

## Methodology of a scientific drawings preparation in entomology on example of ichneumon flies (Hymenoptera, Ichneumonidae)

### Методика подготовки научных иллюстраций в энтомологии на примере наездников (Hymenoptera, Ichneumonidae)

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**Ключевые слова:** насекомые, наездники, научная иллюстрация, графический редактор, Photoshop.

**Abstract.** The principles and methodology of a scientific drawings preparation in entomology are presented. The stages of fulfillment both total insect and taxonomically important parts of body are considered in detail. The stages of a preparation of drawings from contour to colour image of an object are considered. The methods of scientific illustrations both manually and fully in a graphics editor Photoshop are described.

**Резюме.** Изложены принципы и методика подготовки научных иллюстраций в энтомологии. Подробно рассматриваются этапы выполнения как тотальных рисунков, так и таксономически значимых частей тела насекомых. Рассматриваются этапы подготовки рисунков от контурного, до изображения объекта в цвете. Приводятся методики подготовки научной иллюстрации вручную и полностью в графическом редакторе Photoshop.

## Introduction

The necessity of a scientific drawings preparation in entomology is dictated by two circumstances. On the one hand, there is a lot of groups of insects the description of whose signs is a very difficult process and key couplets for such groups are presented by the texts of a considerable volume, that makes identification of taxa of different ranks extremely difficult. Combination of alternatives is especially complex. For example, «... if petiole in the middle has approximately square cross-section, the same time on the border with postpetiole with knoll, or its lateral side is smooth and lower border is not edged (simultaneously ...), or ...» [Rasnitsyn, 1981]. A good example of such group is ichneumon flies subfamily Ichneumoninae (Ichneumonidae). Their morphological diversification is generated not by a diversification of constant combinations of signs, but by a free, almost random combination of the same signs, that is related to character of group evolution, that leads to a plenty of closely related and hardly

differentiated species. Furthermore, the determination of superspecific taxa is more difficult than the determination of species [Rasnitsyn, 1978]. According to G. Heinrich [1967], «...in a young subfamily, as the Ichneumoninae probably are, intermediate characters can be expected to be still in existence more frequently than in most other groups. Hence the genera can not be so sharply separated as our taxonomic mind would like». One of the ways to make easier superspecific taxa identification is preparation of the tables of illustrations of typical or the most characteristic species of subfamily genera. One of the requirements of a successful solution of this problem, in our opinion, is a standard table's preparation performed only by one author who specializes in investigation of the same group [Tereshkin, 2004]. All told above served as the basis for preparation of this work.

On the other hand, at the description of new taxa, particularly high, taxonomist must have typical or comparative material from different, often of difficultly accessible collections. The solution of these problems is also seen in preparation of maximum standard illustrations and descriptions of taxa. The availability of correctly prepared illustration of taxon, by taxonomist, makes it possible to avoid the necessity of using typical material and representatives of relative taxa.

Fulfillment of a scientific illustration in entomology is quite labour-consuming occupation, requiring availability of definite skills and capacities, and also considerable time expenses. According to the German researcher of a botanical illustration C. Nissen [1951] «a combination of artist and researcher in one person is largely rare because the human life is short, and the power is too limited to achieve perfection in both fields». The present work is intended for maximum facilitation of this problem solution, by using modern technologies.

The level of development of modern digital technologies allows to prepare a scientific illustration of

taxon practically without resorting «to a pencil and paper». And, with availability of certain skills, it becomes accessible to taxonomist who has no drawing skills. It is especially important, that the illustration fulfilled by a professional artist, who is not a zoologist and is not familiar with the significance of those or others taxonomic signs, usually has, despite of qualitative fulfillment, low scientific value.

Thus, the illustrations prepared by the specialist on concrete group of insects, are the most valuable and in this case scientific proficiency of the author has the decisive role.

The offered technique was developed within the frames of the work «Illustrated key to Ichneumonini-nae tribes and Platylabini genera of world fauna».

In our opinion, taxonomic research works should be illustrated only by figures fulfilled by the author of work, not the photos. The basic difference between scientific figure and photography, according to our opinion, is the following — photography is only object image fulfilled with this or that degree of skill, whereas the figure is, first of all, graphic presentation of scientific knowledge about object at the given stage and author's own concepts. Proceeding from told, in the process of preparing of a total figure, primary goal is the strengthening of accent on taxonomic signs of object, both their graphic fulfillment and removing of minor characters on «background» under the condition of preservation of a general view and features of object as a whole. Other important condition is the graphic fulfillment of illustrations of objects in «unified foreshortening», that is necessary for the comparative analysis.

The basic principle of a picture representation of morphology of object is the maximum standardization (and unification) of figures. The given approach is vitally necessary for successful realization of further researches, as fulfillment of new descriptions of taxa of a different rank, and taxonomic generalizations. These conditions had served as preconditions for development of a methodology of preparation of the tables of illustrations.

Taxonomic illustration can be fulfilled in three ways — completely manually, using Indian ink and watercolor, or manually, with the subsequent editing of figures in the graphic editor Photoshop (for entomologists having art skills), or completely in the editor Photoshop. In the Plate I the figures ichneumon fly imago, made both completely manually (1), and completely in the graphic editor (2) are shown. In all cases, irrespective of selected method, observance of a number of rules is necessary. 1 — Fulfillment of figures, both total and parts of a body, having basic taxonomic signs, should be performed in the unified scheme. When in use of the figure of total insect, the parts of object's body should be arranged under one standard. For ichneumon flies, a standard position of legs, wings and flagellum is necessary to be observed. One of the known schemes of a picture representation of Ichneumonidae was designed and offered by Henry Townes [1969–1971]. Arrangement of a figure of imago and parts of a body with basic taxonomic signs should have standard character in the table. 2 — Accuracy of detailed representation of taxonomic signs. 3 — Accentuation of signs and moving them out to «foreground». 4 —

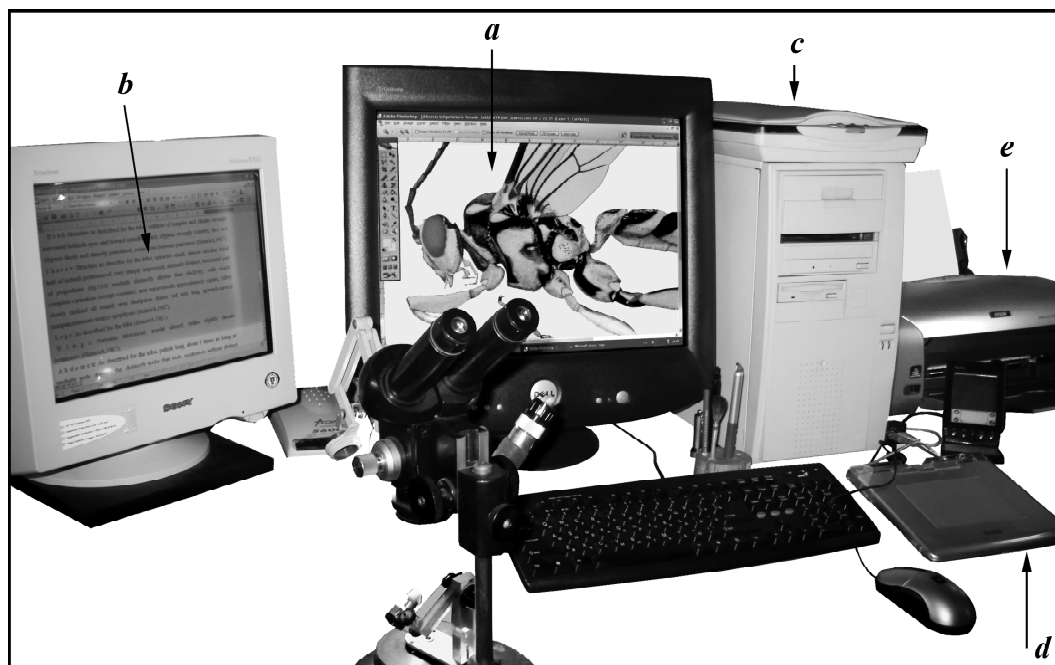


Fig. 1. The complete set of calibrated equipment for preparation of scientific illustration in entomology: *a* — graphic editor for drawing preparation; *b* — text editor with description of taxon; *c* — scanner; *d* — pen tablet; *e* — photo printer.

Рис. 1. Комплект профилированного оборудования для подготовки научной иллюстрации в энтомологии: *a* — графический редактор для подготовки рисунка; *b* — текстовый редактор с описанием таксона; *c* — сканер; *d* — графический планшет; *e* — фотопри́тер.

Preservation of the general appearance of an object at accentuated conclusive taxonomic signs. 5 — Fulfillment of figures in the much greater scale, than sizes of objects in the final table. It allows to eliminate inaccuracies in the drawings while decreasing the scale.

For fulfillment of these regulations the figures of parts of imago body are executed separately. For ichneumon flies this parts are flagellum, thorax, legs (femur, tibia and tarsus), wings (1, 2 separately) and abdomen. Afterwards these parts are mounted to standard arrangement in this or that way. The figures of taxonomically significant parts of body (for Ichneumonidae these are head from above and in front, propodeum and 1–2 segments of a abdomen from above) are prepared in a scale 0,5 in a longitudinal section. Afterwards both halves are integrated as a whole object (see below).

The full set of the equipment required as for editing illustrations prepared manually, as well as for complete fulfillment of figures in the graphic editor, is shown on figure 1.

The devices required for preparation of drawings in color should be calibrated. The color image of an object on the monitor screen should match the color gamma on a hard copy. Therefore, calibration of devices is performed in correspondence to image on the screen to a mark of ink of the ink-jet printer, and a mark of photographic paper. The printed out table of figures is necessary for prepress it for printing in a publishing house, that is updating of image on screen of the file in the CMYK format and image of the finished product.

Obligatory condition, regardless of abilities of a figure's author, is usage of a grid in a microscope for fulfillment of the contour of object. It is necessary for maintaining precise proportions of object's drawing.

## Preparation of illustrations manually and its finalization with graphic editor

If entomologist, specializing on some group of insects has drawing capabilities and skills, «manual» method of scientific illustration can be chosen with the subsequent adaptation by the graphic editor. Very often, this method under specified conditions could be easier and faster, than full preparation of a figure with the graphic editor.

The first step is pencil drawing of contours of separate segments of imago and parts of the body (0.5 in a longitudinal section), with basic taxonomic signs of the studied group on cross-section paper using a grid in the ocular of a binocular microscope. All parts of the final plate are fulfilled in greater scale, because various slight inaccuracies and irregularities of lines will be eliminated in the normal size. The outline of figures of wings and flagellum are fulfilled by a diascope or device for reading microfilms, as described below in detail. Then pencil figures are transferred to a paper by the blueprinting technique. Assembling of the imago contour is performed in compliance with the standard arrangement of the body, flagellum, wings and legs

during the process of blueprinting from the cross-section paper to a paper suitable for usage of Indian ink and watercolor. The most suitable density of paper for fulfillment of these operations, from our point of view, is density of aged photographic paper (back side) and photographic paper for the printer (back side). The contour is outlined by Indian ink, using a rapidograph (0.18, 0.25 mm). The alternative version of a contour preparation is also possible. If some components are made in a small scale, the figures can be scanned, with the subsequent zoom, then with outlining by the graphic editor and printing on the laser printer on the mentioned kinds of a paper.

The next stage is operation of giving volumetric appearance to table's elements. It is done with black watercolor by a thin paintbrush. Detailing and punctuation of composite elements are performed with a rapidograph. These operations can be done using colored watercolor. However it requires considerable drawing skills and capacities.

At the following stage figures are scanned and then finalized with the graphic editor. For editing and deleting some irregularities of lines of an external contour of objects, lines limiting viens of the wing and etc, tools «Polygon Lasso» or «Eraser Tool» with the «Shift» keydown are used. Also for contour outlining, it is possible to use hard brush (Hardness — 100 %, Spacing — 1 %) with diameter 3 px, while holding «Shift» key. The alternative version — outlining of necessary parts by the vector tool «Line», as described in detail below. Coloring the objects, pouring and coloring both compound eye and ocellus, coloring a wing's membrane are also done in the graphic editor in the sequence that is described in the corresponding sections below. The stages of preparing an illustration by the named above method is shown in the Plate II, and an example of a fully completed table in the Plate VI.

## Full preparation of a scientific illustration in the graphic editor

As it was already mentioned above, the development of modern digital technologies allows preparing scientific illustration with no «pencil and paper». For fulfillment of figures in the graphic editor Photoshop the equipment introduced in figure 1 is necessary. Using Pen Tablet is desirable.

The necessary condition for obtaining the final table at printing by the photo printer is calibrating the system to get a correct image on the monitor screen and range of colors of an object on the final print of the table. As mentioned above calibrating of the system is performed by the image on the monitor screen and resulting table depending on type of photographic paper, the printer and also type of used ink for the ink-jet printer. All colored digital figures are fulfilled in the CMYK mode in compliance with the requirements of publishing houses.

The most essential feature of the editor is the possibility of using «Feather» parameter for delimitation of selected area to give «plastic» to the object and its

«rendering», and operating with layers at «refining» in a separate layer and «mounting» of the image.

It is necessary to follow some steps for fulfillment of figures of parts of the body of insect in the editor Photoshop with images saved in separate layers. These steps are: fulfillment of the contour of object (1), pouring (2), plastic and rendering of object (3), refining or workup of image parts (4), coloring (5), final «mounting» of separate figures (6) and combining into figures to the table (7).

#### A. PREPARING CONTOUR OF OBJECT

The fulfillment of a contour of a figure is done in two ways: manually, using binocular microscope and subsequent scanning and editing, using graphic editor capabilities, or fully in the graphic editor.

The first method is more convenient (Plates III: 5,6; IV: 2,3). After fulfillment of a contour on cross-section paper by a pen, the figure is outlined by the rapidograph and scanned in Bitmap (Line) mode. Cross-section paper lines are removed by using Brightness in a scanner menu. The obtained image is converted into Grey mode (Menu: Image–Mode–Gray) with the adequate resolution (600 dpi) in the Photoshop editor. The scanned figure is outlined, using «Line Tool» with adequate thickness (4–6 px in accordance of image scale). It is more convenient to convert scanned figure from Bitmap to CMYK mode and to make outlining by color lines. At the following stage, Background layer containing scanned figure, is selected as the working layer, selected with the command Select All (Ctrl+A) and removed (Del.). A layer Background is made invisible, clicking the icon «eye» (Indicates Layer Visibility). The visible layers are integrated by a command Layer–Merge Visible (Shift+Ctrl+E). (If the work was done in the color mode, the figure has to be converted into Gray mode. The layer, containing contour, is made the working layer, and minimum brightness and maximum contrast is set by the command Image–Adjustments–Brightness/Contrast.). The contour is ready for next stage.

The second version of fulfillment of object's contour is based on refusal from cross-section paper use and subsequent scanning. In this case it is necessary to use Menu function Show–Grid (Menu: View–Show–Grid). The function Snap To–Grid function must to be switched off (Menu: View–Snap To–Grid). In this case lines carried out by pen of Pen Tablet, or mouse will be arbitrary (Plate V: 6). The main condition of figure preparation is to fulfill separate parts of the body in the same scale and copy them into separate layers to the same file.

#### B. FILLING OF A CONTOUR

At this stage figure consists of 3 layers arranged in the following order: Background, Contour (outline) and Navigator.

The layer «navigator» is prepared in black-and-white mode and includes the main external lines of the

object, borders of selected areas and the borders of areas with different coloration (last two borders are implemented using broken lines) (Plate IV: 3). This layer is located on the top and made by lines of any light tone. It is not the working layer, but serves as a navigator for all subsequent operations, because it contains detailed structural lines required for operation «plastic and rendering» (Plate IV: 1). Later the work is performed in the simplified contour layer (outline), which is located under the layer navigator. Before filling, all unnecessary lines of object structure have to be deleted. These lines are visible only in the layer «navigator» and required for orientation during «plastic and rendering» and «refining» operations. The filling in Gray mode is fulfilled by Paint Bucket Tool with indices Mode equal Normal, Opacity — 100 %, Tolerance — 50–55 % saturation is the most convenient for Grey filling. Usually it is necessary to repeat this operation 2–3 times to eliminate light border between black lines of a contour and gray color. In preparing of the figures of a head, compound eye and the ocelli are poured only at the latest stage of work — «coloration» in a separate upper layer. Before this, the areas of antennal socket, compound eye and ocelli remain transparent (white at a visible layer Background). Further, it is possible to shape volume appearance of the figure.

#### C. SHAPING VOLUME APPEARANCE OF AN OBJECT

At the given stage 3 layers are necessary for work in the following order: Background, Pouring (filling up) and Navigator.

At this stage the working layer is the filled one — «filling up» (Pouring). This layer is copied, using a command from the pop-up menu by clicking right mouse button (RMB) on the activated layer «filling up». A new layer is denominated «plastic and rendering». The layer «navigator» located above it remains visible. The working layer contains no structural lines reflecting details of the object; those lines are presented in the visible layer above it and intended for orientation. Outline of compound eye and ocelli in open figure of a head is not contained in the working layer either. They are in the layer «contour» which is performed above the working layer. The filling of compound eye and ocelli, in this case, is fulfilled in lower or upper layer only, after final refining of the object and it's conversion into CMYK mode.

At the first stage, the largest parts of the object are selected, using Polygonal Lasso Tool with Radius of Feather 70 px or more, by orienting on visible, but non-working layer (navigator). Then necessary part of the object is darkened, using command Levels of Image–Adjustments–Levels menu, moving the cursor in a channel Gray, or using command Brightness/Contrast, or both. Remaining areas are darkened the same way, only with Radius of Feather decreased accordingly. The internal parts of the object are selected by Polygonal Lasso Tool or Lasso Tool with decreased Radius of Feather (50 px) (Plate III: 1–4).

It is more reasonable to fill most complex parts of the body to be sculptured, for example, thorax of imago



(mesopleuron), by darker color, and then to shape a volume appearance lightening required parts, by selecting Feather of different Radius.

More laborious («manual») are methods of shaping the object a volume appearance by soft brush or by using «Paint Bucket Tool». Both methods require preliminary selection of working area.

The shaping a volume appearance of the object using selection with required Radius of Feather, much greater than zero, is the filling of selected area by grey of different saturation. Also for fulfilling of this operation, one could select the necessary fragment and tone it by softer brush, which has larger diameter and required saturation.

#### D. SCULPTURATION (REFINING)

Refining is the fourth stage of the preparation of figures of parts of the body. At this stage the second visible layer — «navigator» (outline) is located above the working layer «plastic and rendering». At this stage Pen Tablet is often the necessary tool.

There are two ways to refine the object: refining the complete object using Pen Tablet, or separate fragments (punctures, wrinkles) if considerable parts of the object have uniform structure, using Copy function (Ctrl+C) and then Paste (Ctrl+V). In this case, after fulfilled operation, all visible layers — working and pasted fragments (i.e. except Background and Outline layers) are merged (Merge Visible). This method is most optimal for detailed working out on a suture between two symmetrical halves of the object. Usually both methods are used for the operation of refining (sculpturation). The refining of the object sculpture in a separate layer, situated above the layer «plastic and rendering» is also convenient. It allows correcting unsuccessfully implemented fragments.

Longitudinal wrinkles. It is necessary to recognize that Polygonal Lasso Tool with small Radius of Feather 3–5 px for representation of the figure of longitudinal wrinkles is optimal. After selecting longitudinal wrinkles, they are shaded, using Brightness/Contrast option. Then spaces between wrinkles are clarified in the same way. It is also possible to use soft brush with low hardness, shading selected area (Feather > 0). Using arbitrary brushes is also possible (fig. 2).

Cellular sculpture of a surface. One of the methods is to fulfill one cell figure in a separate layer, copy and paste it to remaining parts of a surface after the corresponding modification (Edit–Transform–Scale/Rotate). Then required layers are merged (Layer–Merge Visible — Shift+Ctrl+E).

Another way is the preliminary design of brushes to depict cells and wrinkles, for specific groups of insects. The example of such set is shown in the figure 2.

For more «natural appearance» of an object, a shadowing of different parts by punctures, as well as at fulfilling of a black-and-white figure manually by Indian ink [Tereshkin, 2004], is useful. For this purpose, a Pen Tablet is used, with established previously Brushes

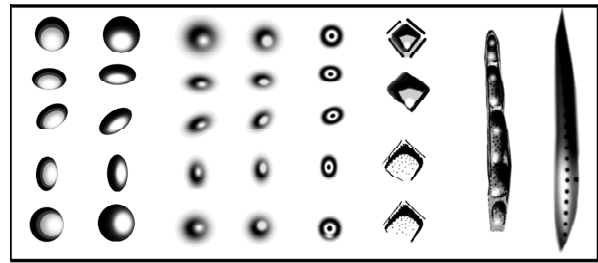


Fig. 2. Samples of arbitrary brushes of cells and wrinkles.

Рис. 2. Образцы произвольных кистей в графическом редакторе.

(Window–Brushes) in window and parameter Spacing up to 200 %, that prevents dots merging, and also corresponding hardness of a brush is used.

#### E. COLORING THE OBJECT

Graphic editor Photoshop allows to color an entomological object, without using watercolor and paint-brush, which is very labor consuming and depends on definite skills and capacities.

At the given stage, the operation is fulfilled in the layer «refining» (sculpturation), which keeps refined and punctuated object in the grayscale (Gray). First step is to convert the figure from Grayscale to CMYK Color. After that, definite coloring parts of the object are selected by Polygonal Lasso Tool or by a pen of the Pen Tablet by the Lasso Tool. At the given stage it is necessary to select the conforming parameter of «hardness of selection», or Radius of Feather (Feather > 0). After that, selected fragment is clarified and contrasted up to the appropriate level (Image–Adjustments–Brightness/Contrast), and basic («medium») color for the fragment is selected from the palette. Then Image–Adjustments–Hue/Saturation operation (key Ctrl+U) is performed. Insert Colorized flag into appeared menu and then by Saturation and Hue sliders select necessary color for the fragment (Plates III: 9; IV: 7; V: 11–12).

It is very important to control the object by the microscope constantly. A lamp with definite spectrum, for example, halogen lamp, is the best for lightening the object.

### Special features of preparation of components

#### A. FULFILLMENT OF WING AND FLAGELLUM FIGURES

The most important taxonomic signs of ichneumon flies' wing are veins arrangement and geometry of cells, less important — veins color and membrane. Hence, the thickness of veins at their image can mismatch the object's proportions for the benefit of clearness of taxonomic signs. Veins and the membrane color on the figure mostly could have schematic character, in accordance with taxonomic signs.

Contour of a wing, precisely reflecting morphology and arrangement of veins and cells could be fulfilled in the editor Photoshop, with no pencil and paper (see

part «Fulfillment of a contour of object» in Photoshop). However, this way is labor-consuming and demands on considerably more expenses of time, than combination of «manual operation» and further finalization in the graphic editor.

There are a few methods for fulfillment of a wing figure, satisfying to the mentioned requirements: scanning, digital photo, and diascope or equipment for reading of microfilms with subsequent scanning of pencil's figure. The first method frequently requires partition of the object, but such damage is unacceptable for type material. Second method requires smoothing the wing that is not always possible and also could damage the object. The most successful, by our opinion, is the last method of those three. The mounted object is put on foam plastic in front of projector's objective or equipment for reading microfilms, under necessary angle perpendicularly to light beam and the object is projected on a sheet of a paper (format A4). After that, a contour of a wing and veins needs to be outlined by a pencil (if necessary, pencil contour could be outlined by rapidograph). The next stage is scanning of the pencil figure. The scanning usually is conducted in a Gray mode with maximum contrast.

Finally, the outline of wing's contour and elaboration of the venation according to postulates mentioned above, are started. At this stage (in Gray mode), working with layers is the most important. The figure, for convenience of the further operations, is converted into Color mode (Image–Mode–Color) that allows outlining the wing by more visible colored lines. First, the outlining of forward wing, with obligatory control of the object by the binocular microscope, is performed by a procedure described below. After the outlining of a front wing is completed, it has to be saved in a layer «wing-1», separately from fulfilled further layer «wing-2» and layer «Background». Then, the scanned pencil drawing has to be removed from «Background» layer, retaining only white background filling (Ctrl+A–Del). The figure is converted to Gray mode again. Then layers which keep images of both wings are shaded and contrasted as much as possible (Image–Adjustments–Brightness/Contrast). So as a result we have a file in Gray mode with three layers: «wing-1», «wing-2» and «Background» with white background filling.

Outlining. For this operation, maximum firm tool Brush with Spacing 1 %, 3–4 pixels size, or 2 pixels Pencil could be used. Another and the most convenient variant is to use the vectorial tool Line for outlining veins. It is necessary to execute «Merge visible» command (keyboard shortcut Shift+Ctrl+E) constantly; previously, other layers (the layer by which outlining is fulfilled) must be turned off. The last variant seems the most easy-to-use for both — quality and speed of fulfillment. The most convenient is a combination of these two methods: option Line for basic outlines and then, for finishing, — firm paintbrush in combination with Shift key.

Coloring wings viens. At this stage, when the image of the wing is located in the separate file on three layers, the coloring of viens is performed. A filling of a

membrane is done only after merging the «wings» file with the «total» file and subsequent merging layers (see below «Mounting figure of imago from separate parts of a body»). First step is to convert the file from Gray to CMYK mode (Menu: Image–Mode–CMYK color). Second step is to select a color with obligatory control of the object by the microscope, and fill veins, using a tool for filling (Paint Bucket Tool). It is necessary to check that the area of the filling is closed that means, all lines must to be solid without gaps. Open parts of veins of the wings have to be limited or temporary, or by line of main color filling. Another and the most rational method is selecting a part of the wing with veins of identical color (tonality). The obligatory condition in this case is a maximum «hardness» of selected area border (Radius of Feather = 0 and Anti-alias flag has been established). If Radius of Feather is more than 0, it is possible to make gradient transition to the open parts of viens of the wing basis. It is not good to coloring black outline of viens, because it will spoil «taxonomic obviousness» of morphology of a wing. During this operation it is necessary to remember, that on the tools panel «Anti-alias» flag should be checked to eliminate visible white border between lines, limiting viens and actual filling. In addition the «Contiguous» flag should be checked to fill veins only, not all selected area. Also, «all layers» flag should be unchecked. After the filling is done, the next step is correction viens tonality of the back wing, that is less intensive color, top longitudinal viens and viens in the base according to object of description with simultaneous control of object under the microscope. For this operation, the most convenient is to use option «Brightness» (Menu: Image–Adjustments–Brightness/Contrast). The necessary area of viens has to be selected in advance, using Lasso Tool or Polygonal Lasso Tool, with «Shift» key, if necessary. Radius of Feather > 0 is usually set to 20 px. In this case the transition from dark to light parts of viens is smooth, and there is no need to retouch transitional areas. The layer with the wing image should be a working one, i.e. allocated. During the operation the remaining two unused layers can be switched off (remove Indicates Layer Visibility in the graphic pallet «Layers» (F7)). Later on, the transitions between parts with different tonality are corrected by blurred brush of appropriate diameter and with appropriate parameter of Spacing in a graphic pallet «Brushes» in combination with the «Shift» key.

Coloring wing's membrane. Coloring wing's membrane is started only after the final «mounting» and merging to the body of the object. Wings of the object with already colored viens are copied and then pasted to the file with the image of the ichneumon fly body. First, front wing is transferred and then the back one, that would be located in final figure over the front wing. It is necessary, that the image of the wing has no background layer and located in the layer without a filling (i.e. in transparent layer). If the image of the wing is not in a separate layer white

background has to be removed by «Magic Eraser Tool». After that the wings layer is copied and pasted into the file with image of ichneumon fly body in separate layer. The next necessary procedure is scaling the wing that is changing the size in accordance with body dimensions. The menu command «Edit–Transform–Scale», holding Shift key, is used for preservation of wing proportions. The procedure is fulfilled by controlling the ratio of length of the wing to length of the body under binocular microscope, using an ocular with a graduated scale. Then the wing is moved to a place under tegula, using the «Move Tool» (key V). Further, necessary position is given to wing using the menu command «Edit–Transform–Rotate». Before executing the command, center of rotation is displaced to the base of the wing under tegula (Plate V: 13). At the following stage the improvement of a wing base is performed. Area of the base of a wing, from the base of viens up to a visible part of a body is limited by a selection tool — «Polygonal Lasso» or «Magnetic Lasso Tool» with Radius of Feather equal 0. It is necessary to achieve required «hardness» of the borders of a filling area between base of viens and thorax of insect. Then filling selected area by the conforming color is performed, using the «Paint Bucket Tool». After that, necessary structures in wing base are finalized, using a brush of appropriate diameter and hardness, with the simultaneous control under a microscope. During fulfillment of all operations, it is necessary to remember, that all operations are carried out in the layer keeping the given wing (active layer). Further, all listed operations are fulfilled with a back wing.

After fulfillment of all procedures, operation of merging of layers is carried out. Layers have to be disposed in the following order — body of the insect, front wing, back wing. All remaining layers are disconnected, by clicking on the icon «Indicates Layer Visibility» and then the menu command: «Layer–Merge Visible» (shortcut key Shift+Ctrl+E) is executed. Only after that the operation of coloring a membrane of a wing is performed.

For filling a wing membrane, after selection of the appropriate color, the «Paint Bucket Tool» is used. The overlapping parts of a membrane of both wings are filled up by more dark tone of the same color as basic color of wings.

Often wings of ichneumon flies and other insects have a different color pattern of spots having a taxonomic value. For study both a shape of spots on wings and their coloration, it is necessary to observe a number of the rules facilitating their study. First of all, it is necessary to select area of a spot using tools «Polygonal Lasso» or «Magnetic Lasso», setting Radius of Feather correspondingly to a level of diffusion of spot borders after a filling with usage of the «Paint Bucket Tool». The more diffused are borders of a spot, the larger is Radius of Feather. If the spot covers several cells, the selection of different parts is made with the Shift key pressed. In case the spot has irregular or heterogeneous color, area of selection is done

with Radius of Feather = 0 and coloring is performed using blurred brushes of large diameter.

Figure of a flagellum. The fulfillment of a flagellum contour has considerable difficulties, connected with number of segments, their proportions, resizing of segments from the base to the top. To facilitate the solution of this labor-consuming problem, it is necessary to apply the method used for fulfillment of a wing figure. That is, a projection of flagellum on a sheet of a white paper with the help of a diascope or device for reading microfilms. As a rule, on a paper the contour of flagellum and, in most cases, borders between segments are well visible. The image of flagellum is outlined by pencil and later improved under constant control of flagellum using a microscope. Prepared draft figure is scanned and outlined by the «Line» tool, as described above for a wing. Further prepared contour is tinted, sculptured and colored by the methods described earlier.

## B. FIGURE OF COMPOUND EYES AND OCELLI

Process of preparation of color images of compound eyes and ocelli at fulfillment of a head image of hymenopterous insects in different foreshortenings has a number of special features. The first condition is performing eye coloring in a separate layer. This is due to the fact that while performing «volume» operation using an option of selection with big Radius of Feather, the parts of the head capsule, adjacent with an eye can be affected. In the layer «contour» or «navigator» all lines, except of lines limiting a compound eye and ocelli are removed. Just in this layer, operations of coloring of compound eye and ocelli are performed. Merging of this layer with a layer keeping the figure of a remaining part of the head capsule is done after completing of these operations.

The fulfillment of a color figure of an eye can be done by two methods — gradient filling of a contour and clarification of the most convex part with the help of Brightness/Contrast option after selecting it with considerable Radius of Feather (Plate III: 13–16).

Gradient filling. A surface of a compound eye and ocellus, if they are not located in a separate layer, is selected with the «Magic Wand Tool». If it is selected by the indicated tool, it is necessary to set Tolerance parameter to 255. But even in this case a narrow unpainted area remains on periphery of the eye after filling. If you are not satisfied with quality of filling, it is necessary to select an internal part of the eye before filling with the «Polygonal Lasso Tool» with Radius of Feather set to 0. After that, in a palette Swatches color of filling is selected by the darkest part of an eye (control of object under a microscope). Gradient Fill is performed by choosing Layers–New Fill Layer–Gradient from the menu. It is necessary to set in the dialog box «Gradient Fill» the conforming parameters of a slope (Angle) depending on the selected direction of «illumination» and contrast of the fill (Scale). It is less convenient to use the «Gradient» tool by clicking the

corresponding button on the toolbar (G) and clicking on the sample Linear Gradient on the parameters panel. Further, if necessary, area of a fill is selected and brightness of area of the gradient fill of a compound eye and ocellus is regulated, achieving maximum conformity to the object, with the simultaneous control under the binocular microscope. If the filling operation is carried out in a separate layer, a layer «Background» in the pallet Layers has to be deselected leaving only basic layer of the head and layer of an eye and ocelli filling. Then, merging the necessary layers is performed in the menu Layers using the «Merge Visible» command, or keyboard shortcut Shift+Ctrl+E.

Clarification. Another way of coloring the compound eye and ocellus is carried out in the following sequence of operations: 1 — full filling all area of an eye by necessary color of the necessary tonality (maximal saturation) by the tool Paint Bucket Tool, 2 — selection of an necessary part of area of an eye by the «Polygonal Lasso Tool» or another tool with Radius of Feather = 60 or more (optimal is 70 px) and then, clearing the selected area by the Brightness command up to the necessary level. The borders of the top of selected area should extend beyond the top border of a compound eye. It is necessary to recognize, that last method is more optimal both by simplicity, and by quality of the final result. The same method can serve as addition after a gradient fill. Examples of application of both methods are presented on figures of Plate III: 13–14 and 15–16 (compare also Plates VI and VII).

#### C. MERGING OF 50 % FRAGMENTS OF OBJECT TO A WHOLE AND RETOUCHING OF A «SUTURE»

As it was told above, separate parts of insect body, carrying main sings of taxon (for Ichneumonidae these are a head in two foreshortenings, propodeum and 1–2 segments of abdomen from above) are done in a magnified scale and in a view of half of object in a longitudinal section. Therefore, after finishing a 50 % fragment (refining and coloration), there is a problem of its transformation into the full scale image. For the solution of this task the following sequence of operations is performed. In a finished figure, keeping 50 % image of object the Background layer is marked as the working one. Further, the «select all» command (Menu: Select–Select All, Ctrl+A) is executed. Further, «copy» (Menu: Edit–Copy), and then «create» (Menu: File–New; Ctrl+N). In the displayed dialog box in the Width field, the value of width more than double width of copying layer Background is set. After pressing the Enter key, a new canvas 2 times larger than image of 50% appears on the screen. At the following stage the layer keeping 50 % fragment is selected as the working one and copying is performed again (Menu: Select–Select All, Ctrl+A). Further, one switches to a newly created file and executes the paste command (Menu: Edit–Paste, Ctrl+V). Next step is executing the command «Flip Horizontal» (Menu: Image–Rotate Canvas–Flip Horizontal). Using the «Move Tool» the pasted

half is displaced to the left-hand border of a canvas, and repeated paste of a copied half of an object from a buffer (Ctrl+V) is conducted. At this stage we have a file with three layers — Background and two layers keeping symmetrical one-half fractions of insect' body fragment. The next step is the maximum fine overlapping of one-half fractions of object by the «Move Tool». Before that, area of a suture is magnified as much as possible to avoid errors at merging of layers with fragments. After operation of merging of one-half fractions of object, a layer Background is disabled. Then a command to merge the visible layers (Merge Visible, Shift+Ctrl+E) is executed (Plates III: 11–12 and IV: 9–10).

As a rule, the visible errors and tracks of «suture» are remaining after merging of two one-half fractions of object. Therefore, there is a necessity to retouch them. A process of retouching is possible to conduct practically «manually» with usage of a Pen Tablet. However, optimum way, according to our opinion, is the operation on copying and subsequent paste of fragments adjoining to retouching area. A copying area is selected by tool Lasso Tool or Polygonal Lasso Tool with parameter Feather > 0 (3–5). Then the Copy command (Ctrl+C) and further Paste (Ctrl+V) are executed. Further merging of layers (except for the Background layer) (keyboard shortcut Shift+Ctrl+E) is fulfilled.

#### D. FIGURE OF IMAGO. MOUNTING IMAGO FROM SEPARATE PARTS OF A BODY

Main prerequisites for preparation of a figure of imaginal stage are observance of precise proportions of each of body parts of imago and fulfillment of image in a unified aspect angle (that is necessary for comparison with the images other taxa). To meet these conditions figures of parts of imago body (head, thorax, and legs) are fulfilled separately using a grid in an ocular of a binocular microscope. The contour of components is fulfilled in a grid of Photoshop using a Pen Tablet, or manually on a graph paper with the subsequent scanning. The figures of wings and flagellum are fulfilled using of a diascope or a device for reading microfilms (see higher). Most convenient method for subsequent integration of full image is maximum division of a body into separate components dislocated in separate layers. For example: flagellum (or its separate parts), head, thorax, abdomen, tarsus-1, tibia-1, femur-1, coxa-1 etc., wing-1 and wing-2. Separation of tarsae on separate segments is also rational. Further, operation of outlining the body parts the Line tool of necessary thickness (4–6 px) with the subsequent merging of layers with separate lines is fulfilled as described above. Then the operations of a filling, to shape an object a volume appearance, sculpturation, refining and coloration are performed. The stages of transformation of separated parts of imago and order of arrangement of layers are shown on figures of the Plate V. As the result the file

with many layers, presenting separate parts of insect body is obtained.

An «integration» of imago from separate parts of a body to defined in advance standard view of object, is made using the Rotate command in the menu Edit/Transform. At this stage, the key value belongs to order of priority of layers arrangement. For example, layer «tibia» of any of a pair of legs, must be under the layer «tarsus» of the same pair. In a simplified version the arrangement of layers is presented on Plate V: 13. For ichneumon fly imago, order of priority of layers arrangement (bottom-up) is the following: Background–abdomen–legs 1, 2, 3–flagellum–thorax–head capsule–wing-1–wing-2.

After shaping to a multilayer figure of imago a standard position, and disabling the Background layer, all visible layers are merged using «Menu: Layer–Merge Visible» command (Shift+Ctrl+E).

### Correction of a finished figure, correction of errors

In case when the figure of object is finished, including coloring, one can find out, that some parts of the figure do not correspond to those or another taxonomic signs. It can happen in case of incorrect preparation of a matrix or model at usage of a grid, necessary for preservation of proportions of separate fragments. In this case it is necessary to avoid manual correction of object, as much as possible. So, for example, after final preparation of a figure of the second tergite it is found out, that in a final figure gastrocoeli are much longer than that of an object. The manual correction connects with very considerable costs of time, not even speaking about labor expense. In this case, using following capabilities of the editor is optimal: 1 — copying of the fragment to a buffer and paste it in a separate layer (above corrected one) and 2 — using transformation function for area copied in a separate layer. In the given example the sequence of operations can be following. In the basic object, area of gastrocoeli, excluding thyridia, shape and sizes of which one, corresponding to the object (i.e. correct) is selected with the help of one of three tools. Then, the selected area is copied to the buffer (command Ctrl+C) and pasted into a separate layer (command Ctrl+V). Then, area of thyridia is selected and the same operation is performed. It is necessary to keep track of layers (their hierarchy). Further, a layer keeping gastrocoeli is made working, command Select All (Ctrl+A) is executed and the layer is transformed (shortened) with the help of the operation Menu–Edit–Transform (Scale, Rotate) or Free Transform. At the following stage untransformed thyridia (thyridia — a working layer) is attached to transformed gastrocoeli. Both layers are merged (keeping other layers invisible) using the Merge Visible command (Shift+Ctrl+E). The merged layers (gastrocoeli+thyridia) are edited. The basic layer is made visible and working and adjoining parts of segments are edited. This operation is performed manually, or by copying and pasting parts of segments surface,

appropriate for the structure. At the final stage all layers are merged (command Merge Visible).

### Preparation of the final table

The preparation of the resulting table is a final stage of illustrating a taxon. The standard table, illustrating any species of ichneumon flies usually includes 5 figures — head in two aspects angle, propodeum from above, 1–2 segments of abdomen and total figure of imago. It is also desirable to place in the table the scanned image of a label. If the table is intended for the characteristic of superior taxon, genus or tribe, then additional illustrations, for example mandibles, figure of scutellum, thyloides of male flagellum, or any other signs that character for taxon of the given rank are placed in it.

Arrangement and the sizes of the table components should be standard whenever possible. It will allow hereinafter conducting the comparative analysis of the taxa. The sizes of components of the table are established with the help of the Menu command: Edit–Transform–Scale/Rotate in a working layer with ruler turned on (Rulers, Ctrl+R).

The final result of the table, illustrating features of any taxon is presented as a multilayer file in the TIFF format. For a print-out of the table the layers keeping figures of imago and separate parts of a body are merged. At the result, file contains three layers — Background, layer with figures and layer keeping a taxon title. It is necessary to remember, that the table prepared for the publication should be fulfilled in the CMYK color mode.

The outcomes of fulfilling of the tables manually and in the graphic editor are presented in the tables of Plates VI and VII.

### Acknowledgements

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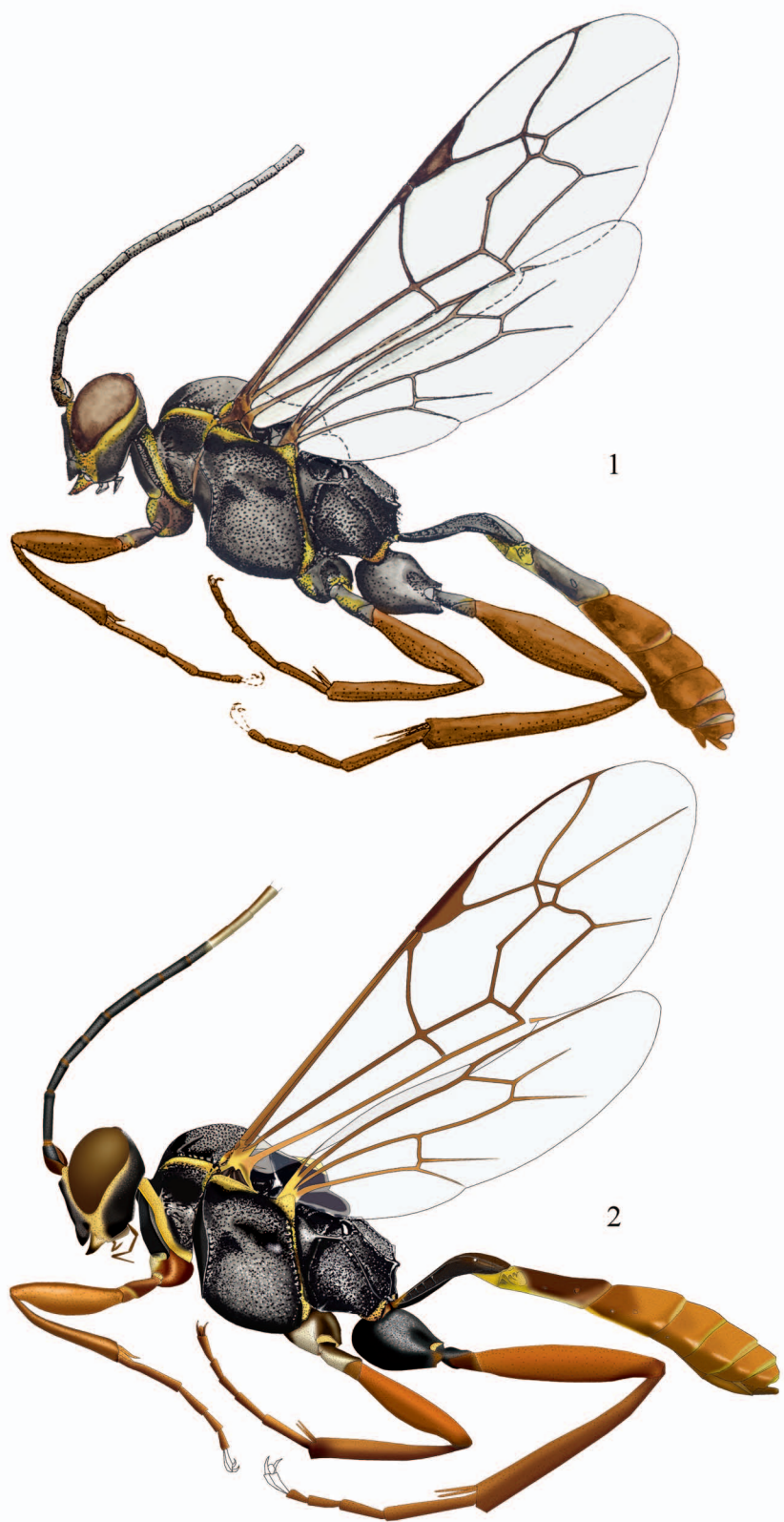


Plate I: Comparison of *Hirtolabus alienoris* Heinrich figures of imago, fulfilled by watercolor (1) and the same fully in a graphic editor (2).

Вклейка I: Сравнение рисунков имаго *Hirtolabus alienoris* Heinrich выполненных акварелью (1) и полностью в графическом редакторе (2).

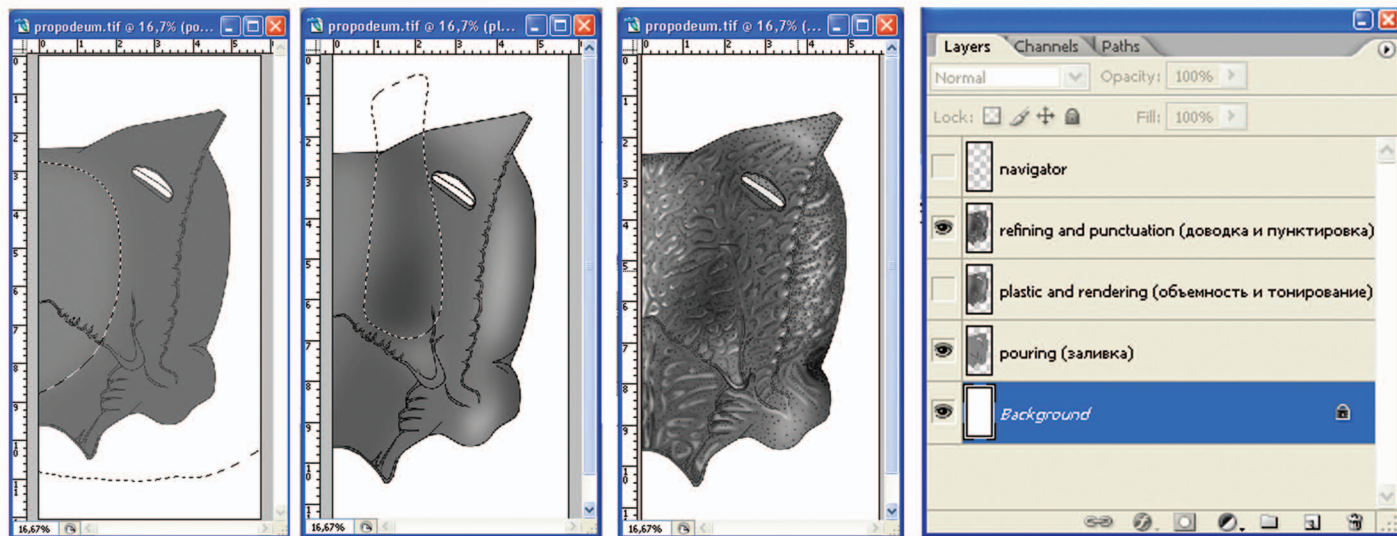




Plate II: Stages of table preparation manually with subsequent improvement in a graphic editor (on example of *Abzaria latipetiolaris* Cameron).

Вклейка II: Этапы подготовки таблицы иллюстраций вручную с последующей доработкой в графическом редакторе (на примере *Abzaria latipetiolaris* Cameron).





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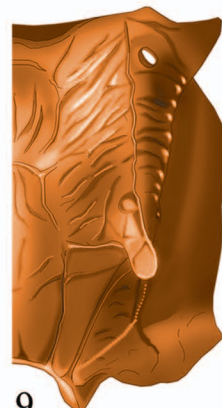
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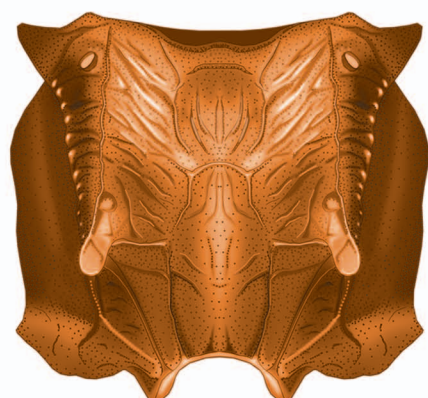
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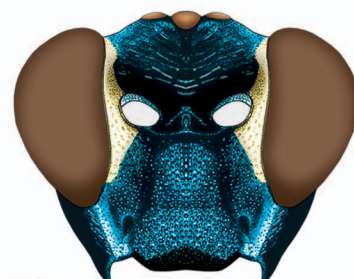
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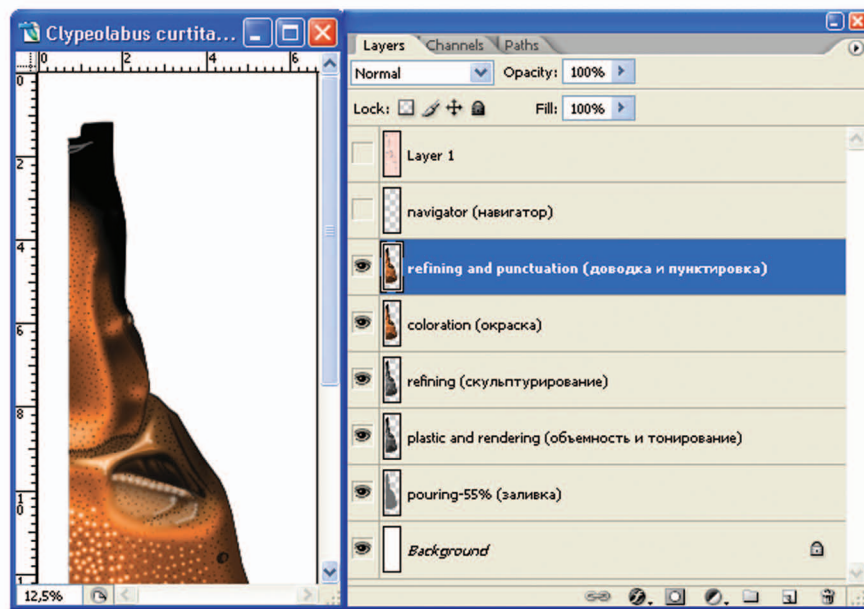


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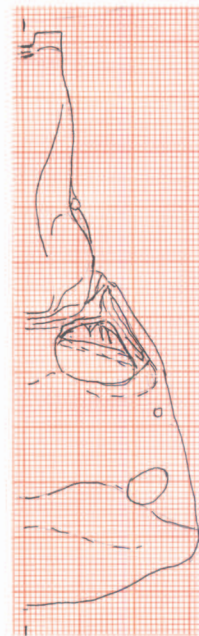
Plate III: The variants of operations of drawings fulfillment in graphics editor; 1-3 – propodeum *Aethioplites madagascariensis* Heinrich, 4 – a sequence of layers arrangement; 5-12 – propodeum *Afrectopius seyrigi* (Heinrich); 13-16 – methods of compound eyes and ocelli coloration (13,14 – gradient fill at *Pachyjoppa tibialis* Cameron; 15,16 – fill and clarification at *Lamprojoppa coerulea* Cameron).

Вклейка III: Варианты операций при подготовке рисунков в графическом редакторе; 1-3 – проподоум *Aethioplites madagascariensis* Heinrich, 4 – порядок расположения слоев; 5-12 – проподоум *Afrectopius seyrigi* (Heinrich); 13-16 – способы окраски глаз и глазков (13,14 – градиентная заливка у *Pachyjoppa tibialis* Cameron; 15,16 – заливка и просветление у *Lamprojoppa coerulea* Cameron).





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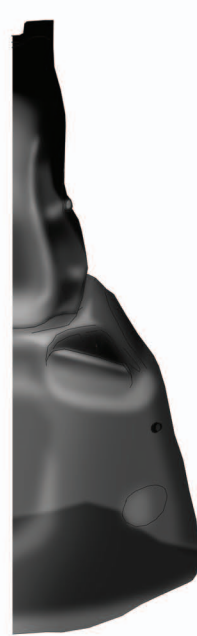
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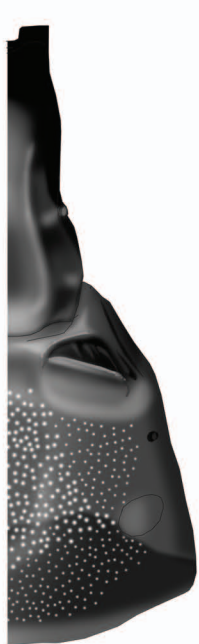
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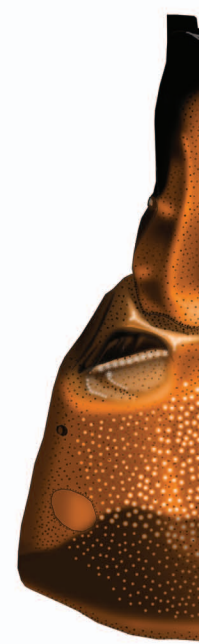
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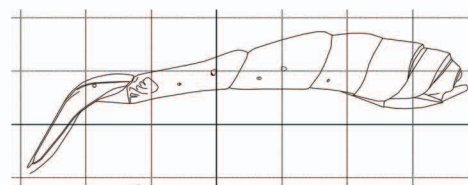
Plate IV: Stages of drawing of 1-2 tergites of abdomen preparation in a graphics editor (*Clypeolabus curtitarsis* Heinrich).  
Вклейка IV: Этапы подготовки рисунка 1-2 тергитов брюшка в графическом редакторе (*Clypeolabus curtitarsis* Heinrich).



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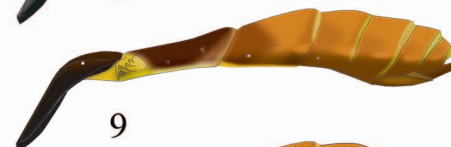
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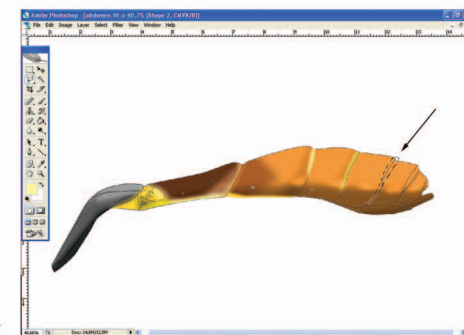
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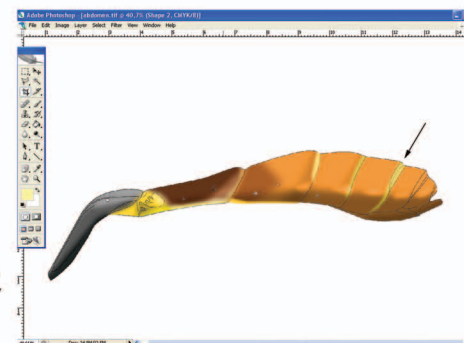
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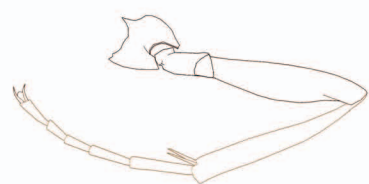
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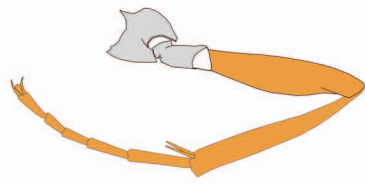
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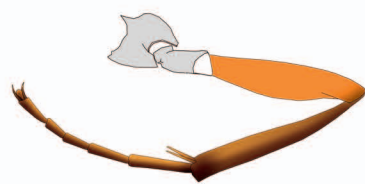
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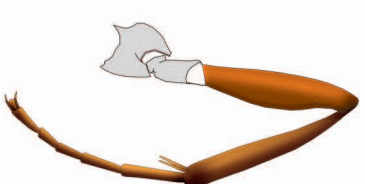
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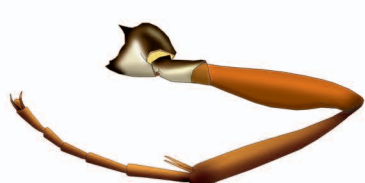
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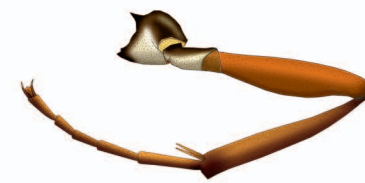
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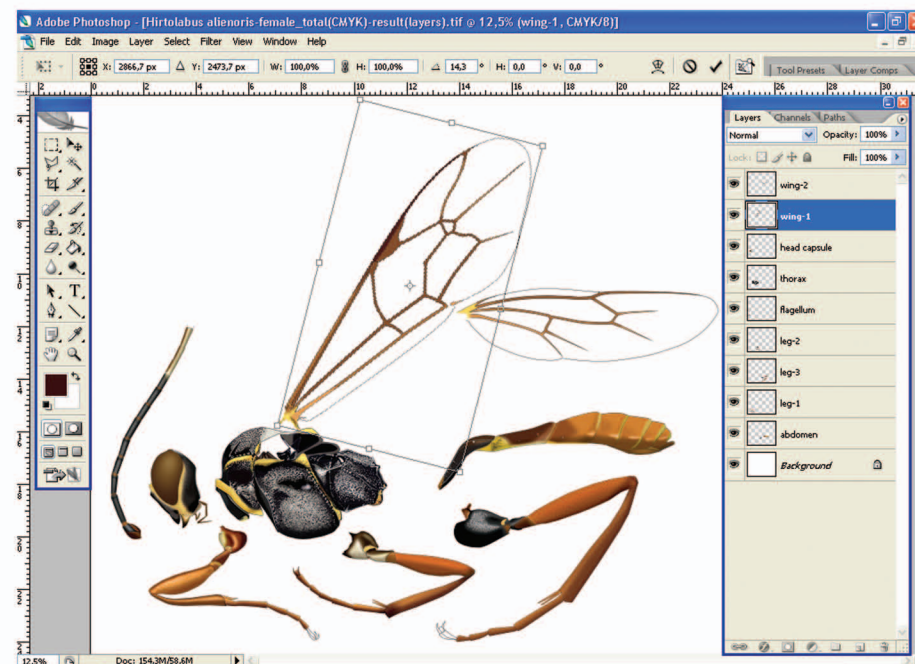
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Hue / Saturation → Selection (5-20-30%)  
→ Brightness + Contrast  
→ Paint Bucket Tool



Completion of drawing (smoothing)  
(Brush Tool)



13

Plate V: Stages of fragments of imago body transformation in a graphics editor (*Hirtolabus alienoris* Heinrich).

Вклейка V: Этапы преобразования фрагментов тела имаго в графическом редакторе (*Hirtolabus alienoris* Heinrich).

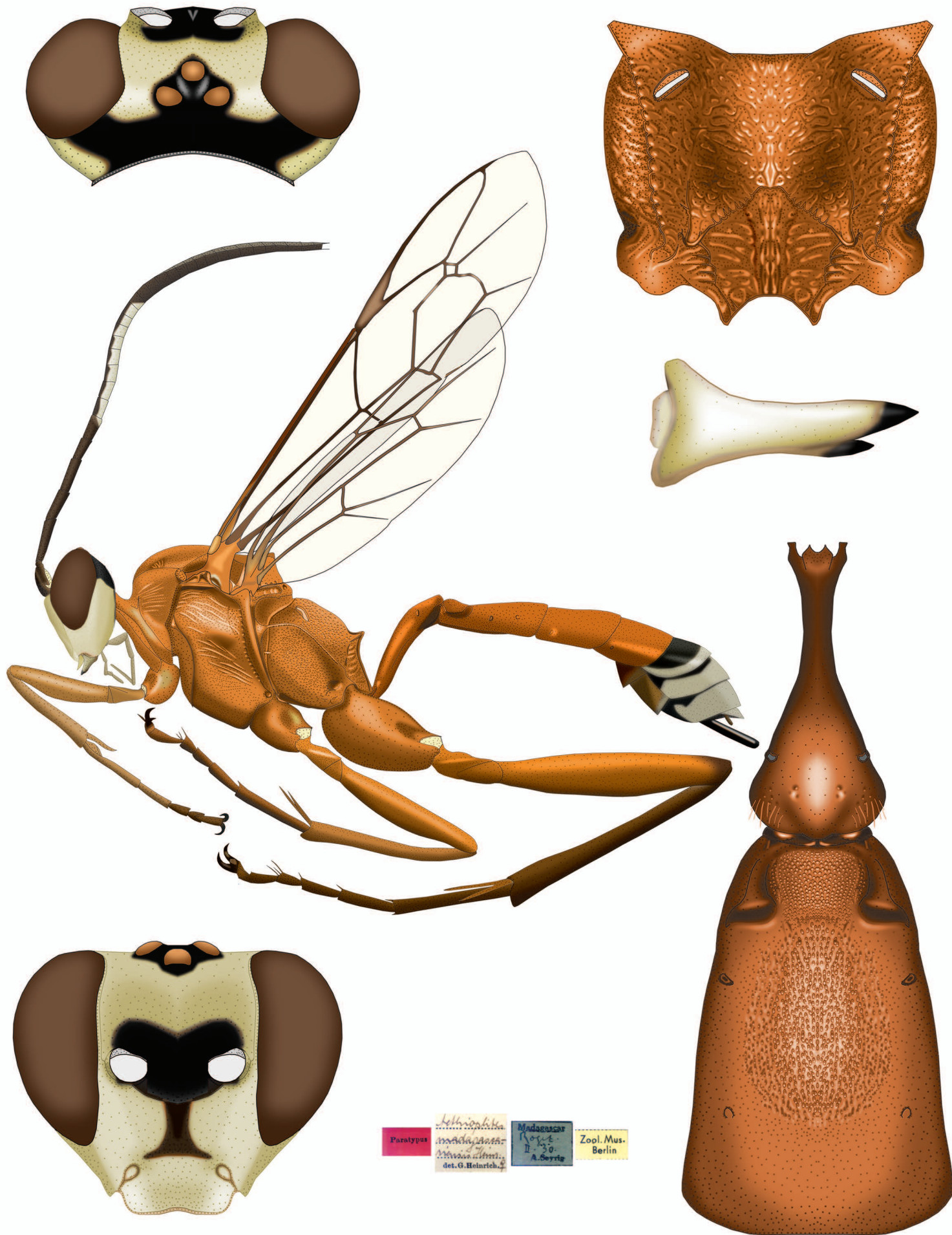




*Clypeodromus thyridialis* Tereshkin, 1992, female, male

Plate VI: Example of table fulfilled manually and improved in a graphics editor.  
Вклейка VI: Образец таблицы, выполненной вручную и доработанной в графическом редакторе.





***Aethioplites madagascariensis* Heinrich, 1938, female**

Plate VII: Example of table, fully prepared in a graphics editor.

Вклейка VII: Образец таблицы, полностью подготовленной в графическом редакторе.