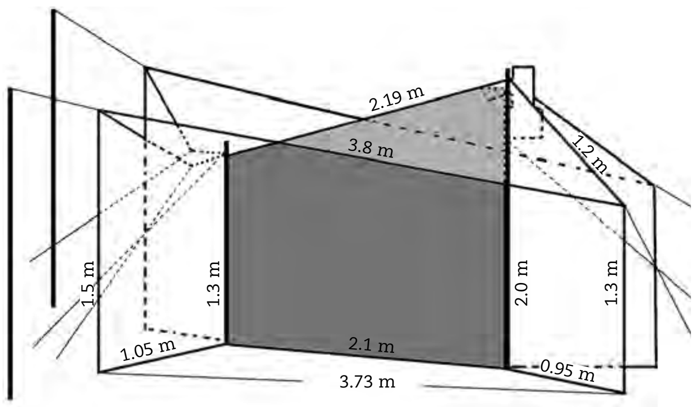

**3.** Gressitt design of the Malaise trap (6 m long version).
**3.** Gressitt ontwerp van de Malaiseval (6 m lange versie).

scales and extruded fluids. Cyanide (KCN or NaCN) encapsulated within plaster of paris is a possibility but dangerous; several entomologists have been poisoned. Less dangerous is the use of PVC strips with 2,2-dichclorovinyldimethylphosphate (dichlorvos; Vapona); paper tissue should be added to absorb extruded fluids and to provide shelter for the specimens. Hymenoptera and Diptera should never be directly prepared from the alcohol if they were in for more than one day to avoid damage to the specimen. Either critical point drying or (especially for large specimens and for large quantities) the AXA-method should be used (see box 1). The bottle of the Malaise trap, if filled with alcohol, may be changed every week up to once per month. It depends on the season and the amount of flying butterflies and moths; the latter may fill up the bottle very quickly. Half-sized copies of the Townes design have been used successfully by me when the vegetation is low and/or the trap should be inconspicuous to avoid stealing. The half-sized copies catch much less butterflies than the usual sized one and have also a half-sized collector designed by me in 1979 (see further in text).

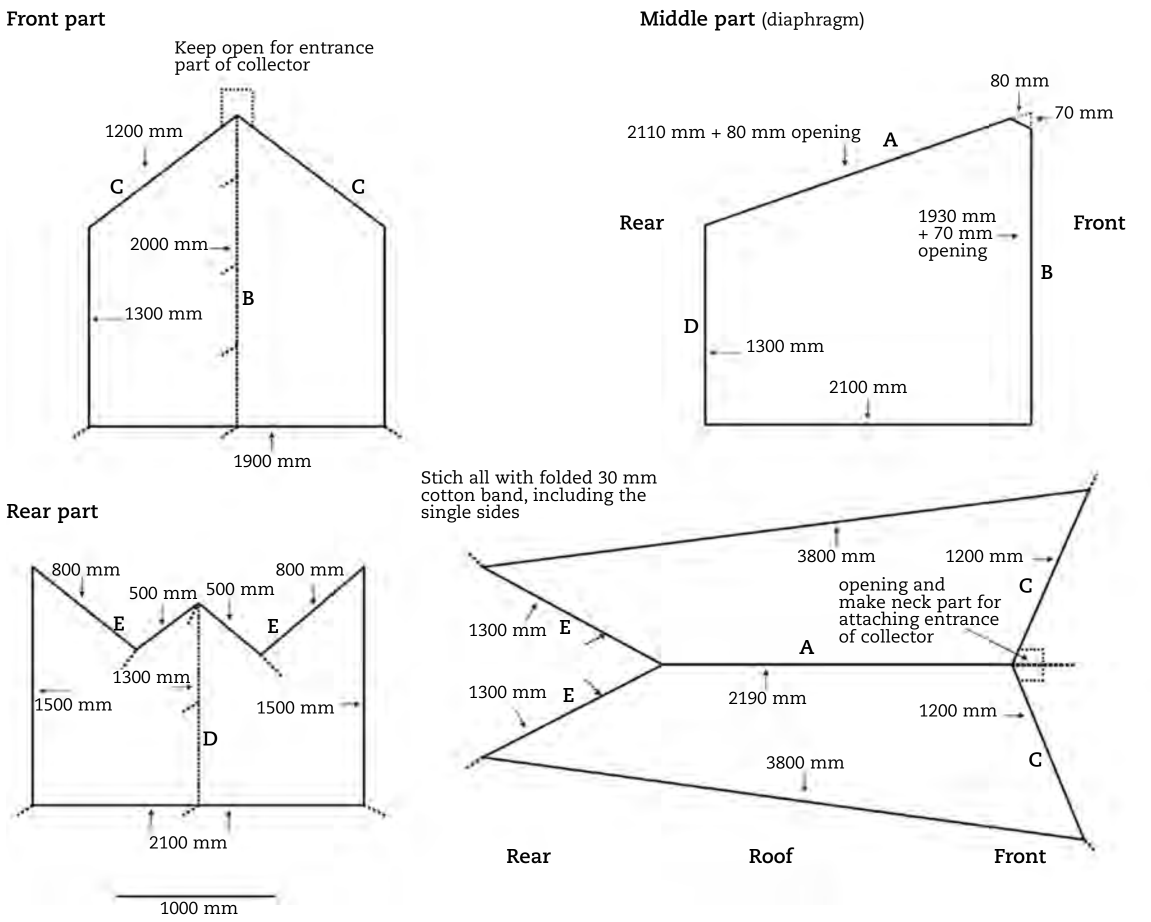
The effectiveness of a Malaise trap depends first of all on its placement within the micro-habitat (see text at the end of this article), second on its design and last on the mesh-size (Darling & Packer 1988). According to Matthews & Matthews (1983) the design is the most important, followed by its correct placement in the flyways of insects. About the mesh-size, if small parasitoid Hymenoptera (mainly Platygastroidea, Chalcidoidea and Diapriidae) need to be collected, fine mesh material should be used for the construction. In most other cases a medium-sized mesh will be sufficient and may be more effective because of less interrupted air movement.

**4.** Schacht trap (5 m long version). Photo: C. van Achterberg
**4.** Schachtval (5 m lange versie).

**5.** An earlier version of the redesigned Malaise trap. Photo: C. van Achterberg
**5.** Een eerdere versie van de nieuw ontworpen Malaiseval.




**6.** Scheme of the redesigned Malaise trap.
**6.** Schema van de nieuw ontworpen Malaiseval.




**7.** Scheme for manufacturing the redesigned Malaise trap.
**7.** Schema voor het maken van de nieuw ontworpen Malaiseval.

Remains the design of the trap; Malaise proposed already three designs, of which the bilateral (= with two open sides) Townes design is the most used type. The bilateral Townes design (figure 2) is vastly superior to the quadrolateral type with a central collector (the 'Cornell type' was used for comparison, similar to the SLAM design – figure 11 – but square) according to Matthews & Matthews (1983). The Townes design (Townes 1962, 1972) is the most commonly used design because of its handy format and low weight. Most commercially sold versions of the Townes design have on average an opening (total sampling surface of both sides) of 3 m$^2$ (Matthews & Matthews 1983), resulting in a sampling surface of 1.92 m$^2$ per m length of diaphragm. A strongly enlarged version is the Gressitt trap (Gressitt & Gressitt 1962; actually two Malaise traps joined with the rear parts), which is frequently used for mosquito research. It has two summits each with a collector and resulting in a large trap (figure 3). The opening of the commercially sold version of 6 m long (www.johnwhock.com) is about 2.3 times longer than the common Townes design. At one side the sampling surface is 4.5 × 1.3 m, thus for both sides the total sampling surface is 11.7 m$^2$, resulting in 2.6 m$^2$ sampling surface per m length of diaphragm. The migration trap is a specialized Gressitt trap with separate collecting per open side to allow the determination of the flight direction.

Even if taken in account that the opening of the Gressitt trap is about 2.3 times longer than the Townes trap, the sampling surface of the Townes trap is comparatively low. To enlarge the sampling surface (and likely its efficiency) two approaches are possible. First is to use a completely new design; the most recent one is the Schacht trap without diaphragm (figure 4). The Schacht trap (Schacht 1988) is designed by Mr Wolfgang Schacht (research associate at the Diptera section of the Zoologische Staatssammlung München) based on the idea that insects hitting an oblique surface will walk up the surface and in case of a trap, to the collecting bottle. There is no diaphragm because it will also deter insects, which may be up to 80% of Hymenoptera flying into a Malaise trap according to Dr Townes (pers. comm.). The first results show that the Schacht trap is an excellent trap to sample a large area as a kind of emergence trap and, because it is a large white object, for a large variety of Diptera.

The other approach is to redesign the Townes trap to enlarge the sampling surface without loosing the diaphragm and too much of the advantages. The redesign is based on four approaches. First is to lift up the rear corners of the roof, second to place the transverse sections more outwards (figures 5-6), third by using a somewhat longer and higher diaphragm (figure 7) and finally using an improved collector (figures 8-10).

The new redesigned Malaise trap has a sampling surface ratio of 2.73 m$^2$ per m length of diaphragm, thus improving the Townes design by 42%. The ratio is similar to that of the Gressitt trap but the latter is about 50% higher and, therefore, a third less efficient if the height is taken in account and its larger height (2.6 m) may influence negatively the catch of low and/or weakly flying and minute Hymenoptera. In addition, the Gressitt trap has two collecting heads, more difficult to find a suitable place for it and is heavier.

Finally the improvement of the collector: commercially sold collectors have a horizontal entrance, the collecting bottle is comparatively small and the connection between upper and lower part of the collector deteriorates after prolonged use. I designed a simple and durable collector in 1979 (figures 8-9) with a 45° angled entrance made of PVC sewage pipe (75 mm/45°, 3.2 mm + insert to prolong the entrance). The top is closed with a circular piece of Perspex (polymethylmethacrylate) and an opening made opposite to the entrance is covered by a piece of Perspex too. It is almost indestructible, cheap and will not degrade by UV light. The Hangzhou type is

**8.** Large grey 75 mm PVC collector for Malaise traps with 1 l bottle. Photo: C. van Achterberg
**8.** Grote grijs 75 mm PVC verzamelpot voor Malaisevallen met 1 l plastic pot.

**9.** Small grey 50 mm PVC collector for Malaise traps with 0.2 l bottle. Photo: C. van Achterberg
**9.** Kleine grijs 75 mm PVC verzamelpot voor Malaisevallen met 0.2 l plastic pot.

**10.** Large white 75 mm UPVC (Unplasticised PolyVinylChloride or rigid PVC) collector for Malaise traps (Hangzhou type) with 1 l bottle. Photo: C. van Achterberg
**10.** Grote witte 75 mm UPVC verzamelpot voor Malaisevallen met 1 l plastic pot.

**11.** SLAM (Sea Land & Air Malaise) trap version with a top and a bottom collector for suspending in trees (from: http://bugdorm.megaview.com.tw).
**11.** SLAM ontwerp met boven- en onderverzamelpot om in bomen te verzamelen (van: http://bugdorm.megaview.com.tw).

even cheaper to manufacture by re-using bottles and plastic containers (figure 10). For the new design a comparatively large container is used because of the large amount of insects caught per week in full season. The first impression of the catches by the new design is that the amount of specimens of some groups is about doubled, but the improvement differs per family. The trap has not been used long enough to give comparative data yet. The new model will be commercially available in near future. For more information please contact the author.

Several new designs have been developed recently. Light-weighted designs can be suspended in the canopy by a haling system and a bottom collector may be added to for insects with negative phototropic reaction (figure 11). Others do not need rods for support, are faster to place, have a rounded roof and a screen to avoid butterflies and large moths to enter the collector (figure 12). The sampling surface ratio of this design is 2.0 $m^2$ per m length of diaphragm, thus slightly improving the Townes design. For details, see www.bugdorm.megaview.com.tw. Mr J. de Rond (Lelystad) made a smaller and low-weighted design with triangular opening for collecting small Hymenoptera in low vegetation (figures 13-14). Mr H.J. Vlug (Scherpenzeel)


**12.** Bugdorm design of Malaise trap with rounded roof and no rods. Photo: C. van Achterberg
**12.** Bugdorm ontwerp van Malaiseval met rond dak en zonder stokken.

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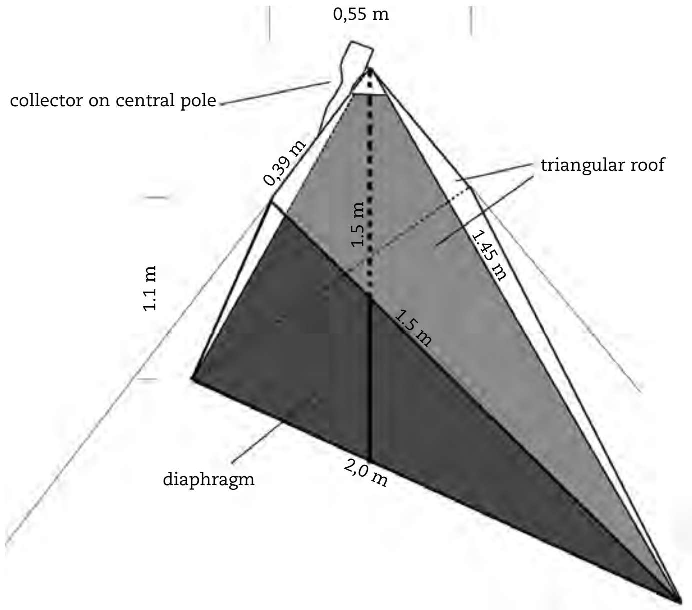
**13.** Bilateral Malaise trap with triangular opening and a central collector. Photo: J. de Rond
**13.** Tweezijdige Malaiseval met driehoekige opening en een centrale verzamelpot.




**14.** Scheme of bilateral Malaise trap with triangular opening and a central collector.
**14.** Schema van tweezijdige Malaiseval met driehoekige opening en een centrale verzamelpot.

**15.** Ball and hood (LOER-2007) trap for collecting horse flies. Left the collector with flies killed by heat. From: www.dazenval.nl
**15.** Dazenval (LOER-2007) voor wegvangen van dazen. Links de verzamelpot met vliegen gedood door de warmte.

designed in the 1970s a small freestanding trap of two Perspex plates. Triangular at the top, one indented at the basis, the other at the top, connected perpendicularly and covered by a polyester fabric roof with a small central collector. Finally, new traps have been designed to lower the nuisance of horse flies (Tabanidae), e.g., the 'LOER -2007'(Lokken, Opvangen En Ruimen; Dutch acronym for 'attract, collect and remove') or 'dazenval' (Dutch for 'horse fly trap') by F. van Dungen (Heesch). It has a massive black ball half covered by a white fabric hood to attract the flies, when the flies fly off they are intercepted by the hood and will die in the central collector by heat at sunny days (figure 15). For collecting 200-400 horse flies per sunny day the ball should be far from the ground level (the total trap is about 3 m high), the trap should be placed near woodland edges and in the sun.

## Placement of traps

The proper placement is extremely important; improper placement may lower the catches by more than 50% in the same micro-habitat. In general the trap should be either blocking a corridor (e.g., a path in the forest) or placed perpendicular to a barrier (e.g., border of a forest, with the collecting head directed to the border and the sun). The collecting head should always be in the sun. Relative small changes result in large differences in the collection efficiency (Matthews & Matthews 1983). Malaise (1937) was already very aware of a proper placement: 'The chief difficulty in using this trap is to find a suitable place. A trap put up in an open field would doubtless catch insects too, but the number of insects passing that special spot is a restricted one compared with a place where they are for some reason or other concentrated. Such concentrations are not uncommon; the insects are, e.g., more numerous along the border of a wood or field than in the middle of it. Most, if not all, flying insects have an instinctive fear of being blown away by the wind, and are therefore always trying to keep against it, thereby taking advantage of depressions and other irregularities of the earths surface, that will furnish them shelter or help them in advancing against the current. Stronger insects are not so dependent on shelter, but have nevertheless a special liking for streamlets, ravines, shores, wood-fringes, forest-roads, clearings, etc. where they patrol back and forth. Weak fliers very often prefer such openings to the dense wood. Such places are as a rule very good for traps, which must be expanded at right angles to the main direction, and preferably with the entrance away from the prevailing wind, so that insects working their way against the current may enter the trap'.

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## Samenvatting

**Kunnen Townes type Malaisevallen verbeterd worden? Enige recente ontwikkelingen**
Malaisevallen gemaakt volgens het ontwerp van Henry Townes (1962) worden veel gebruikt zonder dat er veel onderzoek gedaan wordt naar het verhogen van de efficiëntie. Een nieuw ontwerp van de Malaiseval wordt voorgesteld om het verzameloppervlak met ongeveer 40% te verhogen. Evenals het ontwerp van een goedkope en zeer stevige verzamelpot gemaakt van PVC (PolyVinylChloride of de chemische naam PolyChloorEtheen (PCE)) of UPVC (Unplasticised PolyVinylChloride of rigid PVC). De Schachtval, het Bugdorm ontwerp van een Malaiseval, een nieuw ontworpen val met driehoekige opening van J. de Rond en de dazenval worden als andere nieuwe ontwikkelingen kort genoemd en afgebeeld.

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