

CONSERVATION AND RESTORATION OF A SPECIMEN FROM THE PRIVATE LEPIDOPTERA COLLECTION

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Abstract: The subject of this paper relates to the restoration of a damaged butterfly specimen from the private collection. It belongs to a group of three separately stored butterflies that were placed in glass frames, adhered to the backside by an adhesive. After the frames accidentally fell down, one specimen suffered damage. The analysis of the existing state showed that three wings were detached, out of which one was broken, and that the abdomen and antennae were missing. Before approaching the restoration of the specimen of interest, all materials and methods of conservation-restoration work were tested on the experimental Lepidoptera collection. It consisted of specimens from other private collections, pinned and placed in boxes, which were discarded due to existing damages. Main problems to be dealt with were the following: removal of adhesives and pins from bodies, reconstruction of missing body parts (wings, abdomen and antennae), their appropriate joining and retouching. Finally, it was necessary to provide placement in new protective storage. The undertaken interventions served as a basis for the suggestion of a method for conservation and restoration of Lepidoptera specimens. The proposition includes both – methods of entomological practice as well as practices common in conservation-restoration work. As step-by-step explanation of this kind of merged approach has not been explained in the literature so far, in this paper methodology for conservation and restoration of Lepidoptera specimens was suggested in detail. The principle of reversibility was followed as much as applied materials allowed it.

Keywords: Lepidoptera, Conservation, Restoration, Insects

For centuries Lepidoptera collections have been subject of great interest,¹ from a scientific as well as from educational and aesthetic points of view.² Their charming appearance, which is primarily based on a wide range of wing colors and patterns, is what generally makes them attractive to collectors.³ Due to their delicate structure, handling butterfly specimens within collections may cause damage through detachments, breaks and losses of body parts. Wings stand out among all Lepidoptera body parts by their visual identity. The subject of this work was the conservation and restoration of a specimen from the private collection. The damaged specimen along with two more specimens, makes a unique part of the collection by the specific way of specimen placement. All three of them were placed between round glass sheets, framed with metallic frame and fixed to the glass base with an adhesive. There were no labels present within the frames, however the owners provided the information on butterfly species based on oral information given from the seller during the purchase: *Morpho aega* (Hübner, 1822), *Morpho achilles* (Linnaeus, 1758) and *Heliconius besckei* (Ménétriés, 1857). The damaged specimen was then identified as *Morpho aega*. Based on the information given, the scientific names of butterflies are used throughout this paper. Although the initial request from the owner was to have the damaged specimen restored and placed in a new frame resembling the old one, after inspecting the found state of the specimen, which was very fragile, and based on the consulted literature, a new way of placing has been proposed. Considering the general lack of literature regarding conservation and restoration of Lepidoptera specimens, a methodology for the conservation and restoration of Lepidoptera specimens has been developed. Special attention was devoted to the reconstruction and retouch of missing wing parts. Wings represent the most visually appealing part of Lepidoptera body, which significantly contributes to the aesthetic dimension of Lepidoptera collections. Other body parts (antennas and abdomens) were reconstructed based on the existing undamaged specimens and the information found in the literature. Due to very small dimensions and large fragility of missing legs, as well as the fact that specimens were finally intended to be pinned, with their upper side shown, the restoration of legs was not performed in this work. Of course, one should have in mind that this segment can be explored by further research. The principle of reversibility has been followed at all times, i.e. all applied materials could be removed from the original material applying adequate techniques.

THE MAIN BODY PARTS AND ORIGIN OF COLOURS IN LEPIDOPTERA ORDER

The insect order Lepidoptera comprises butterflies and moths.⁴ The name of the order comes from Greek words *lepidos* and *ptēris* meaning “wings covered with scales”,⁵ which indicates a specific characteristic of this order i.e. presence of four membranous wings covered with scales from both sides.⁶ Lepidoptera body consists of three main segments: head with antennae, thorax with wings and legs, and abdomen.⁷ Presence

1 Natural History Museum, London. *Adventures of the oldest butterflies*, 19. 03. 2016. <https://www.nhm.ac.uk/discover/adventures-worlds-oldest-butterflies.html>. [retrieved 20. 11. 2019]

2 B. L. Manthle and M.S. Upton, Introduction, in: *Methods for Collecting, Preserving and Studying Insects and other terrestrial arthropods*, 5th Ed, Canberra, 2010, 1.

3 P. Smart, Introduction, in: *The Illustrated Encyclopedia of the Butterfly World*, London, 1995, 10–11.

4 J. L. Capinera, (ed.). *Encyclopedia of Entomology* Vol. 4, 2nd Edition, Springer Science&Business Media B.V., Dordrecht, The Netherlands, 2008, 626.

5 S. Berthier, *Iridescences: the physical colors of insects*, Springer Science and Business Media, Berlin, 2007, 14.

6 *ibid.*, 22.

7 P. Smart, *op.cit.*, 18–24.

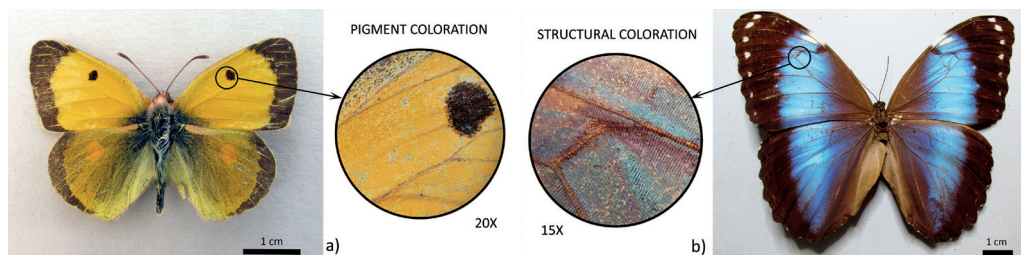


Fig. 1

of wing colour is mainly connected to the scales surface.⁸ Depending on the source of colour there are two types of colorations: pigment and structural. Pigment coloration is due to the presence of pigments and it is based on selective absorption and reflection of light (Figure 1a).⁹ Structural coloration is consequence of light interference and diffraction,¹⁰ i.e. light interaction with nanoscaled structures.¹¹ While pigment coloration is subject to discoloration due to influence of light, that is not the case with structural coloration, as it has physical basis.¹² Structural colours can be iridescent and non-iridescent. If structural colour changes with the observation angle than it is iridescent (Figure 1b), if it does not change than it is non-iridescent.¹³

OVERVIEW OF RECOMMENDATIONS FOR CONSERVATION AND RESTORATION OF LEPIDOPTERA SPECIMENS FROM LITERATURE AND EXAMPLES FROM PRACTICE

Members of the Lepidoptera order are generally present in significant quantity in natural history collections.¹⁴ The purpose of collections can be scientific, i.e. they are the base for various researches in anatomy, taxonomy, climate change and genetics.¹⁵ Besides that, there is also an educational purpose, as a collection presents “certain live textbook for a broad scale of people across many layers of society”.¹⁶ There is also purely aesthetical purpose of collections.¹⁷ When it comes to conservation and restoration of specimens from Lepidoptera collections, there are various approaches, depending on the collection purpose. For example, the *Guidelines for the Care of Natural History Collections* generally states that for the specimens intended for scientific researches preventive conservation is preferred, as physical and

8 D. Z. Pavlović, *Photonic characterization of cuticular structures of selected species of Coleoptera and Lepidoptera*, Doctoral dissertation, Faculty of Biology, University of Belgrade, Belgrade, 2019, 25.

9 R.C. Mc Phedran et al., Structural colours through photonic crystals, *Physica B*, 338, 2003, 182.

10 *ibid.*

11 S. M. Doucet and M. G. Meadows. Iridescence: a functional perspective. *Journal of The Royal Society Interface*, 6, 2009, 116.

12 R.C. Mc Phedran et al., *op.cit.*, 182.

13 D. Z. Pavlović, *op. cit.*, 9.

14 C. Soowon et al., Preserving and vouchering butterflies and moths for large-scale museum-based molecular research, *PeerJ*. 4, 2016. <https://peerj.com/articles/2160>. [retrieved 17. 11. 2019]

15 A. Warren, “Why we still collect butterflies”, *The Conversation*, 11. 06. 2015. <https://theconversation.com/why-we-still-collect-butterflies-41485>. [retrieved 18. 11. 2019]

16 J. De Prins, “Lepidoptera Collection Curation and Data Management”, in *Lepidoptera*, ed. F. K. Perveen, London, 2017. <https://www.intechopen.com/books/lepidoptera/lepidoptera-collection-curation-and-data-management>. [retrieved 20. 07. 2019].

17 M. R. Berenbaum, *Bugs in the System: Insects and Their Impact on Human Affairs*, Cambridge, Massachusetts, 1995, 584.

chemical alterations can decrease their analytical potential. The Guide also explains that concealing the real nature of a specimen is not ethical and that presence of restorations should be detectable but not conspicuous. In addition, there has to be a full documentation of materials and methods used.¹⁸ Regarding historical as well as private collection specimens, factors such as age and method of preparation can influence their suitability for genetic research, though they could be used for other scientific purposes.¹⁹ Further on, the *Care and Conservation of Natural History Collections* states that consultation is necessary prior to any intervention on a specimen (dissection, restoration, etc.) and that conservation grade materials should be used and everything should be documented.²⁰

Examples of wing restoration practice show that, throughout history, wing parts of other specimens were used, either from the same kind or from the other species. These parts, added from the ventral side, were replacing missing parts of wings.²¹ Mica sheets were also used, as well as paper.²² Later on, Japan paper was introduced for this type of restorations, due to its' quality, durability and strength.²³ Regarding other body parts, for reconstruction of antennae trimmed feather barbs were used; for abdomen and thorax there were indications of cork and wood usage.²⁴ It is interesting to mention here that cellulose, as the main component of paper,²⁵ and chitin, as the main component of wing scales,²⁶ share similar chemical structure and biological function, both are structural biopolymers from the group of polysaccharides (cellulose in plants and chitin in arthropods).²⁷

BASIC ENTOMOLOGICAL STEPS FOR LEPIDOPTERA SPECIMEN PREPARATION

The usual preparation procedure for Lepidoptera specimens involves dry specimen relaxation, pinning and placement on a spreading board. The aim of relaxation is to moisten the specimen body, i.e. expose it to high humidity atmosphere, which helps avoiding possible body shattering and allows manipulation with body parts. The relaxation is performed in a relaxing chamber: the bottom is covered with a moistened base (paper, sand, peat) and covered with a net or cotton, making a barrier for direct contact of specimen and moistened medium. Specimens are usually kept from several hours to a couple of days. In order

18 Society for the Preservation of Natural History Collections, *Guidelines for the Care of Natural History Collections*, <http://cool.conservation-us.org/byorg/spnhc/spnhc1.html>. [retrieved 22. 11. 2019].

19 M. Colvin, Entomological Collections – Their Historic Importance and Relevance in the 21st Century, *Dispar The Online Journal of Lepidoptera*, 28. 12. 2014. <http://www.dispar.org/reference.php?id=92>. [retrieved 25. 11. 2019].

20 D. J. Carter and A. K. Walker, Policies and procedures, "Chapter 9: Policies and Procedures", in: *Care and Conservation of Natural History Collections*, eds. Carter, D. and Walker, A. Oxford, 2017, 178.

21 G. Brown and E. G. Hancock, The Historical Repairs Of Butterflies And Moths From The Eighteenth Century Collection Of William Hunter, University Of Glasgow, *NatSCA News*, Issue 12, 2007, 16–17. <http://www.natsca.org/article/207>. [retrieved 28. 06. 2019].

22 *ibid*.

23 J. Tauber, "The study and conservation of the 20th century wooden chest and its Lepidoptera collection, Repairing methods of Lepidoptera collections", *CeROArt* [Online], EGG 6 | 2017, 28. 05. 2018. <https://journals.openedition.org/ceroart/5264>. [retrieved 28. 06. 2019].

24 G. Brown and E. G. Hancock, *op.cit.*, 16.

25 J. C. Roberts, *The Chemistry of Paper*, The Royal Society of Chemistry, Cambridge, 1996, 20.

26 J. Gu, Z. Di and Y. Tan. *Metallic Butterfly Wing Scales: Superstructures with High Surface-Enhancement Properties for Optical Applications*, Springer, 2015, 38.

27 P. S. Chawla, S. R. Kanatt, and A. K. Sharma, Chapter 35: "Chitosan", in: *Polysaccharides*, Springer International Publishing, 2014, 220.

to prevent mould, naphthalene, thymol or similar substance is added. After relaxation, specimen is placed on a pinning block and pinned by inserting entomological pin vertically through the thorax. After that, specimen is positioned on the spreading board in such a way that the body is put in a groove between two parallel boards. Stainless steel pins are preferred in order to prevent corrosion. Wings are placed in the adequate position and then fixed with paper strips and pins: hind edge of the forewing should be perpendicular to the groove line.²⁸ Due to the delicate structure of the wing, direct contact with hands is avoided, so entomological forceps and tweezers are used.²⁹

THE EXPERIMENTAL COLLECTION

Before interventions on the damaged *Morpho aega* specimen, tests for used materials and methods were performed on the specimens from the experimental collection. Experimental collection specimens are provided from other private collections, and were discharged due to damages. The experimental collection consisted of the following specimens with identification labels:

1. Specimen No. 1 – *Colias croceus* (Fourcroy, 1785) – missing: large area of inner side of right hindwing, small part of inner down edge of left hindwing and left antenna.
2. Specimen No. 2 – *Vanessa atalanta* (Linnaeus, 1758) – missing: lower half of left hindwing, spreading from inside to lower part of outer edge (inside edge was present) and right antenna.
3. Specimen No. 3 – *Papilio podalirius* (Linnaeus, 1758) – missing: right hindwing extension, minor area along central part of outer edge of right hindwing, left antenna; tear on the right side of left hindwing extension.
4. Specimen No. 4 – *Brenthis daphne* (Denis & Schiffermüller, 1775) – missing: central area of left hindwing outer edge, minor area along upper parts of both hindwings; few tears along outer edges of all four wings.
5. Specimen No. 5 – *Pieris rapae* (Linnaeus, 1758) – missing: tear along left hindwing central part, minor area along upper part of left forewing outer edge.
6. Specimen No. 6 – *Aglais io* (Linnaeus, 1758) – detached antennae and abdomen
7. Specimen No. 7 – *Gonepteryx rhamni* (Linnaeus, 1758) – detached abdomen
8. Specimen No. 8 – *Saturnia pavonia* (Linnaeus, 1758) – missing: part in the corner between inner and outer lower edge of left hindwing, part of left hindwing attached to thorax (nervature present); few small tears along outer edges of all four wings.

OVERVIEW OF MATERIALS USED DURING CONSERVATION AND RESTORATION

Prior to performing tests, the adequate literature was consulted. It concerns preparation procedures, prescribed suggestions regarding conservation and restoration, as well as information from practice.³⁰

28 M. E. Schauff (ed.). *Collecting and preserving of insects and mites. Techniques and Tools*, Systematic Entomology Laboratory, USDA, 1986, 27–37. <https://www.ars.usda.gov/ARSUserFiles/80420580/CollectingandPreservingInsectsandMites/collpres.pdf>. [retrieved 28. 06. 2019].

29 A. K. Walker et al., Chapter 2: “Insects and other invertebrates”, in: *Care and Conservation of Natural History Collections*, eds. Carter, D. et Walker, A. Oxford, 2017, 39–40.

30 See the chapter “Overview of recommendations for conservation and restoration of Lepidoptera specimens from literature and examples from practice”.

All materials used were conservation grade materials. The list of used materials along with their general characteristics is given below:

1. Additional materials:
 - Pergamine paper (archival grade material) – used for keeping Lepidoptera specimens and body parts, and also for fixing wings on spreading board,
 - Hollytex paper (archival grade material) – used as a separator between spreading board and specimen and a base for placing specimens on spreading board during interventions,
 - Blotting paper (archival grade material) – used as a base in relaxing chamber
 - Melinex foil (archival grade material) – used as a base for placing specimens on the spreading board during interventions,
 - Acid-free cardboard (archival grade material) for making storage boxes for specimens,
 - Paper for wrapping cardboard boxes (archival grade material).
2. Restoration materials:
 - Gampi paper, 12 g/m² – for reconstruction of larger missing parts of the wings and abdomen
 - Kozo paper, 6 g/m² – for reconstruction of larger missing parts of the wings, for strengthening minor tear joints without missing parts,
 - Langfaserseidenpapier, 9 g/m² for wing lining.
3. Adhesives:
 - pH neutral Polyvinyl Acetate (PVAc) adhesive – for joining detached and reconstructed missing body parts,
 - starch-based adhesives: wheat and rice starch – for joining reconstructed wing parts with original wings, for joining wing tears.

METHODOLOGY OF LEPIDOPTERA SPECIMENS CONSERVATION AND RESTORATION PROCESS

Based on the given problems it was possible to establish a methodology of conservation and restoration of Lepidoptera specimens. It includes the following steps:

1. Mechanical cleaning of specimens
2. Removal of entomological pins and adhesives from specimens
3. Specimens relaxation
4. Re-pinning and placing specimens on the spreading board
5. Joining existing detached and restored body parts with original body
6. Retouch of the wings
7. Placement in protection storage boxes

Mechanical cleaning of specimens. This process is performed using soft gentle painter brushes, with the purpose of dust removal from specimens, preferably under a stereomicroscope, as augmentation helps in precision (Figure 2a). A special attention should be paid to lightness of brush move since scales, when exposed to higher pressure, can be removed from the wing.

Removal of entomological pins and adhesives from specimens. Old pins were removed from specimens because their composition was unknown. As it was not possible to remove pins mechanically, due to their strong attachment to specimens' bodies, two removal methods were used. The first method involved dripping few ethanol drops on the top connection spot of pin and thorax, then on the bottom connection spot. Although for a majority of samples this was enough for pin removal, there were couple resistant to this method. In this case pins were heated using restoration hot iron with needle ending (Figure 2b). Heat

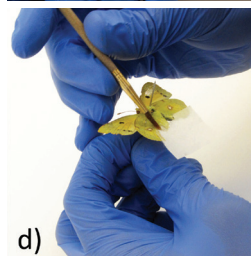


Fig. 2

Fig. 3

from the needle enabled softening of specimens' bodies in touch with it. Special care was taken not to damage wings with hot ending. Some specimens were not pinned but were adhered to basis instead. For adhesive removal hot iron was also applied, by approaching the adhesive from all sides carefully, not to damage wings and body. This enabled adhesive softening and removal of specimen from basis.

Relaxation of specimens. Specimens were exposed to high humidity in the relaxation chamber. Blotting paper was placed on the cork base and moistened using the thymol water solution. A net was put over the blotting paper on which the specimens were placed and covered with a glass bell (Figure 3a). Relaxation took from several hours to couple of days, depending on the stiffness of the specimen.

Re-pinning and placing specimens on spreading board. After relaxation, specimens were re-pinned and then placed on the spreading board where their wings and other body parts were positioned correctly (Figure 3b). Some specimens did not require full relaxation, so they were partially relaxed with steam scalpel, and smaller body segments were corrected. After proper spreading, wings were fixed from the upper side with Hollytex or Pergamin paper strips in order to prevent position change.

Joining existing detached and restored body parts with original body. In this phase joining of existing detached antennas, abdomens and wings was performed (Figure 3c) using pH neutral PVAc adhesive. Missing antennas were reconstructed using fine paint brush hair which was retouched in proper tone that matches the original antenna color. Missing abdomens were reconstructed from Japan paper soaked in PVAc adhesive which was formed to resemble abdomen shape and then retouched. For joining of reconstructed parts with original body PVAc was also used.

Regarding reconstruction of missing parts of the wing, which was actually the main focus of this paper, based on available literature, as well as on insight into delicate wing structure and practical tests, the following types of Japan paper were chosen: gampi (12 g/m²), kozo (6 g/m²) and Langfaserseidenpapier (9 g/m²). Japan paper was cut into shapes of missing wing parts just a couple millimeters wider. It was joined with the original wing using starch adhesive (Figure 3d). After drying, the excess Japan paper was cut out with fine scissors following the contour of undamaged corresponding wing (Figure 4a). For larger missing parts gampi paper was used, while kozo was used for smaller ones. The available literature regarding

adhesives used in entomology gives the following basic requirements: they should be of archival grade, reversible, easy for preparation and usage.³¹ In this work the focus was on the following adhesives that are commonly used in paper conservation (as Japan paper was used for reconstructions of wing parts): starch-based adhesives, algae-based adhesives and cellulose ether adhesives. During practical adhesive testing on the experimental collection specimens it was concluded that the optimal adhesive behavior was shown by the following combination: starch-adhesive-Japan paper. Application of starch adhesive did not excessively moisten wings so no curving deformations occurred on both wing and Japan paper. Further on, used 12g/m² gampi paper showed to be compatible with original wings as, after the joining, it followed existing natural curvature of wings, i.e. it took a shape that resembled a real wing. Regarding algae-based (funori) and cellulose esters adhesives (methyl-cellulose, ethyl-cellulose, Klucel), when compared to starch-based adhesives there were two situations noticed. In one case they wetted wings a lot (both natural and reconstructed parts), so a certain amount of wing bending occurred. In the other case, system wing – adhesive joint – reconstructed part did not visually appear as a whole and had a discontinuity on joint line.³² In the process of choosing the adhesive type that should be applied, both visual criteria and simplicity of manipulation were taken into consideration. Decision to use rice starch adhesive in combination with paper (cellulose) was made according to information found in literature, concerning the link between the starch components percentage composition and better adhesive performances. Namely, two basic starch components are amylose and amylopectin. Amylopectin proved to be better adhesive for cellulose materials, and it is found in greater percent in rice starch compared to wheat starch.³³ All joining processes were performed on spreading board (covered with Hollytex paper or Melinex foil), which served as a backup against possible deformations of various body parts.

Retouching wings. When it comes to retouching the wings, it should be noted that all specimens from the experimental collection possess pigment coloration. The following techniques of retouching were tested: watercolour, gouache and rubbing of dry pigments. Although all three techniques gave satisfying results regarding the colour, the disadvantage of watercolour technique was an excessive wetting of the wings, while the rubbing of dry pigments included application of a certain force that presented a physical threat for the original wing and the reconstruction materials. Gouache technique showed itself as the most suitable – it minimally wetted the basis, and induced virtually no pressure during the application by brush (Figures 4b–4d). During the retouch, specimens were placed on a spreading board.

Placement in protective storage boxes. According to the studied literature, extensive temperature and relative humidity fluctuations and light exposure are unfavorable factors in keeping the natural history collections. The suggestion was made for specimens to be stored in protective boxes with the following characteristics:

- a) boxes should be made of acid-free cardboard,
- b) the bases for pinned specimens should be made of archival grade polyethylene foam, optionally covered with Hollytex paper for aesthetic purposes, and

31 A. R. Deans, A review of adhesives for entomotaxy, *PeerJ Preprints*, 11. 09. 2018, 1. <https://peerj.com/preprints/27184/>. [retrieved 14. 11. 2019].

32 It is likely possible that in both cases adjusting the density of adhesive was to be done. However, since starch-based adhesive gave satisfying results after the first application, this was not further investigated.

33 W. Henry et al. Chapter 23: "Consolidation/Fixing/Facing", in: *Paper Conservation Catalog*. Washington D.C.: American Institute for Conservation Book and Paper Group, 1988, 3. http://cool.conservation-us.org/coolaic/sg/bpg/pcc/23_consolidating-fixing-facing.pdf. [retrieved 17. 11. 2019].

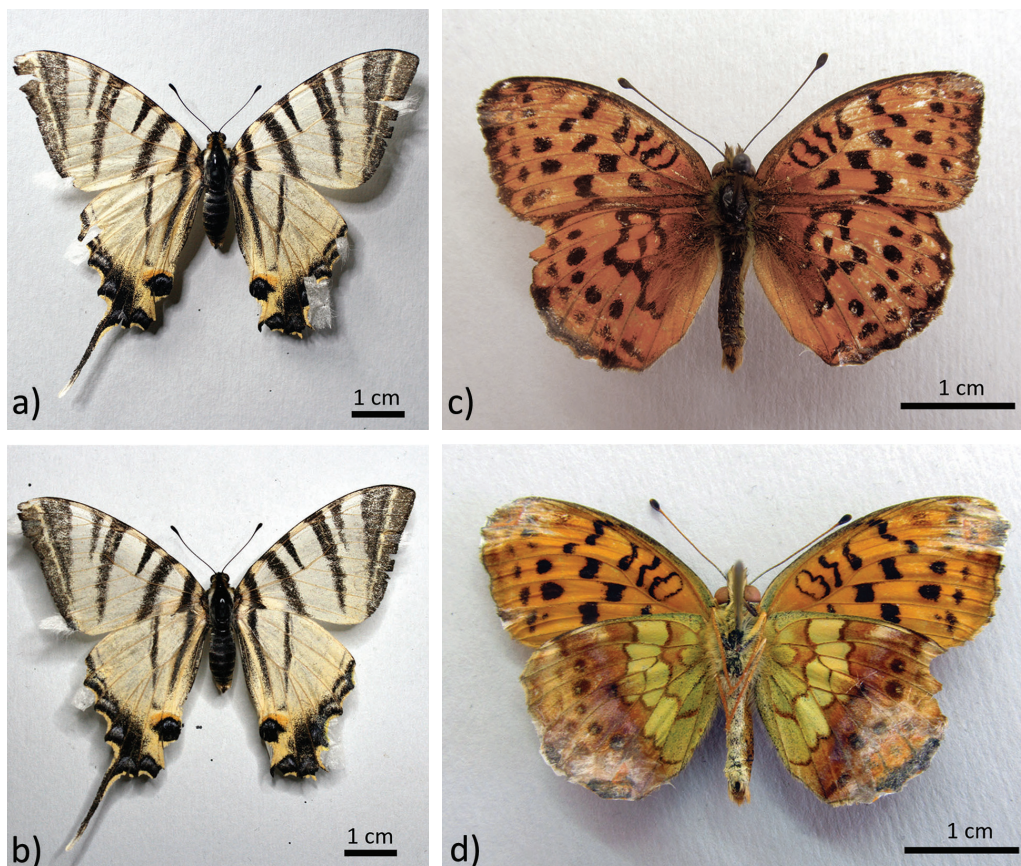


Fig. 4

c) glass on protective boxes should have UV protection.

Regarding the storage conditions, the following parameters should be controlled: temperature, relative humidity and illumination. The recommended temperature range is 18–20°C, but for the spaces where no people are located it should be a bit lower. Relative humidity should be between 40–50%, although it is difficult to obtain such conditions in real environment. If the relative humidity reaches 60–65% there is a possibility of mould growth, while relative humidity lower than 30% can cause shrinkage and brittleness of specimens and adhesives. In order to prevent light caused damages specimens should not be exposed to direct sunlight. Recommended illumination is 50 lux with elimination of ultraviolet radiation sources. Regarding the material for protective boxes, if wood is chosen, it should be kept in mind that some types of wood can release organic acid fumes that can induce entomological pins corrosion.³⁴

³⁴ D. J. Carter and A. K. Walker, "Chapter 7: Collection environment", in: *Care and Conservation of Natural History Collections*, eds. Carter, D. and Walker, A., Oxford, 2017, 144–146.



Fig. 5



Fig. 6

CONSERVATION-RESTORATION INTERVENTIONS ON THE DAMAGED MORPHO AEGA SPECIMEN

After establishing the methodology for conservation and restoration of Lepidoptera specimens, interventions on the damaged *Morpho aega* specimen were performed. The final state analysis showed the following:

1. Specimen No. 1 – *Heliconius besckei* (Ménétriés, 1857); specimen found in good condition with no damages to the body, damaged frame, with crack along whole bottom side of lower glass sheet.
2. Specimen No. 2 – *Morpho achilles* (Linnaeus, 1758); specimen found in good condition, no damages. Previous conservation intervention of joining wing tear with an adhesive was visible. The abdomen was missing. Regarding the position of hindwings, which seemed to be primarily placed without abdomen present, it was not possible to join reconstructed abdomen in its natural position (i.e. not to be highly positioned above the line of thorax). Therefore, it was decided to avoid further intervention regarding this issue, following the principle of minimal intervention. In this way, relaxing was not performed because of potential damages, as the specimen was found in very good condition.
3. Specimen No. 3 – *Morpho aega* (Hübner, 1822); Since the frame in which the specimen was placed fell down, it suffered damages – three wings detached and two of them with small tears along wing edges. One wing was broken into parts. The fourth wing was joined with the body, also with few tears along wing edges (Figure 5). Antennas and abdomen were missing, as well as the scales in few wing areas. Before interventions the wings were stored in Pergamin paper envelopes for safety and further damage prevention.

Considering the fragile condition of the *Morpho aega* wings, it was decided to apply full wing lining – wings were very thin and fragile so any partial strengthening using Japan paper could lead to new tears. Langfaserseidenpapier (9 g/m²) was used for wing lining. It proved to be suitable for adhesive application across all surfaces compared to other tested papers, as it did not deform after adhesive drying. Wings were placed on Langfaserseidenpapier which was fixed on a frame, after which rice starch adhesive was applied on the bottom side of paper. Wings were then gently pressed from the upper side in order to help

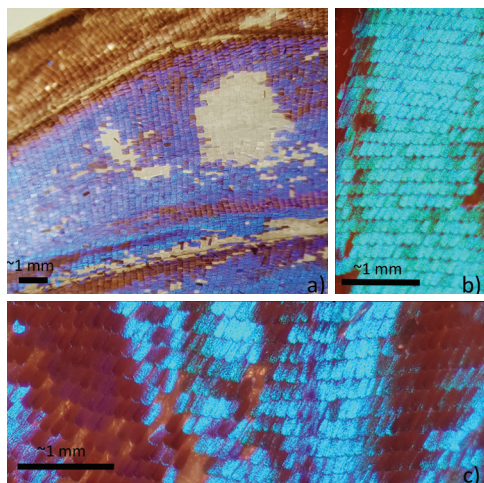


Fig. 7



Fig. 8

full contact of wings and paper (Figure 6). After drying, wing retouch was done. Unlike specimens from the experimental collection, which all have pigment coloration, *Morpho aega* has structural coloration (Figure 7a–7c). Having in mind that such coloration originates from complex interactions of light and nanostructured surfaces, it was questionable whether it was possible to obtain an iridescence effect by retouch, i.e. to achieve the effect of colour change with the change of observation angle. Tests were done with Liquitex iridescent medium in combination with pigments, however they did not yield satisfying results. Cosmetic make-up material showed as a suitable alternative, in a tone that was able to blend in the surrounding colours. After the retouch, wings were cut-out from the frame and joined with the body using PVAc adhesive. Antennas and abdomen were reconstructed in previously described manner,³⁵ and joined with the body using the same adhesive.

All three specimens were pinned prior to placing into new protective storage boxes (Figure 8). The bottoms of storage boxes were covered with Hollytex coated polyethylene foam blocks. UV protective foil was applied on box glass. The following storage conditions were recommended: relative air humidity 40–50%, temperature 18–20°C and illumination of 50 lux.

ILLUSTRATIONS

1: Wing coloration: a) pigment, b) structural

Боја крила: а) пигмент, б) структурна

2: a) Mechanical cleaning, b) Entomological pin removal

а) Механичко чишћење, б) Ентомолошко уклањање чиноде

3: a) Specimen relaxation, b) Placing of specimen on spreading board, c) Abdomen joining, d) Reconstruction of missing wing part

а) Опуштање узорка, б) Постављање узорка на даску за ширење, ц) Спајање трбуха, д) Реконструкција недостајућег дела крила

4: Wing reconstruction and retouch: a) *Papilio podalirius* (front side) reconstruction, b) *Papilio podalirius* (front side), retouch, c) *Brenthis daphne* (front side) retouch, d) *Brenthis daphne* (back side), retouch

³⁵ See the chapter “Methodology of Lepidoptera specimens conservation and restoration process”

Реконструкција и ретуш крила: а) *Papilio podalirius* (предња страна) реконструкција, б) *Papilio podalirius* (предња страна), ретуш, в) *Brenthis daphne* (предња страна) ретуш, д) *Brenthis daphne* (задња страна), ретуш

5: *Morpho aega* specimen, found state

Примерак *Morpho aega*, затечено стање

6: *Morpho aega* specimen, lining and retouch

Примерак *Morpho aega*, облагање и ретуширање

7: Enlarged images of wing scales representing iridescence

Увећане слике крилних љусака које представљају иридесценцију

8: *Morpho aega* specimen in new protective box

Примерак *Morpho aega* у новој заштитној кутији

LITERATURE

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КОНЗЕРВАЦИЈА И РЕСТАУРАЦИЈА ПРИМЕРКА ЛЕПТИРА ИЗ ПРИВАТНЕ ЗБИРКЕ

Резиме: У овом раду, чија је примарна сврха конзервација и рестаурација оштећеног примерка лептира *Morpho aega* из приватне колекције, дат је предлог основне методологије конзервације и рестаурације колекција лептира. Главно усмерење је било на конзервацији и рестаурацији крила. Примерак *Morpho aega* лептира оштећен је услед пада рама у коме се налазио. Три крила су била одвојена, од којих се једно поломило, а антене и абдомен су недостајали. Пре него што се приступило конзерваторско-рестаураторским интервенцијама, сви материјали и методе су испитани на експерименталној збирци. То је омогућило развијање методе конзервације и рестаурације, која је подељена на следеће кораке: механичко чишћење примерака, уклањање ентомолошких игала и адхезива са примерака, релаксација примерака, поновно стављање ентомолошких игала и постављање примерака на разапињач, спајање постојећих и рестаурација недостајућих делова тела са оригиналним телом примерка, ретуш крила и смештање у заштитне кутије. Посебан изазов представљао је ретуш крила *Morpho aega* услед присуства структурне обојености. Имајући у виду да ова врста обојења потиче од сложене интеракције светла и наноструктурираног материјала, ретуш крила само делимично опонаша ефекат иридесценције, која је карактеристична за структурну обојеност. Тон за ретуш одбаран је тако да се тапа са околним тоновима присутним на крилу. Како би се одговарајуће чували, примерци су смештени у нове заштитне кутије, уз дате препоруке о условима чувања, који укључују избегавање промена влажности и температуре ваздуха, као и излагања директном светлу.

Кључне речи: Lepidoptera, конзервација, рестаурација, инсекти