# STUDIES ON THE COMPOUND EYES OF LEPIDOPTERA

## 4. On the Compound Eyes of Two Genera, *Colias* and *Aporia*, in Pieridae*

By

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### INTRODUCTION

The pseudopupils of Pieridae are generally arranged in hexagonal row surrounding the central pupil as seen in *Pieris*, *Colias*, *Leptidea*, *Eurema* and *Anthocaris* (YAGI. 1951). In *Gonepteryx* the ground area around these seven pupil patterns is pigmented (YAGI & KOYAMA, 1955). The most special type of pupil is found in the eyes of *Aporia* which manifest no pupils as in Papilionidae. Contrasted this appearance with the other Pierid butterflies the structure of these eyes will show some differences as well as in functions.

This article treated the comparative anatomy of the eyes of *Aporia* and *Colias*, and demonstrated the fact that structural difference of the eye is related to the environment and also phylogeny.

### MATERIALS AND METHODS

Fresh materials were fixed with Carnoy's solution and sectioned with paraffin in 7~10$\mu$ thickness. Half of the materials were stained with Delafield's haematoxylin and Heidenhein's iron haematoxylin after bleached with Grenacher's solution, and the rest were left in unstained condition for the microscopical observations.

The samples used were two *Colias* species from different localities as *C. erate polyographus* MOTSCHULSKY from Ueda and *C. palaeno sugitanii* ESAKI from Japan Alps, and two *Aporia* species, *A. crataegi adherbal* FRUHSTORFER from Hokkaido and *A. hippia* MATSUMURA from central mountains in Japan.

### INTERNAL STRUCTURE

1. ***Colias*** (Fig. 1, A. B)

The corneal lens is concavo–convex and transparent with many chitinous layers in 25$\mu$ thickness similarly to that of *Pieris napi* (NOWIKOFF, 1931).

The corneal process is 13$\mu$ in thickness underlying at the cornea, both being adequately stainable.

Four Semper's cells are found above the crystalline cone containing large round

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nucleus (6 $\mu$ in diameter), being well stained (Photo 5).

The crystalline cone is long conical shape (15 $\mu$ in diameter, 30 $\mu$ in length) and not easily stainable with Heidenhein's haematoxylin (Photo 5) when compared with that of *Pieris* and *Gonepteryx*.

The two iris pigment cells cover the crystalline cone containing irridescent granules (Photo 1・15) which were called iris tapetum (GRENACHER, 1879). *Colias erate* contains much of these granules but in *C. palaeno* they are scanty. These granules are liable to be destructed in paraffin treatment when heated in 55~60°C and disappear as if diffusing (Photo 2). In living condition they migrate downward in light and upward in dark with lesser degree as in the eye of *Gonepteryx*, exhibiting no change of pseudopupils.

Conspicuous constriction from the accessory pigment cell is found between each iris pigment cell attaching to depressed portion of the corneal process (Photo 3). This constricted part bears no pigment granules differing apparently from that of *Gonepteriyx* and *Aporia*.

Six accessory pigment cells cover the upper one fourth of the retinula containing full of purplish brown pigments, being provided with the large elliptical nucleus of 5~7 $\mu$ in diameter.

The retinular pigment cells (usually six in number) surround the rhabdom being connected with the basal pigment cell. The colour of the retinular pigments are deeper in *erate* than in *palaeno*.

Four lines of purplish red colour are found in rhabdom (Photo 6) being arranged proximally as a cross shape and connected to the nerve through the basement membrane.

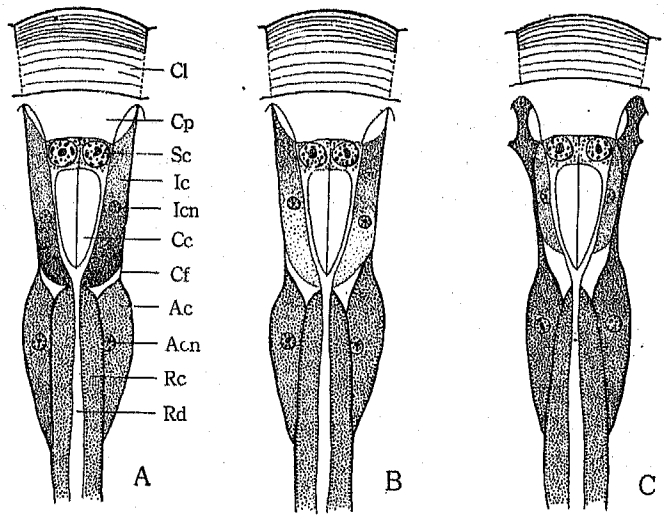


**Fig. 1** Ommatidial structures of
A. *Colias erate* (light adapted)
B. *Colias palaeno* (dark adapted)
C. *Aporia hippia* (in light condition)
Abbreviations are explained at the end of the paper.

2. ***Aporia*** (Fig. 1, C)

The corneal lens in two species of *Aporia* is thinner (22$\mu$ in thickness) than that of *Colias* being provided with the thicker corneal process than the latter.

The shapes of Semper's cell and the crystalline cone are similar to those of *Colias* but the less developed iris pigment cells situate rudimentally at the lower side of the cone. The irridescent granules in this cell (Photo 4 · 9 · 16) are scanty in the case of *crataegi* and diffusible by heat as in *palaeno* but stable in *hippia*.

The most conspicuous character of this genus is found in the accessory pigment cell which has stout connective constriction at the distal end and the part contains large quantity of pigment granules filling up the interspace of corneal processes and covering almost the iris pigment cell (Photo 4). This fact is the cause that the eye of *Aporia* exhibits no pseudopupil and looks dark when contrasted with the eye of *Colias* and *Gonepteryx* in which the granules are none or very rare.

The structure of the retinular part differs not so much in *Pieris* and *Colias*, while the colour of retinular pigments in *hippia* is more purplish than that of *crataegi*.

The colour of rhabdom and nerve is the same in both subspecies.

## CONSIDERATION

According to the above descrived studies the authors want to conclude temporarily three types of structure of the compound eye about species of Pieridae. The types are

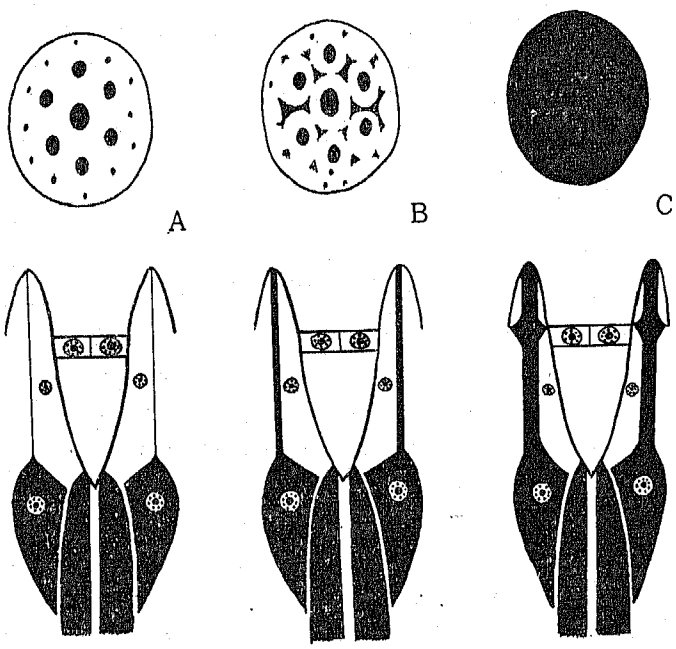


**Fig. 2** Three types of the compound eye in Pieridae
A: *Pieris* type
B: *Gonepteryx* type
C: *Aporia* type

as follows.

1. The constricted long part (connective fiber) of the accessory cell contains no pigments *Pieris*, *Colias*, *Leptidea* and *Eurema* belong to this type (Fig. 2, A).
2. The constricted long part of the accessory cell contains a little quantity of pigments *Gonepteyx* eye belongs to this type being pigmented around the pupils (Fig. 2, B).
3. The constricted part of the accessory cell contains large quantity of pigments *Aporia*'s eye shows no pseudopupils (Fig. 2, C).

From the view of phylogeny based on the structure of the eye in Pieridae, the eye of *Aporia* is near to Papilionidae though the former has reflecting granules in the iris cell, and next *Gonepteryx* then *Pieris* group succeeds.

Taking Papilionidae to be most developed group in butterflies, the order of development may be arranged from A to C (Fig. 2) in respect of existence of pigment granules within the constricted part of accessory cell. *Aporia* will stand between Pieridae and Papilionidae. It may not be far-fetched consideration that the quantity of iris pigments which reflect the light correspond to the environment of its owner. *Colias palaeno* which has the least pigments is very sensitive to the sunshine and does not fly when clouded, while *C. erate* flying out any day time.

The fading tendency by heat in pigment granules of the iris cell is conspicuous in the eyes of *C. palaeno* and *A. crataegi*, and lesser in the eye of *C. erate* and *A. hippia*, respectively. The former two species are distributed in cooler places than the latter two as *A. crataegi* lives in northern part and *C. palaeno* does on high mountain in south or in north, while *A. hippia* lives in deciduous forest of mountain in south, and *C. erate* inhabits anywhere in fields. Under such circumstances it is conceivable that there occurred certain adaptation in the structure of the eye especially on the reflecting pigment in the iris cell.

## SUMMARY

1. The compound eye of *Colias* group is similar to that of *Pieris napi*. The eye of *C. erate* has great quantity of reflecting granules in its iris cell. The eye of *C. palaeno* has not so much of granules as *C. erate* and they are liable to be decomposed by heat.

2. The distal end of the accessory pigment cell of *Colias* extends outward as a constricted fiber and contains no pigments.

3. The corneal lens of *Aporia* is thinner than that of *Colias*, and the iris cell develops rudimentally containing reflecting granules which is liable to be destructed by heat. The quantity of granules of *A. crataegi* is lesser than that of *A. hippia*.

4. The accessory pigment cell of *Aporia* has a stout connecting protrusion in which ample quantity of pigments exists to accomplish the absorption of light. The existence of this pigment is the cause of no appearance of pseudopupils in *Aporia* eye.

5. By the degree of existence of pigments in the accessory cell protrusions, three types

of the compound eye are found in Pieridae in which genus *Aporia* stands very near to Papilionidae.

6. The construction of compound eye seems to suggest the specific activity and ecological niche in distribution.

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### Abbreviations in Fig. 1 and Photos

**Ac** : Accessory pigment cell **Acn** : Nucleus of accessory pigment cell **Bc** : Basal pigment cell **Bm** : Basement membrane **Cc** : Crystalline cone **Cf** : Constricted connection of accessory pigment cell **Cl** : Corneal lens **Cp** : Corneal process **Ic** : Iris pigment cell **Icn** : Nucleus of iris pigment cell **Nv** : Nerve **Rc** : Retinular pigment cell **Rcn** : Nucleus of retinular pigment cell **Rd** : Rhabdom **Sc** : Semper's cell

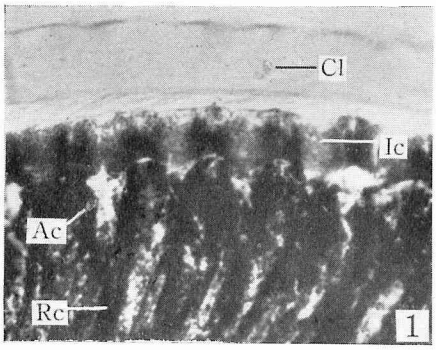
### Explanation of Photos

Plate I. Longitudinal sections

1. Upper part of the eye of *Colias erate polyographus*, unstained.
2. Ditto of *Colias palaeno sugitanii* (iris pigments diffused), unstained.
3. Ditto of *Colias erate polyographus*, stained. The constricted connection of the accessory cell is seen.
4. Ditto of *Aporia crataegi adherbal*, unstained.
5. Ditto of *Aporia hippia*, stained after depigmentation
6. Middle part of the retinula of *Colias palaeno sugitanii*, unstained.
7. Proximal part of the eye of the above species, stained.
8. Basal part of the eye of *Calias erate polyographus*, unstained.

Plate II. 9~14, cross sections of the eye of *Aporia hippia*. 15·16, longitudinal sections.

9. Distal part of crystalline cone, unstained.
10. Proximal part of the cone, unstained.
11. Middle part of the retinula, unstained.
12. Proximal part of the above, unstained.
13. Ditto, stained after depigmentation.
14. Basal part, stained after depigmentation.
15. Reflecting granules in the iris cell of *Colias* eye, in dark field.
16. Ditto of *Aporia eye*, in dark field.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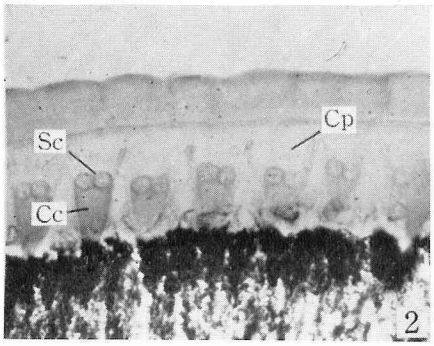
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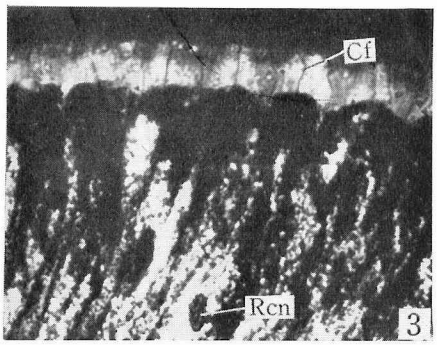
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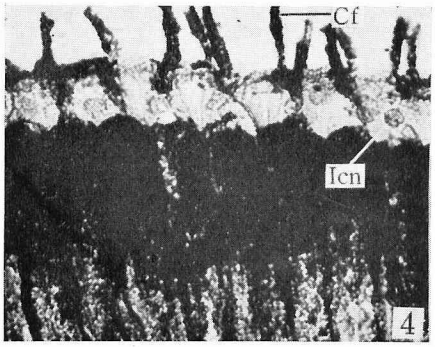
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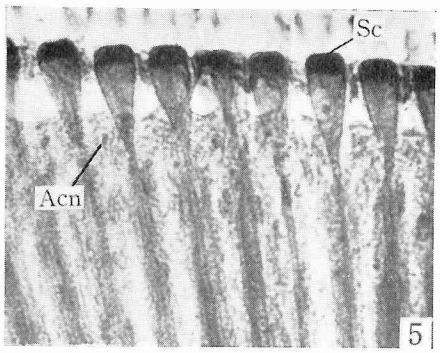
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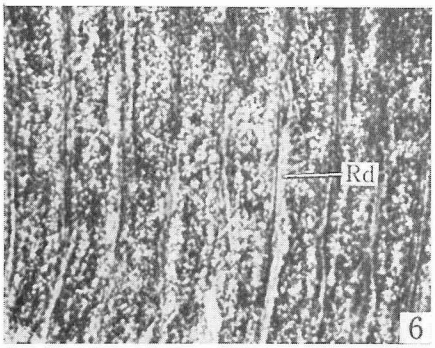
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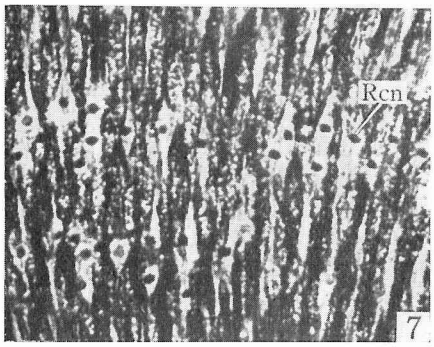
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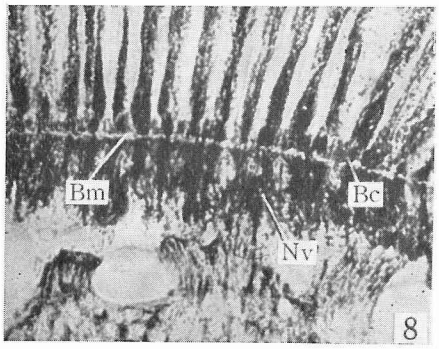
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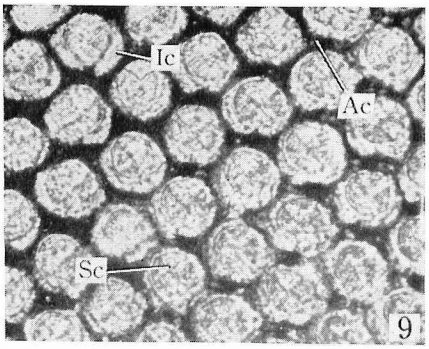
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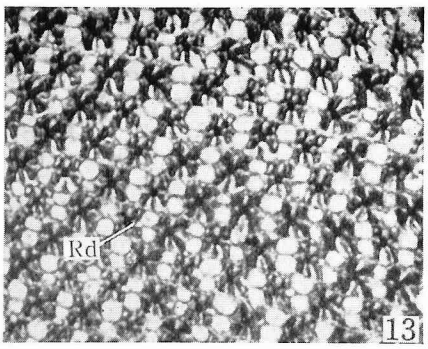
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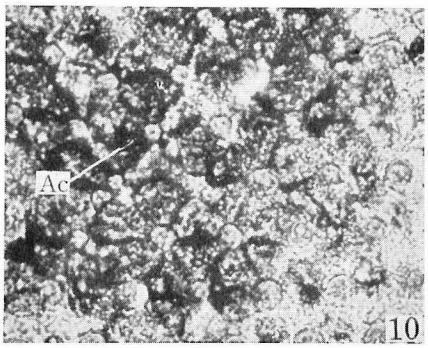
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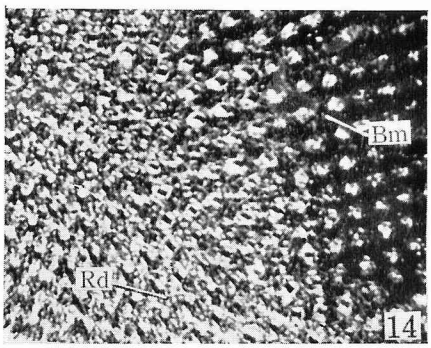
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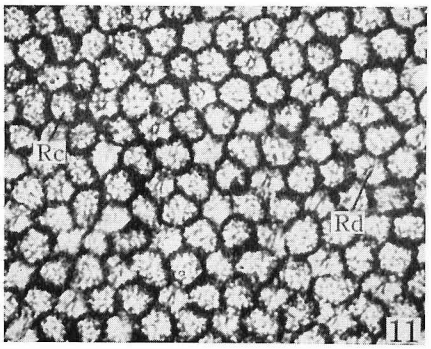
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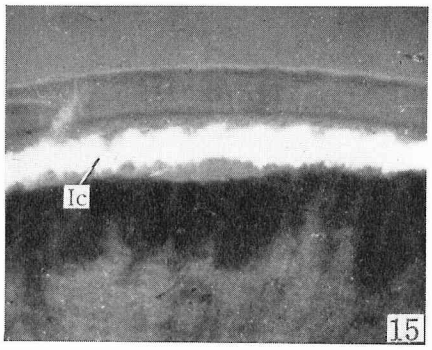
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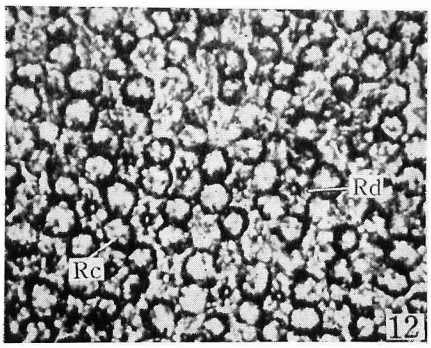
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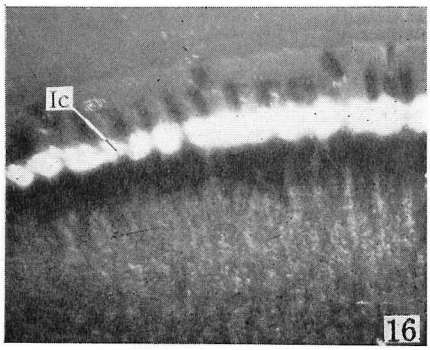
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