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A Comparative Study of the Alimentary Canal in Butterflies, with Special Reference to Their Systematic Relationships¹⁾

By

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(With 60 Text-figures)

I. Introduction

So far as the writer is aware, the morphological works on the alimentary canal in butterflies have been published rather scantily, compared with those in other groups of insects. In butterflies, Bordas (1920), Dauberschmidt (1933), Dobkiewicz (1933) and others studied on the comparative morphology of the organ, and above all the work by Dauberschmidt has been valuable to his followers. The comparative morphology of the internal structures of butterflies may possibly give some suggestions on the taxonomy of this group, based mainly on the external characters; wing veins, colour patterns, palpi, antennae, legs and genitalia. From this viewpoint the present writer undertook the comparative study of the alimentary canal of butterflies, taking their taxonomic relationships into his consideration. In the present study the writer took up the following characters; mesenteron, anterior intestine, rectum and Malpighian tubules, and among them a special attention has been paid to the characters of the mesenteron, which were observed by him to be valuable among different groups.

Before going further, the writer must express his cordial thanks to Professor Tohru Uchida for his kind guidance and encouragement. The writer is also indebted to Messrs. Shôichi F. Sakagami, Shôzô Ehara and other gentlemen for their continued interest and many useful suggestions upon the study.

II. Material and method

The specimens used were collected by the writer throughout Hokkaido, except those of *Erynnis montanus*, *Choaspes benjaminii*, *Papilio protenor nymphis*,

1) Contribution No. 322 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan.

Jour. Fac. Sci., Hokkaido Univ., Ser. VI, Zool., 12, 1954.

P. memnon thunbergii, *P. helenus niconiccolens*, *Eurema hecabe mariesi*, *E. laeta bethesba*, *Curetis acuta paracuta*, *Arhopala japonica* and *Niphanda fusca shijima* which were collected in Honshû by his friends.

The species examined include the following fifty-seven species belonging to six families¹⁾:

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| Fam. Hesperidae | Motschulsky |
| Subfam. Pyrginae | Trib. Pierini |
| 1. <i>Erynnis montanus</i> (Bremer) | 21. <i>Pieris rapae crucivora</i> |
| Subfam. Rhopalocampinae | Boisduval |
| 2. <i>Choaspes benjaminii</i> (Guérin) | 22. <i>P. melete aglaope</i> Motschulsky |
| 3. <i>Bibasis aquilina</i> (Speyer) | 23. <i>Aporia crataegi adherbal</i> |
| Subfam. Hesperinae | Fruhstorfer |
| 4. <i>Ochlodes venata</i> (Bremer et Grey) | Fam. Lycaenidae |
| 5. <i>O. ochracea rikuchina</i> (Bremer) | Subfam. Curetinae |
| 6. <i>Halpe varia obscura</i> Nakahara | 24. <i>Curetis acuta paracuta</i> de Nicéville |
| 7. <i>Parnara guttata</i> (Bremer et Grey) | Subfam. Amblypodinae |
| Fam. Papilionidae | 25. <i>Arhopala japonica</i> (Murray) |
| Subfam. Zerynthiinae | Subfam. Lycaeninae |
| 8. <i>Lühdorfia puziloi yessoensis</i> Rothschild | Trib. Theclini |
| Subfam. Parnassinae | 26. <i>rtopoëtes pryrei yezoensis</i> Nakahara |
| 9. <i>Parnassius stubbendorfi hoenei</i> Schweitzer | Trib. Strymonini |
| 10. <i>P. glacialis glacialis</i> Butler | 27. <i>Strymon w-album fentoni</i> (Butler) |
| 11. <i>P. eversmanni daisetsuzana</i> Matsumura | Trib. Lycaenini |
| Subfam. Papilioninae | 28. <i>Lycaena phlueas daimio</i> (Seitz) |
| 12. <i>Papilio machaon hippocratides</i> Verity | Su fam. Plebejinae |
| 13. <i>P. protenor nymphis</i> Fruhstorfer | Trib. Castaliini |
| 14. <i>P. memnon thunbergii</i> von Siebold | 29. <i>Taraka hamada hamada</i> (Druce) |
| 15. <i>P. helenus niconiccolens</i> Butler | Trib. Lampidini |
| 16. <i>P. bianor japonicus</i> Butler | 30. <i>Niphanda fusca shijima</i> Fruhstorfer |
| 17. <i>P. maackii jezoensis</i> Matsumura | Trib. Glaucopsychini |
| Fam. Pieridae | 31. <i>Glaucopsyche lycormas lycormas</i> (Butler) |
| Subfam. Pierinae | Fam. Nymphalidae |
| Trib. Coliadini | Subfam. Argynninae |
| 18. <i>Eurema hecabe mariesi</i> (Butler) | 32. <i>Boloria thore jezoensis</i> Matsumura |
| 19. <i>E. laeta bethesba</i> (Janson) | 33. <i>B. freija asahidakeana</i> (Matsumura) |
| 20. <i>Colias hyale poliographus</i> | 34. <i>Brenthis ino mashuensis</i> (Kono) |
| | 35. <i>Argynnis paphia geisha</i> |

1) The classification applied in this paper is based on the system of Esaki and Shirôzu (1951).

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| <p>Hemming</p> <p>36. <i>A. churlotta basalis</i> Matsumura</p> <p>37. <i>A. laodice japonica</i> Ménétériès</p> <p>38. <i>A. ruslana</i> Motschulsky</p> <p>Subfam. Limenitinae</p> <p>39. <i>Limenitis camilla japonica</i> Ménétériès</p> <p>40. <i>Neptis coenobita aino</i> Shirôzu</p> <p>Subfam. Nymphalinae</p> <p>41. <i>Araschnia levana levana</i> (Linné)</p> <p>42. <i>A. burejana strigosa</i> Butler</p> <p>43. <i>Polygonia c-aureum c-aureum</i> Linné</p> <p>44. <i>P. c-album hamigera</i> (Butler)</p> <p>45. <i>P. l-album samurai</i> Fruhstorfer</p> <p>46. <i>Nymphalis io geisha</i> (Stichel)</p> <p>47. <i>Aglais urticae connexa</i> (Butler)</p> | <p>48. <i>Vanessa indica</i> (Herbst)</p> <p>Subfam. Apaturinae</p> <p>49. <i>Apatura ilia substituta</i> Butler</p> <p>50. <i>Sasakia charonda charonda</i> (Hewitson)</p> <p>Fam. Satyridae</p> <p>51. <i>Ypthima argus argus</i> Butler</p> <p>52. <i>Erebia niphonica doii</i> Nakahara</p> <p>53. <i>E. ligea rishirizana</i> Matsumura</p> <p>54. <i>Oeneis daisetsuzana</i> Matsumura</p> <p>55. <i>Lethe callipteris diluta</i> Esaki et Nakahara</p> <p>56. <i>Aranda schrenckii menalcas</i> Fruhstorfer</p> <p>57. <i>Neope goschkevitschii</i> goschkevitschii (Ménétériès)</p> |
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The entire body, without dissected, was fixed and preserved in about 75% alcohol. In the present study, males were employed in all cases, with a few exceptions in which females were used.

III. Observations

The alimentary canal of butterflies is of a tubular form, being straight in some species or looped in others. The canal is distinctly divided into a stomodaeum, a mesenteron and a proctodaeum. The wall of the mesenteron is relatively thick and the walls of the other two sections are thin and generally transparent. Two circular valve-like folds separate the three sections, one between the stomodaeum and mesenteron is stomodaeal valve, the other between the mesenteron and proctodaeum is proctodaeal valve. In some species, the anterior part of the mesenteron surrounding the stomodaeal valve is distinguished as the cardia (Figs. 1, 10, 11, etc.). The stomodaeum is divided into the three regions; the pharynx, the oesophagus and the crop. The proventriculus is reduced to a slightly dilated tube. The crop is a large food reservoir, which is connected with the stomodaeum by a short narrow duct. The mesenteron, which is called sometimes stomach, is of a somewhat flat tube or elongate sac of relatively small capacity and nearly uniform diameter, and in some species differentiated into two regions. The mesenteron is generally provided with many circular folds on its surface, and in some species, furnished with numerous processes on the surface of the anterior part, though variable in shape among species. The mesenteron seems to be of a remarkable specific characters, though sometimes slightly variable partially among individuals in its externals. The proctodaeum is divided into an anterior intestine, which is looped upon itself in most cases, and a rectum. The two regions are separated externally by a constriction. The rectum is dilated anteriorly into a rectal sac,

and narrows posteriorly to form a rectal proper which is represented by a straight tube and reaches directly the anus. Generally the anterior intestine opens into the rectum on the side of rectal sac, the anterior region of which forms a diverticulum, a rectal caecum, sometimes tinted yellow for its contents. The epithelium of rectal sac, and in a few cases, also that of the rectal caecum, forms

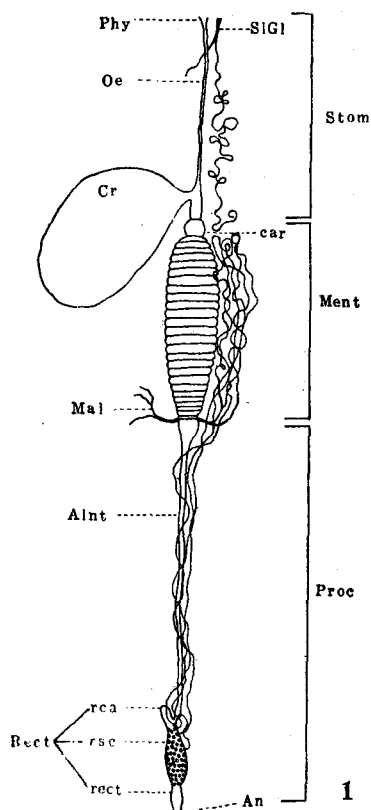


Fig. 1. *Parnassius stubbendorfi hoenei* Schweitzer. Stom, stomodaeum; Ment, mesenteron; Proc, proctodaeum; Phy, pharynx; Oe, oesophagus; Cr, crop; Car, cardia; SlG1, salivary gland; Mal, Malpighian tubules; Alnt, anterior intestine; An, anus; Rect, rectum (rect, rectum proper; rsc, rectal sac; rca; rectal caecum).

numerous conspicuous structures known as the rectal papillae. The chief outgrowth of the alimentary canal forms a pair of Malpighian tubules. On either side, the tubule is generally divided into three branches at a common point, or, in other species, successively at two points of a distance, as shown in Fig. 8. A type of the alimentary canal of butterflies is shown in Fig. 1.

In this study, the mesenteron attracted the writer's attention, as already mentioned. The following characters were observed in the alimentary canal of males, but, so far as the writer observed, in most species, the sexual difference in the externals of the canal is not ascertained. The technical terms used in this paper are mainly based on those of Snodgrass (1935).

Fam. HESPERIIDAE

1) *Erynnis montanus* (Bremer) (Fig. 2)

Specimens examined: 5 males.

The mesenteron is somewhat flat and straight tube, on the surface of which many circular folds appear, and the folds are bordered with narrow grooves. The anterior part of the mesenteron is slightly wider than the posterior part of that. The anterior intestine is approximately 2-3 times as long as the mesenteron. The rectal caecum is moderately developed, without papillae. The Malpighian tubule is divided into three branches successively at two close points.

2) *Chaspedes benjaminii* (Guérin) (Fig. 3)

Specimens examined: 5 males.

The mesenteron bearing many circular folds all over the surface widens gradually towards the anterior end, and slightly winds

upon itself. The anterior intestine is about 3-4 times as long as the mesenteron. The rectal caecum is moderately developed, without papillae. The Malpighian tubule is divided into three branches successively at two points of a distance.

3) *Bibasis aquilina* (Speyer) (Fig. 4)

Specimens examined: 5 males and 1 female.

The externals of the alimentary canal are closely similar to those of *Choaspes benjamini*. As far as the writer observed, it seems impossible to find the difference between the two species.

4) *Ochlodes venata* (Bremer et Grey) (Fig. 5)

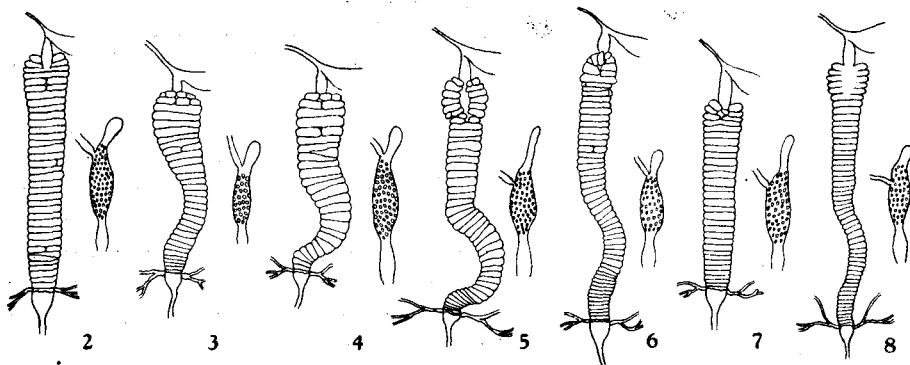
Specimens examined: 5 males and 1 female.

The mesenteron furnished with many circular folds all over the surface is somewhat flat and pretty long, and slightly winds upon itself. The anterior part of the mesenteron somewhat swells laterally. The anterior intestine is about 2-3 times as long as the mesenteron. The rectal caecum, without papillae, is moderately developed and pretty long. The Malpighian tubule is divided into three branches successively at two points in the distance.

5) *O. ochracea rikuchina* (Bremer) (Fig. 6)

Specimens examined: 5 males and 1 female.

The externals of the alimentary canal are closely allied to those of *O. venata*, but the rectal caecum of this species seems not so elongate as that of *O. venata*.



Figs. 2-8.

6) *Halpe varia obscura* Nakahara (Fig. 7)

Specimens examined: 5 males.

The externals of the canal closely resemble those of *Erynnis montanus* and *Augiades comma* which was illustrated by Dauberschmidt (1933), and it seems difficult to catch the difference among these species.

7) *Parnara guttata* (Bremer et Grey) (Fig. 8)

Specimens examined : 10 males.

The mesenteron with numerous circular folds on its surface is pretty long and comparatively flat, and slightly winds upon itself. The anterior part of the mesenteron is somewhat swelled out laterally. The anterior intestine is about twice as long as the mesenteron. The rectal caecum is moderately developed, without papillae. The Malpighian tubule is divided into three branches successively at two points in the distance.

Fam. PAPILIONIDAE

8) *Lühdorfia puziloi yessoensis* Rothschild (Fig. 9)

Specimens examined : 2 females.

The mesenteron forms a somewhat flat tube and the anterior half part of it is provided with the circular folds and is, more or less, wider than the posterior half part with no fold. The cardia is naked only in the apical part, and separated from the stomodaeum by a constriction. The anterior intestine is approximately 1.5–2 times as long as the mesenteron. The rectal caecum, without papillae, is moderately developed. The Malpighian tubule is divided into three branches successively at two points of a distance. The external characters of the alimentary canal of this species are closely related to those of the species belonging to the genus *Parnassius*, but easily distinguished from the latter by the absence of the circular folds on the posterior half part of the mesenteron.

9) *Parnassius stubbendorfii hoenei* Schweitzer (Fig. 10)

Specimens examined : 20 males and 5 females.

The mesenteron is of a somewhat flat tube, the apical and caudal part of it are narrower in width than the mid-part of it, with relatively clear circular folds all over the surface. The cardia is bare. The anterior intestine is approximately twice as long as the mesenteron. The rectal caecum, without papillae, is moderately developed. The Malpighian tubule is divided into three branches successively at two points of a distance. The external characters of the alimentary canal are almost identical with those of *P. glacialis glacialis* and *P. evermanni daisetsuzana*.

10) *P. glacialis glacialis* Butler (Fig. 11)

Specimens examined : 20 males and 2 females.

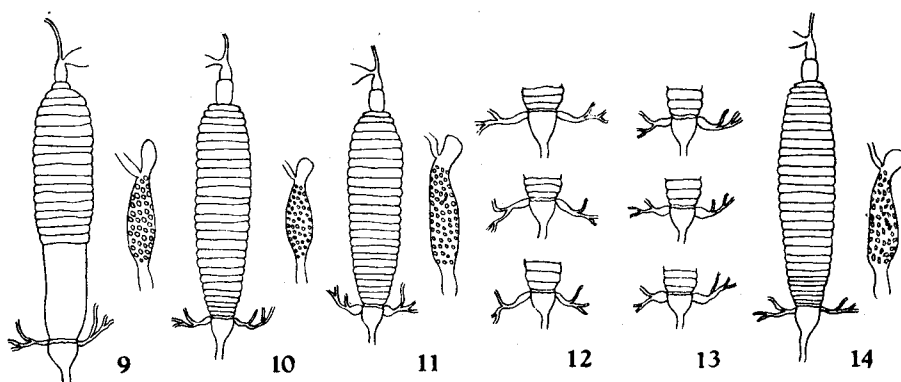
The external characters of the alimentary canal of this species are similar to those of *P. stubbendorfii hoenei* and *P. evermanni daisetsuzana*, but differ from the latter in the following respect. In this species, the opening part of the Malpighian tubule into the alimentary canal considerably swells, except a few specimens, while that of the latter slightly swells or not at all (Figs. 12, 13).

11) *P. evermanni daisetsuzana* Matsumura (Fig. 14)

Specimens examined : 5 males.

The external characters of the alimentary canal of this species are very similar to those of *P. stubbendorfii hoenei* and *P. glacialis glacialis*, but separable from the latter in the following points. So far as the writer observed, a rectal

papilla in this species is generally somewhat longer and more irregular in shape than that of the latters. The external characters of the alimentary canal of *Parnassius mnemosyne*, as illustrated by Bordas (1920), are considerably different from those of the species belonging to *Parnassius* distributed in Japan in the following respects. In *P. mnemosyne* the cardia is not separated from the mesenteron by a constriction, and the dilated rectal caecum, which possesses a number of rectal papillae all over the surface, is almost as large as the rectal sac, while in Japanese *Parnassius* the cardia is clearly separated from the mesenteron by a constriction, and the rectal caecum, without papillae, is pretty smaller than the rectal sac.



Figs. 9-14.

12) *Papilio machaon hippocratides* Verity (Fig. 15)

Specimens examined : 5 males.

The mesenteron is somewhat tube-like, with a median groove on the dorsal side and the anterior half part is somewhat wider than the posterior half part. The mesenteron is provided with the numerous circular folds all over the surface. On the surface of the cardia no median groove appears. The anterior intestine is about 5-6 times as long as the mesenteron. The rectal caecum is moderately developed, without papillae. The Malpighian tubule is generally divided into three branches at a common point. The external characters of the canal are extremely similar to those of *P. bianor japonicus* and *P. maackii jezoensis*, but differ from the latters in the appearance of the median groove on the dorsal side of the mesenteron.

13) *P. protenor nymphis* Fruhstorfer (Fig. 16)

Specimens examined : 5 males.

The externals of the alimentary canal are closely similar to those of *P. machaon hippocratides*, but differs from the latter in the absence of the median groove on the dorsal side of the mesenteron.

14) *P. memnon thunbergii* von Siebold (Fig. 17)

Specimens examined : 5 males.

Some of the folds on the mesenteron are sometimes constricted into some portions, as in the folds of *P. protenor nymphis*. As far as the writer has observed, the externals of the canal of this species are closely similar to those of *P. protenor nymphis* and *P. helenus niconiccolens*, and it seems impossible to find the difference among these three species.

15) *P. helenus niconiccolens* Butler (Fig. 18)

Specimens examined : 5 males.

The externals of the canal are greatly similar to those of *P. protenor nymphis* and *P. memnon thunbergii*, as already described.

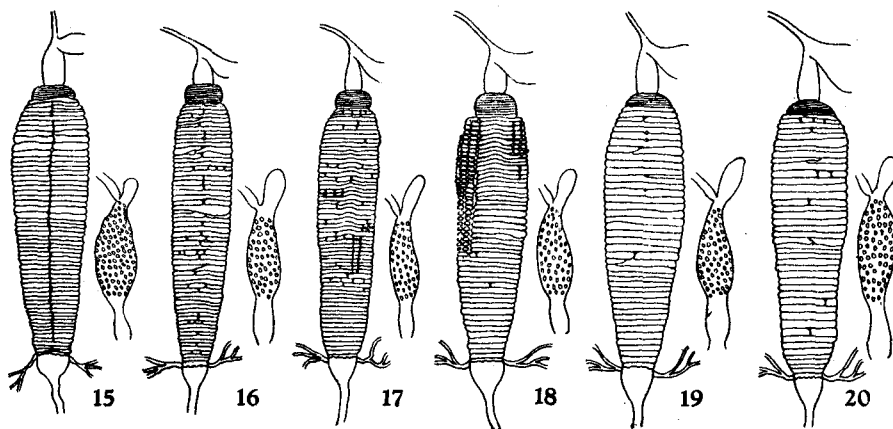
16) *P. bianor japonicus* Butler (Fig. 19)

Specimens examined : 5 males.

The externals of the canal are very similar to those of *P. maackii jezoensis*, and as far as the writer observed, it seems impossible to find the difference between the two species. The externals of the canal of the summer brood, *P. bianor dehaanii*, seem to be identical with those of this form.

17) *P. maackii jezoensis* Matsumura (Fig. 20)

The externals of the canal closely resemble those of *P. bianor japonicus*, as already described.



Figs. 15 - 20.

Fam. PIERIDAE

18) *Eurema hecabe mariesi* (Butler) (Fig. 21)

Specimens examined : 5 males.

The mesenteron is elongate, slightly flat and straight, the folds of which could hardly be observable. The cardia is bare and of a spindle-shaped, separated

from the stomodaeum by a constriction. The anterior intestine is about 3 times as long as the mesenteron. The rectal caecum is moderately developed, without papillae. The Malpighian tubule is divided into three branches at a common point close to its opening part. The externals of the canal of the autumn brood, *E. hecabe connexiva*, seem to be identical with those of this form. The externals of the canal are similar to those of species belonging to the other genera of *Pieridae* studied by the writer.

19) *E. laeta bethesba* (Janson) (Fig. 22)

Specimens examined : 5 males.

The externals of the canal are closely similar to those of *E. hecabe mariesi*, but as far as the writer observed, the two species are separated in the following points. In *E. laeta bethesba*, the rectal caecum is well developed and the anterior intestine is about 2 times as long as the mesenteron, but in *E. hecabe mariesi*, the rectal caecum is not so developed as that of the former and the anterior intestine is approximately 3 times as long as the mesenteron.

20) *Colias hyale poliographus* Motschulsky (Fig. 23)

Specimens examined : 10 males and 2 females.

The mesenteron is comparatively elongate, slightly flat and straight, the folds of which are frequently constricted into some portions. The cardia is bare and separated from the stomodaeum by a constriction. The anterior intestine is almost as long as the mesenteron. The rectal caecum is moderately developed, without papillae, while according to Bordas (1920), in *C. hyale*, the papillae are scattered all over the surface of the rectum. The Malpighian tubule is divided into three branches at a junction point, and the tubule fairly swells at the opening part as well as that of *C. hyale*.

21) *Pieris rapae crucivora* Boisduval (Fig. 24)

Specimens examined : 10 males and 2 females.

The mesenteron is pretty elongate and somewhat flat, and in many cases, bearing a number of circular folds on the surface of the mid-part. The cardia is naked and of a spindle-shaped. The anterior intestine is about 1.5 times as long as the mesenteron. The rectal caecum is moderately developed, without papillae. According to Dauberschmidt (1933), in *P. brassicae*, the greater part of the rectum is occupied by the extremely dilated rectal caecum, while the rectal sac and the rectum proper are united together and form a narrow tube. The rectal papillae of this species are 30–40 in number, but according to Bordas (1911, after Palm (1952)), the rectal papillae of the species of the *Pieridae* are 80–140 in number. The Malpighian tubule is divided into three branches at a common point. The externals of the canal of this species resemble those of *P. melete aglaope*.

22) *P. melete aglaope* Motschulsky (Fig. 25)

Specimens examined : 5 males.

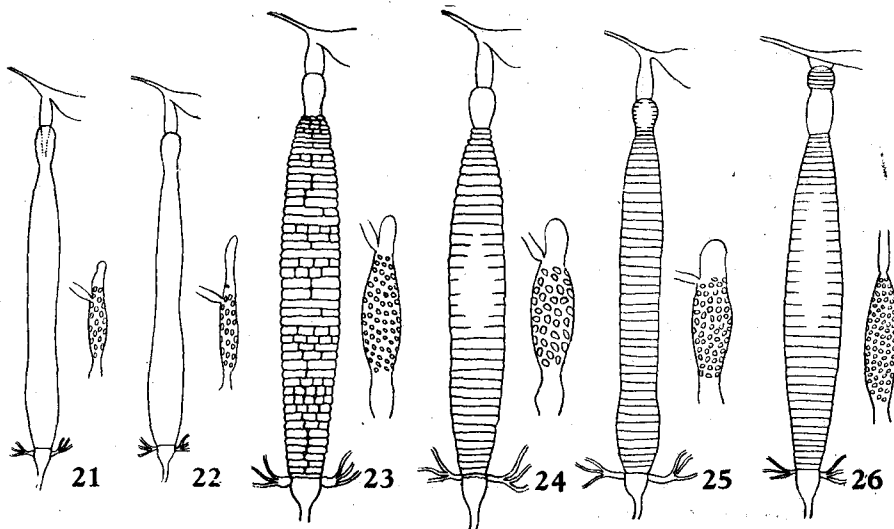
The externals of the canal are similar to those of *P. rapae crucivora*, but differ from the latter in the following points. The canal of this species provided

with the slight circular folds on the surface of the cardia, while in *P. rapae crucivora* no folds are observable on the cardia. The rectal papillae of this species are more distinctly and more in number than those of *P. rapae crucivora*.

23) *Aporia crataegi adherbal* Fruhstorfer (Fig. 26)

Specimens examined: 5 males.

The mesenteron is peculiar in the form, elongate, spindle-shaped and slightly flat, and the folds on the surface are comparatively clear. Close to the apical end of the mesenteron the region without folds is present. The cardia is bare and connected directly with the opening part of the crop into the oesophagus. The anterior intestine is approximately 2.5 times as long as the mesenteron. The rectal caecum is undifferentiated, but according to Bordas (1920), *A. crataegi* is provided with a well developed rectal caecum.



Figs. 21 - 26.

Fam. LYCAENIDAE

24) *Curetis acuta paracuta* de Nicéville (Fig. 27)

Specimens examined: 5 males.

The mesenteron is represented by an elongate spindle-shaped and slightly flat tube, without folds on the surface. The cardia is relatively clear. The anterior intestine is about 2.5-3 times as long as the mesenteron. The Malpighian tubule is divided into three branches at a common point close to its opening part. The rectal caecum is undifferentiated.

25) *Arhopara japonica* (Murray) (Fig. 28)

Specimens examined : 5 males.

The mesenteron is formed by an elongate spindle-shaped and slightly flat tube, and bears some folds in the anterior region. The cardia is naked. The anterior intestine is about twice as long as the mesenteron. The rectal caecum is moderately developed, without papillae. The Malpighian tubule is divided into three branches at a common point.

26) *Artopoëtes pryeri yessoensis* Nakahara (Fig. 29)

Specimens examined : 5 males.

The mesenteron, without the folds, is somewhat flat and elongate in form, provided with a slight constriction near the caudal end. The cardia is not distinguished. The anterior intestine is almost same as long as the mesenteron. The rectal caecum is moderately developed, without papillae. The Malpighian tubule is divided into three branches successively at two points of a distance.

27) *Strymon w-album fentoni* (Butler) (Fig. 30)

Specimens examined : 5 males.

The mesenteron is somewhat flat and elongate spindle-shaped tube, provided with the folds on the surface except the anterior part. The anterior intestine is about twice as long as the mesenteron. The rectal caecum is undifferentiated. The Malpighian tubule is divided into three branches successively at two points of a distance.

28) *Lycaena phlaeas daimio* (Seitz) (Fig. 31)

Specimens examined : 5 males.

The mesenteron is represented by a somewhat flat and elongate spindle-shaped tube, and some individuals are provided with the folds on both the anterior and posterior part. The cardia is not so clear. The anterior intestine is about 1.5 times as long as the mesenteron. The rectal caecum is moderately developed, without papillae. The Malpighian tubule is divided into three branches successively at two close points.

29) *Taraka hamada hamada* (Druce) (Fig. 32)

Specimens examined : 5 males.

The mesenteron, without folds, is formed of spindle-shaped and somewhat flat tube. The cardia is slightly distinguished. The anterior intestine is about 3 times as long as the mesenteron. The rectal caecum is not differentiated. The Malpighian tubule is divided into three branches at a common point. The opening part of the crop into the oesophagus is peculiar in its position being in the distance from the apical end of the mesenteron.

30) *Niphanda fusca shijima* Fruhstorfer (Fig. 33)

Specimens examined : 5 males.

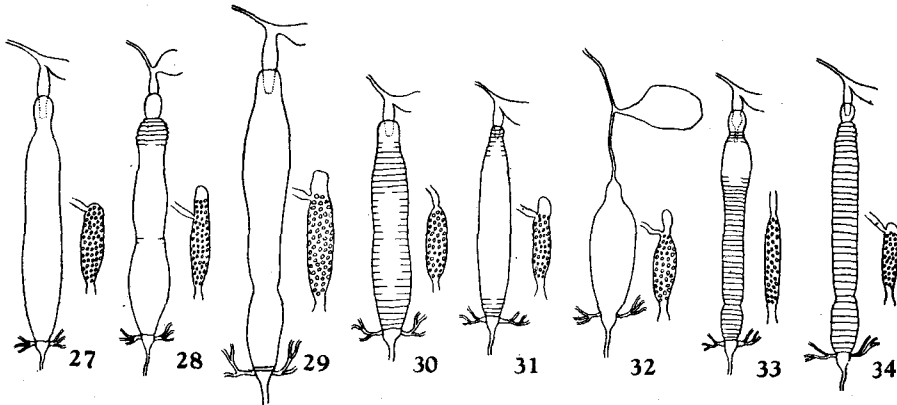
The mesenteron is of a somewhat flat and elongate tube, provided with the folds on the surface except the anterior part swelling slightly, and forms a slight constriction near the caudal end. The cardia is clear. The anterior intestine approximately 1.2-2 times as long as the mesenteron. The rectal caecum is not

differentiated. The Malpighian tubule is divided into three branches successively at two close points.

31) *Glaucopsyche lycormas lycormas* (Butler) (Fig. 34)

Specimens examined : 5 males.

The mesenteron is made of a somewhat flat and elongate tube, provided with the folds all over the surface, and forms a slight constriction near the caudal end. The cardia is naked. The anterior intestine is about 1-2 times as long as the mesenteron. The rectal caecum, without papillae, appears slightly. The Malpighian tubule is divided into three branches successively at two close points.



Figs. 27 - 34.

Fam. NYMPHALIDAE

32) *Boloria thore jezoensis* Matsumura (Fig. 35)

Specimens examined : 5 males.

The mesenteron, of a slightly flat and elongate form, widens gradually towards the apical end. In general, each fold on the surface of the mesenteron except the posterior one-third part is constricted into many processes. The cardia is not naked. The anterior intestine is about 1.5 times as long as the mesenteron. The rectal caecum, without papillae, is moderately developed. The Malpighian tubule is divided into three branches successively at two close points.

33) *B. frejia asahidakeana* (Matsumura) (Fig. 36)

Specimens examined : 5 males.

The externals of the canal are almost identical with those of *B. thore jezoensis*, and as far as the writer observed, no difference between the two species is to be caught.

34) *Brenthis ino mashuensis* (Kono) (Fig. 37)

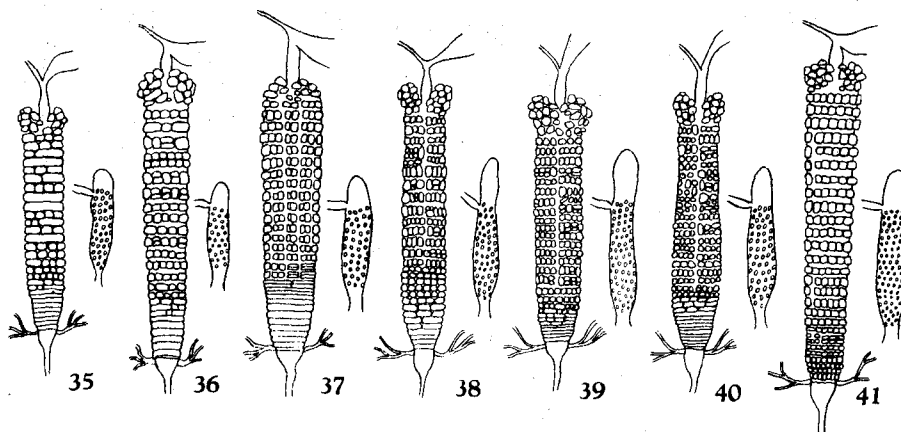
Specimens examined : 5 males.

In the mesenteron many small processes derived from the folds are to be found except the posterior about one-third part of that. The externals of the canal are closely similar to those of *Boloria thore jezoensis* and *B. freija asahidakeana*, but the processes in the mesenteron of this species are generally smaller than those of the latters.

35) *Argynnis paphia geisha* Hemming (Fig. 38)

Specimens examined : 5 males.

The mesenteron, of a slightly flat and elongate form, is provided on the apical part with the lateral distentions bearing many processes, and each fold on the surface of that except the posterior part is constricted into many processes. On the anterior region of the surface of the mesenteron the median groove is to be seen on the dorsal side. The cardia is not naked. The anterior intestine is about 1.5–2 times as long as the mesenteron. The rectal caecum, without papillae, exceedingly developed. The Malpighian tubule is divided into three branches successively at two points of a distance. The externals of the canal resemble those of the other species belonging to the genus *Argynnis* studied by the writer.



Figs. 35–41.

36 & 37) *A. charlotta basalis* Matsumura (Fig. 39); *A. laodice japonica* Ménétériès (Fig. 40)

Specimens examined : Both 5 males.

The external characters of the alimentary canal in those two species closely resemble each other, and as far as the writer observed, no difference between the two species is to be caught. And then the externals of the canal in these species are almost identical with those of *A. paphia geisha*.

38) *A. rulsana* Motschulsky (Fig. 41)

Specimens examined : 5 males.

The externals of the canal are similar to those of *Boloria freija asahidakeana*,

but each section of the canal in this species is larger in size as well as in the body length than the latter.

39) *Limenitis camilla japonica* Ménétrières (Fig. 42)

Specimens examined: 5 males.

The mesenteron, of a slightly flat and elongate form, is provided on the apical part with two lateral semicircular distentions bearing many processes closely arranged, and each one of the folds all over the surface of that except the posterior part is constricted into numerous processes. On the surface of the mesenteron except the posterior part the median groove is to be seen in the dorsal side. The cardia is not naked. The anterior intestine is almost twice as long as the mesenteron. The rectal caecum is undifferentiated. The Malpighian tubule is divided into three branches at a common point.

40) *Neptis coenobita aino* Shirôzu¹⁾ (Fig. 43)

Specimens examined: 5 males.

The externals of the canal are highly allied to those of *Limenitis camilla japonica*, but the lateral semicircular distentions of the mesenteron in this species are provided with the folds, 7-8 in number.

41) *Araschnia levana levana* (Linné) (Fig. 44)

Specimens examined: 5 males.

The mesenteron is of somewhat flat tube in form, provided with the folds all over the surface, some of which are constricted into a few portions. Generally the anterior part of the mesenteron forms the lateral distentions. In some individuals there occurs the median groove along the dorsal surface of the anterior half part of the mesenteron. The anterior intestine is about 2-4 times as long as the mesenteron. The rectal caecum, without papillae, is moderately developed. The Malpighian tubule is divided into three branches successively at two points of a distance.

42) *A. burejana strigosa* Butler (Fig. 45)

Specimens examined: 5 males.

The external characters of the canal are almost identical with those of *A. levana levana*, and as far as the writer observed no difference between the two species is to be caught.

43) *Polygonia c-aureum c-aureum* Linné (Fig. 46)

Specimens examined: 5 males.

The mesenteron is divided into two regions, the anterior one of which occupies about two-thirds the surface of that, and the posterior one forms folds, some of which are constricted into a few portions. In the anterior region few masses of the processes are arranged longitudinally in two rows. The mesenteron is provided in the apical part with two lateral semicircular distentions bearing many processes. The cardia is concealed. The anterior intestine is about 2-2.5

1) Scientific name is according to Shirôzu (1952).

times as long as the mesenteron. The rectal caecum seems to be not differentiated. The Malpighian tubule is divided into three branches at a common point.

44) *P. c-album hamigera* (Butler) (Fig. 47)

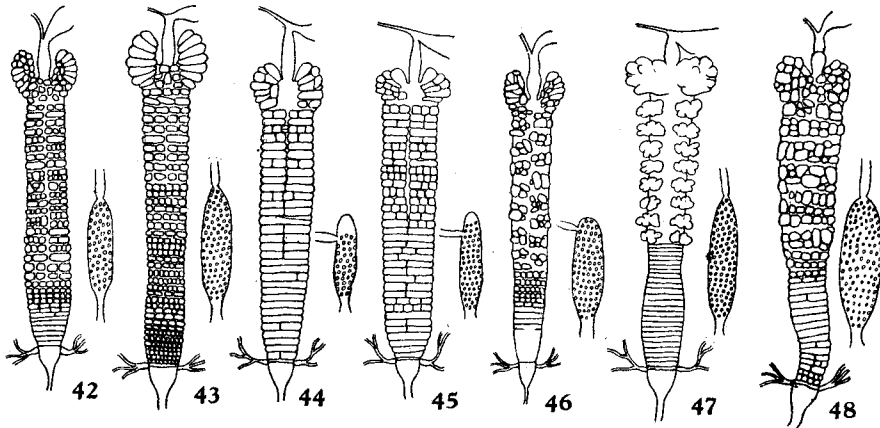
Specimens examined : 5 males.

The mesenteron is divided into two regions, the anterior one of which occupies about two-thirds the surface of that, and the posterior one forms many folds. In the anterior region, there found to arrange the large processes, 8-10 in number, on either side, and the apical two processes exceedingly swell laterally. The cardia is concealed. The anterior intestine is about 2-3 times as long as the mesenteron. The rectal caecum is undifferentiated. The Malpighian tubule is divided into three branches successively at two points of a distance.

45) *P. l-album samurai* Fruhstorfer (Fig. 48)

Specimens examined : 5 males.

The mesenteron is somewhat flat and widens gradually towards the apical end which slightly swells laterally. In general, anterior two-thirds the surface of the mesenteron forms numerous processes, and the posterior about one-third part bears circular folds. The cardia is naked. The anterior intestine is about 3 times as long as the mesenteron. The rectal caecum is not differentiated. The Malpighian tubule is divided into three branches at a common point.



Figs. 42-48.

46) *Nymphalis io geisha* (Stichel) (Fig. 49)

Specimens examined : 5 males.

The externals of the canal closely resemble those of *Polygonia c-album hamigera*, and so far as the writer observed no difference between the two species is to be caught, though in some individuals of this species the rectal caecum, with papillae, is slightly developed.

47) *Aglais urticae connexa* (Butler) (Fig. 50)

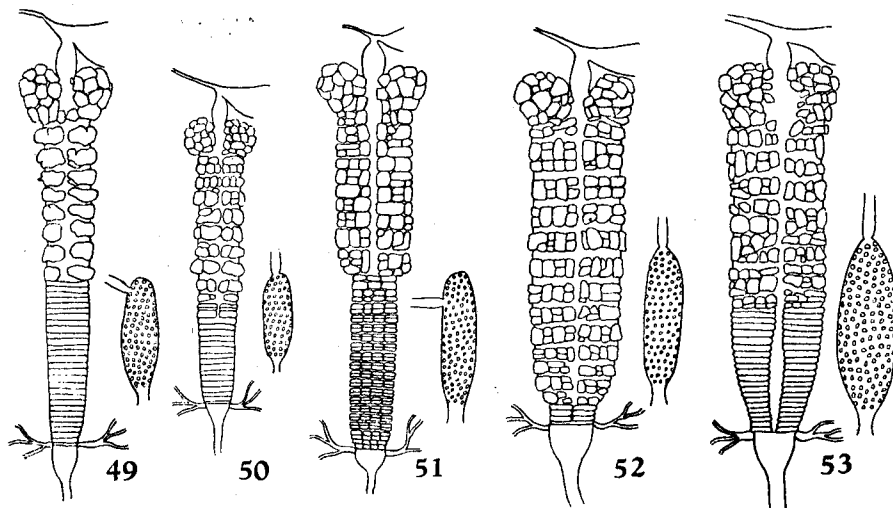
Specimens examined : 5 males.

The externals of the canal are almost identical with those of *P. l-album samurai*, but differ from the latter in the cardia which is not naked.

48) *Vanessa indica* (Herbst) (Fig. 51)

Specimens examined : 5 males.

The mesenteron, the apical part of which fairly swells laterally, is divided into two regions. The anterior one, which is wider than the posterior one, possesses numerous processes arranging closely, but deficient in processes along the median area of the dorsal side, thus formed a groove. The posterior one forms many circular folds, each of which is generally constricted into several portions. The cardia is not naked, while the tube between the mesenteron and the opening part of the crop into the oesophagus swells considerably. The anterior intestine is about 2-3 times as long as the mesenteron. The rectal caecum, with papillae, is moderately developed. The Malpighian tubule is divided into three branches successively at two points of a distance.



Figs. 49-53.

49) *Apatura ilia substituta* Butler (Fig. 52)

Specimens examined : 5 males.

The externals of the canal are similar to those of *Vanessa indica*, but differ from the latter in the appearance of the processes almost all over the surface of the mesenteron except the caudal part, and the rectal caecum of this species is not differentiated at all.

50) *Sasakia charonda charonda* (Hewitson) (Fig. 53)

Specimens examined : 5 males and 1 female.

The externals of the canal closely resemble those of *Apatura ilia substituta*, and it seems to be difficult to find the difference between the two species, but, in general, the mesenteron of this species is longer in length than that of the latter as well as in body length.

Fam. SATYRIDAE

51) *Ypthima argus argus* Butler (Fig. 54)

Specimens examined : 5 males.

The mesenteron is pretty elongate, somewhat flat tube and of nearly uniform diameter. Each of the folds of the mesenteron is constricted into several processes arranged closely. The cardia is not naked. The anterior intestine is almost same as long as the mesenteron. The rectal caecum, without papillae, is moderately developed. The Malpighian tubule is divided into three branches successively at two points of a distance.

52) *Erebia niphonica doii* Nakahara (Fig. 55)

Specimens examined : 5 males.

The mesenteron, a somewhat flat and elongate tube, is provided with the folds all over the surface. Some of the folds are constricted into a few portions. The cardia is not naked. The anterior intestine is about 1.5–2 times as long as the mesenteron. The rectal caecum, without papillae, is well developed. The Malpighian tubule is divided into three branches successively at two points in the distance.

53) *E. ligea rishirizana* Matsumura (Fig. 56)

Specimens examined : 5 males.

The externals of the canal are very closely similar to those of *E. niphonica doii*, but as far as the writer observed the rectal caecum in this species is moderately developed and no well developed one is to be found.

54) *Oeneis daisetsuzana* Matsumura (Fig. 57)

Specimens examined : 2 females.

The externals of the canal are somewhat similar to those of *Ypthima argus argus*, but the mesenteron of this species is far shorter in length than that of the latter. The apical part of the mesenteron is slightly dilated laterally. The cardia is not bare. The anterior intestine, the posterior part of which is covered with a cylindrical sheath bearing circular folds, is almost two-thirds as long as the mesenteron. The rectal caecum, without papillae, is well developed. The Malpighian tubule is divided into three branches successively at two points of a distance.

55) *Lethe callipteris diluta* Esaki et Nakahara (Fig. 58)

Specimens examined : 5 males.

The externals of the canal are closely similar to those of *Ypthima argus argus*, but as far as the writer observed, in this species, a few folds of the apical part of the mesenteron are not constricted.

56) *Aranda schrenckii menalcas* Fruhstorfer (Fig. 59)

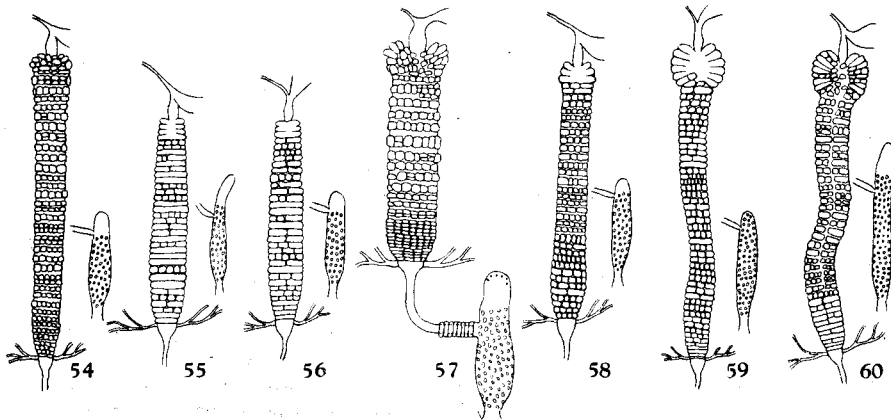
Specimens examined : 5 males.

The externals of the canal are similar to those of *Neptis coenobita aino*, but differ from the latter in the following respects. The mesenteron of this species is narrower in width than that of the latter, and the form of the semicircular distention is different between the two species. And the canal of this species is provided with the rectal caecum bearing the rectal papillae, and the Malpighian tubule is divided into three branches successively at two points of a distance, while in the canal of *Neptis coenobita aino* the rectal caecum is not differentiated, and the Malpighian tubule is divided into three branches at a common point.

57) *Neope goschkevitschii goschkevi'schii* (Ménétrières) (Fig. 60)

Specimens examined : 5 males.

The external characters of the alimentary canal closely resemble those of *Aranda schrenckii menalcas*, but differ from the latter in the rectal caecum which is well developed, and in the appearance of the median groove on the dorsal surface of the mesenteron.



Figs. 54 - 60.

IV. Discussion

Although the species studied are rather few in number to discuss the taxonomic relationships of butterflies, from the result of the present study the writer wishes to consider an outline of this problem. As far as the writer observed, the individual variation of the alimentary canal in butterflies is not so frequent. In all components of the canal, it is the mesenteron that is clearly variable interspecifically.

On the externals of the alimentary canal, in butterflies,

a) The species belonging to the same genus generally resemble each other, and then the generic characters are to be caught.

- b) The genera belonging to the same subfamily resemble each other, and then, in general, the subfamily characters are to be caught.
- c) The subfamilies belonging to the same family somewhat resemble each other, and then, in general, the family characters are to be caught.

That is to say, in the external characters of the alimentary canal of butterflies, there exist specific, generic, subfamily and family characters, and above all it is the family characters that are easily to be caught among these characters.

Concerning the taxonomic relationships, some interesting facts were found in the present study. As regards the externals of the alimentary canal,

1. The family Papilionidae somewhat resemble the family Pieridae, and the family Nymphalidae resemble the family Satyridae.
2. The well differentiated canals were found in many species belonging to the family Nymphalidae, and relatively simple one was observed in the family **Lycaenidae**.
3. *Taraka hamada hamada* (Fam. Lycaenidae), the larvae of which are carnivorous, clearly differs from the other butterflies studied.

The results of the present study on the externals of the alimentary canal in butterflies are generally in accordance with classification used in this paper, with the following attractive facts.

As regards the externals of the alimentary canal,

1. In the species of which the externals are closely similar to each other, sometimes it is impossible to find the difference among them. For examples, *Papilio bianor japonicus* and *P. maackii jezoensis*; *P. protenor nymphis*, *P. memnon thunbergii* and *P. helenus niconicolens*; *Araschnia levana levana* and *A. burejana strigosa*; *Polygonia c-album kamigera* and *Nymphis io geisha*, etc..
2. In the subfamily Pierinae, *Colias hyale poliographus* (Trib. Coliadini) is considerably similar to both of *Pieris rapae crucivora* and *P. melete aglaope* belonging to the tribus Pierini, while *Aporia crataegi adherbal* (Trib. Pierini) clearly differs from above three species.
3. *Vanessa indica* (Subfam. Nymphalinae) is fairly different from *Araschnia levana levana* and *A. burejana strigosa* belonging to the same subfamily, and in some points the former species resembles both of *Sasakia charonda charonda* and *Apatura ilia substituta* belonging to the subfamily Apaturinae.¹⁾

Yagi (1951) stated that the family Hesperidae, the eye of which is of a superposition type, must be separated from the group of butterflies according to its similarity to the moth eye, and reviewed the studies of Kiriakoff (1946, 1948), who proposed an idea that Hesperidae must be separated from butterflies according to its possession of "crowned" prolegs in larval stage, no tympanal organ and rudimentation of simple eye in adult form, and put Hesperidae into subfamily Hesperoidea together with Thyrididae and Pterophoridae. In the present study, the externals of the alimentary canal of *Erynnis montanus* and *Halpe varia obscura* seem to be of a type of butterflies. And the externals of the canal of *Augiades comma*, on which Dauberschmidt (1933) observed, is also of the same type. But as far as the writer observed, the canal of the other species studied slightly winds upon itself, and this character is also found in the canal of most moths. Concerning this problem, it is desirable to be carried out the further investigation.

1) In the classification of Clark 1948 (after Shirôzu 1949), this subfamily is situated in the family Apaturidae.

V. Summary

1. A comparative study of the external characters of the alimentary canal in butterflies was carried out with special reference to their taxonomic relationships in fifty-seven species belonging to six families. Among the components of the canal, the mesenteron was found to be variable interspecifically.

2. With respect to the externals of the alimentary canal, most species studied are, more or less, of a specific characters. Moreover, there also exist the characters of higher categories ; genera, subfamilies and families.

3. In general, the data obtained from the present study coincided with the taxonomic system used by entomologists.

4. The externals of the canal of Papilionidae are somewhat similar to those of Pieridae, and those of Nymphalidae closely resemble those of Satyridae.

5. The well differentiated canal was found in many species belonging to the Nymphalidae, and relatively simple one was observed in the Lycaenidae.

6. The externals of the canal of *Taraka hamada hamada*, the larvae of which are carnivorous, clearly differ from those of the other butterflies.

VI. Literature

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Explanation of figures 2 to 60

Figs. 2-8.

2, *Erynnis montanus*. 3, *Choaspes beniamini*. 4, *Bibasis aquilina*. 5, *Ochlodes venata*. 6, *O. ochracea*. 7, *Halpe varia obscura*. 8, *Parnara guttata*.

Figs. 9-14.

9, *Lühdorfia puziloi yessoensis*. 10, *Parnassius stubbendorffii hoenei*. 11, *P. glacialis glacialis*. 12, *P. stubbendorffii hoenei*. 13, *P. glacialis glacialis*. 14, *P. eversmanni daisetsuzana*.

Figs. 15-20.

15, *Papilio machaon hippocratides*. 16, *P. Protenor nymphis*. 17, *P. memnon thunbergii*. 18, *P. helenus niconiccolens*. 19, *P. bianor japonicus*. 20, *P. maackii iezoensis*.

Figs. 21-26.

21, *Enrema hecabe mariesi*. 22, *E. laeta bethesba*. 23, *Colias hyale poliographus*. 24, *Pieris rapae crucivora*. 25, *P. melete aglaope*. 26, *Aporia crataegi adherbal*.

Figs. 27-34.

27, *Cnretis acuta paracuta*. 28, *Arhopara japonica*. 29, *Artopoeles pryori yessoensis*. 30, *Strymon w-album fentoni*. 31, *Lycaena phlaeas daimio*. 32, *Taraka hamada hamada*. 33, *Niphanda fusca shijima*. 34, *Glaucopsyche lycormas lycormas*.

Figs. 35-41.

35, *Boloria thore yezoensis*. 36, *B. freija asahidakeana*. 37, *Brethis ino mashuensis*. 38, *Argynnis paphia geisha*. 39, *A. charlotta basalis*. 40, *A. laodice japonica*. 41, *A. ruslana*.

Figs. 42-48.

42, *Limenitis camilla japonica*. 43, *Neptis coenobita aino*. 44, *Arashnia levana levana*. 45, *A. burejana strigosa*. 46, *Polygonia c-aureum c-aureum*. 47, *P. c-album hamigera*. 48, *P. l-album samurai*.

Figs. 49-53.

49, *Nymphalis io geisha*. 50, *Aglais urticae connexa*. 51, *Vanessa indica*. 52, *Apatura ilia substituta*. 53, *Sasakia charonda charonda*.

Figs. 54-60.

54, *Ypthima argus argus*. 55, *Erebia nipponica doti*. 56, *E. ligea rishirizana*. 57, *Oeneis daisetsuzana*. 58, *Lethe callipteris diluta*. 59, *Aranda schrenckii menalcas*. 60, *Neope goschkevitschii goschkevitschii*.