



New mechanical manipulator for studies of mounted insects using stereo microscopes

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An improved design of stereo microscope manipulator for observation of small insects, mounted on card or card-point, is presented. The device allows movement of an object around three perpendicular axes in the field of vision. There is only one flexible joint between all the elements, and rotational movement is not realised by belt or gear drives. A standard pointer is used to mark the intersection point of all axes in 3D space for optimizing the mounting of the sample insects. An additional movable white screen can give a suitable backdrop for improved visualization of the insect samples. The main achievement of the device is reaching a precession (the slow movement of the axis of a spinning body around another axis) deviation in the intersection point of axes of approximately 0.3-0.5 mm.

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Introduction

In taxonomic entomological investigations it is very important to have the exact measurements of different parts of an insect's body and the ratio of its dimensions. Usually, the entomologists hold up and move the entomological pin by hand under the stereo microscope or use a piece of foam plastic, plasticine or other material for stable fixing of the pin at an accurate position. These methods are time-consuming, sometimes dangerous for the object or can cause errors in measurements of fine structures when the microscope's magnification is high. An easier and relatively automated way to observe is by using a mechanical manipulator. The manipulator is the most suitable device for precise measurements using the stereo microscope. A considerable disadvantage of the

Oliver (1969) and Köppen (1966) manipulators, is the absence of rotation movement around the permanent vertical axis. This is corrected in the Lobanov & Kotjurgin (1975) design, allowing rotation of the investigated object around three perpendicular axes while it remains permanently in the field of vision. The design is constructed for pinned specimens and there is a great number of coupling elements. A new modification is available on the American market from "Rose Entomology" - a division of "Rose Engineering and Research, Inc." (www.roseentomology.com). It has object movement with two degrees of freedom and a new design, and contains a smaller number of components and greater reliability. It is also designed for pinned specimens.

In the proposed new manipulator, the belt drive "outside" the supporting arm, after Lobanov & Kotjurgin (1975), is replaced by a solid flexible coupling "inside" the supporting arm. This allowed us to create modifications while retaining the features of earlier designs and corresponds better to the specific requirements for entomological studies of small insects, mounted on card or card-point.

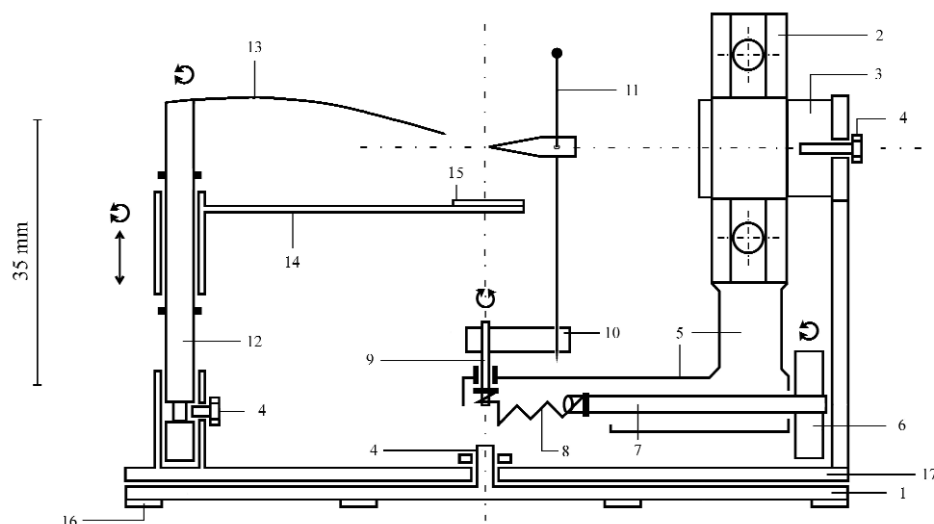


Fig. 1. Manipulator scheme of principle: 1 – sub-base (steel or plastic); 2 – ball race diameter 35 mm; 3 – bearing bush; 4 – screw; 5 – supporting arm; 6 – knob; 7, 9 – axial drivers; 8 – helical spring; 10 – rubber base; 11 – entomological pin; 12 – holder; 13 – standard pointer; 14 – screen arm; 15 – white screen; 16 – rubber feet; 17 – steel base.

Description of manipulator

The device presented has been developed for the improved observation and measurements of insects mounted on card or card-point according to Martin (1977) and Noyes (1982). In this case the mounted object is placed eccentrically toward the entomological pin axis. The design of the manipulator provides object movement with three degrees of freedom with small precession displacement.

The proposed device (Figure 1) consists of: a bearing (2) with an external diameter of 35 mm; supporting arm (5) with a rubber base (10) for holding an entomological pin (11); sheet steel base (17); sub-base (1) with screw (4), providing rotation of the steel base 360° around its axis. Pointer (13) marking the axes-intersection reference point, mounted on supporting pillar (12). Two rotational spindles at 90° to each other (7 and 9), mechanically coupled by a helical spring drive (8) 'inside' the supporting arm, provide the accurate rotation of spindle (9) when the knob (6) is turned. An outline and dimensions of the steel base are presented in Figure 2. The device has been designed so that spindle (9) and the sub-base screw (4) are par-axial: the insect is placed along this axis at a higher position above the rubber mount (10). The standard pointer is used to determine the intersection point of all the axes. The final 30mm of this pointer (13) should be made of hair so as to avoid damaging an object whilst the entomological pin is being positioned in the rubber base (10).

The pillar on which the standard pointer (13) is mounted also supports a white screen (15) attached to an arm (14) capable of rotation and

vertical movement below the specimen. The screen is designed to act as a white background at the intersection of the axes, when contrast background to the specimen is required. This holder is restrained vertically, to prevent sample damage.

If the procedure of adjusting and fixing has been performed exactly, the insect can be rotated around the intersection point of axes while remaining in the field of vision in high magnification.

This allows observation of the object in all possible positions with a small number of manipulations. In the process of changing the position, defocusing is possible when the magnification is high by reason of the small depth of focus and volume of the object.

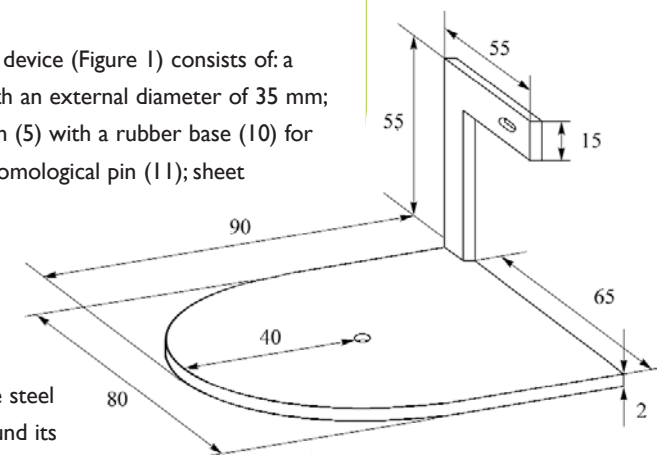


Fig. 2. Schematic diagram of steel base. Dimensions in millimeters.

The proposed manipulator has a more reliable connecting mechanism for rotational movement and a simplified design allowing ease of handling. It can be made easily with limited workshop facilities.

Assembling and adjusting

In the assembly process, one point must cross three axes. This is accomplished by using a stereo microscope with an eyepiece micrometer and a test-object with a size 0.2 - 0.3 mm. The test-object is mounted on a card-point and the latter is positioned at 12-13 mm from the top of the entomological pin – a standard length (after Martin 1977).

In assembly, first connect the bearing and the steel base with bush (3) (Figure 1) and screw. Next connect the supporting arm to the bearing so that

The insect can be rotated around the intersection point of axes while remaining in the field of vision in high magnification.

from the beginning small movements in position are possible. After this, it is necessary to set the test-object above the axis of the spindle (9) so as to rotate around itself by turning the knob (6). This is observed and calibrated using the eyepiece micrometer at high magnification and the components locked in their relative positions using either solder or cyanoacrylate adhesives. Following this, the base (17) and sub-base (1) are assembled and adjusted to be on-axis with the test object. The precessional error on rotating all axis should not be greater than 0.3 – 0.5 mm. Finally, the supporting pillar (12) for the standard pointer (13) is fixed to the steel base so that the pointer is within about 5mm of the axes intersection point.

High viscosity grease will help to damp mechanical vibration movements within the mechanism. The ball race (2) may be made stiffer by the judicious application of cyanoacrylate adhesive to the bearing cage, to help prevent unwanted rotation of this assembly.

Thus constructed, the manipulator allows common work with other well-known stereo microscopes used for entomological research. It is necessary to set the mounted insect at the intersection point of the axes for the correct use of the proposed device. This is easy to accomplish when all elements are set in the initial position shown in Figure 3. Then the top of the standard marks the intersection point of the axes 5 mm forward. This position can be found easily if, in process of assemblage, it was marked on the already fixed holder (Figure 3). The screen is turned farther to one side so as not to be an obstacle. One should hold up the rubber base with two fingers of the left hand and stick the pin on the rubber base with the other hand, so that the insect stands 5 mm in front of the top of the standard. The standard can then be turned to one side so as not to be an obstacle. It is sufficient to rotate the knob completely to check the correctness of the fixing. If the fixing had been made correctly the insect may be turned around completely at the intersection point of axes. If it cannot, the pin must be re-fixed. In cases

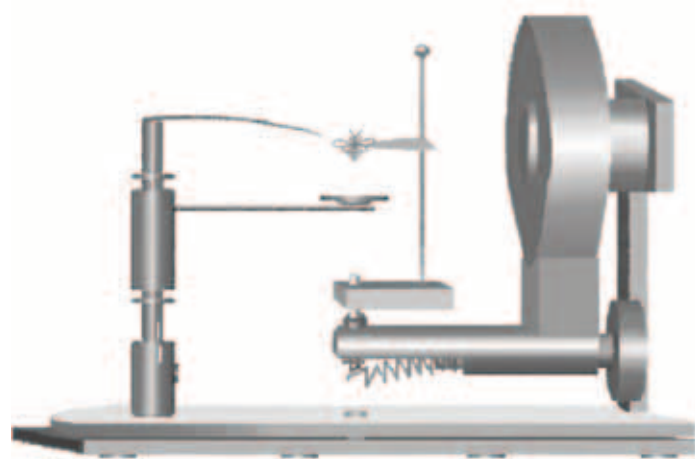


Fig. 3. Three-dimensional view of manipulator.

when the object is close to the intersection point, small changes in the position of the entomological pin over the rubber base can be made.

Using the ideas presented in this paper many variations are possible. For the left-handed operator the steel base can be created in mirror image of the schematic diagram in Figure 2; for objects larger than 1 cm, manipulators of larger dimensions may be created by increasing the length of the supporting arm (5) (Figure 1) and a proportional increase in the dimensions.

Results

The schematic diagram shown is the result of the experience of a three-year experiment (2001–2004) by the first-named author in creating the optimum mechanical manipulator for faunistic and taxonomic study of small insects, mounted on card or card-point. Seven working devices have been successfully created, of which six have been placed at the disposal of Dr. A. Gumovsky (Schmalhausen Institute of Zoology, Ukraine), Dr. V. Beshovsky (Institute of Zoology, Bulgarian Academy of Science, Sofia), Dr. A. Stojanova and Dr. D. Bechev (Department of Zoology, University of Plovdiv, Bulgaria), Dr. S. Petrov and Assist. Prof. O. Todorov (Agricultural University, Plovdiv, Bulgaria). The manipulators are used for taxonomic and faunistic investigations of different species of insects from Hymenoptera and Diptera. The number of specimens investigated is over 3,000, including type specimens from genus *Puklina* Graham, *Entedon* Dalman and *Glyphomerus* Förster (Hymenoptera, Chalcidoidea).

Each of the devices has been tested for alignment accuracy at the end of assemblage. For this purpose, a test-object (0.2 – 0.3 mm) mounted on card-point and fixed at a standard distance from the top of the entomological pin has been used. The eyepiece measure scale was calibrated in advance with an object-micrometer. The precess deviation

was measured using a similarly calibrated stereo microscope at maximum magnification when the test-object was at the intersection point. The test results showed that each manipulator has a precess deviation at the intersection point on the order of 0.3–0.5 mm. This deviation is perfectly sufficient even for observing and investigating small insects with dimensions of 0.7–10 mm. The tests also showed that insects remain in the microscope's field of vision during rotation, changing the observation position if the entomological pin is fixed correctly. When the position is changed, small defocusing results from object volume and the small depth of focus are possible. This requires fine re-tuning of the stereo microscope focus.

One of the main requirements of the type specimen studies (especially holotypes and paratypes) is absolutely secure fixing of the object in the process of observation. The proposed manipulator fully satisfies this requirement by the advance dismantling of the holder (12) (Figure 1).

Specimens were safeguarded from accidental damage in the entire process.

Then the base performs the part of the screen for object observation. In this case, observation of the insect's transparent parts was accomplished in diffuse reflected light when the white-coloured steel base was irradiated by an additional light source placed near the stereo microscope.

Most of the above-mentioned objects investigated have dimensions of 1–10 mm. Using the proposed manipulator, the time for observation and determination was shortened considerably by the quick and exact adjustment of the insect in the field of vision at the right angle of view. In addition, the specimens were safeguarded from accidental damage in the entire process of investigation.

Conclusion

The proposed manipulator allows the entomologist a simple and exact adjustment of insects in the right position (angle of view) for observation and at the same time ensures the maximum security of the objects being investigated. The device facilitates entomologists in their investigation of small insects and shortens the time for adjusting and measuring. In addition, the proposed manipulator allows observation of insects from different orders, including type specimens with dimensions up to 1 cm.

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