A Chromosome Survey in Thirty Species of Moths

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Beginning with the work of Carnoy as early as 1885, the order Lepidoptera has furnished favorite material for chromosome cytology ; extensive studies have been made on the chromosomes of many species. Knowledge of the chromosomes of Japanese moths, however, has remained very limited, in contrast to that of Japanese butterflies in which a considerable number of species has been cytologically dealt with (cf. the list of Makino 1956). Recently, the present author (Saitoh 1959a, b) has studied the chromosomes of nineteen species of Japanese moths in comparison with those of related foreign species. The present article deals with the chromosomes of thirty species of moths occurring in Japan.

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Material and method : In all species of moths herein reported upon, testes were treated by the acetic dahlia squash method for study. Unless otherwise stated, testicular materials taken from mature larvae were used for observation. The following descriptions are based exclusively on the male haploid chromosomes.

Results

1) *Marumba gaschkewitschii echephron* Boisduval (Momo-suzume) (Figs. 1, 2)

This species and the next one are members of the Sphingidae. Testes taken from prepupae of the I-color form were available for the chromosome study. Twenty-eight chromosomes in haploid were observed in meiotic phases I and II without exception.

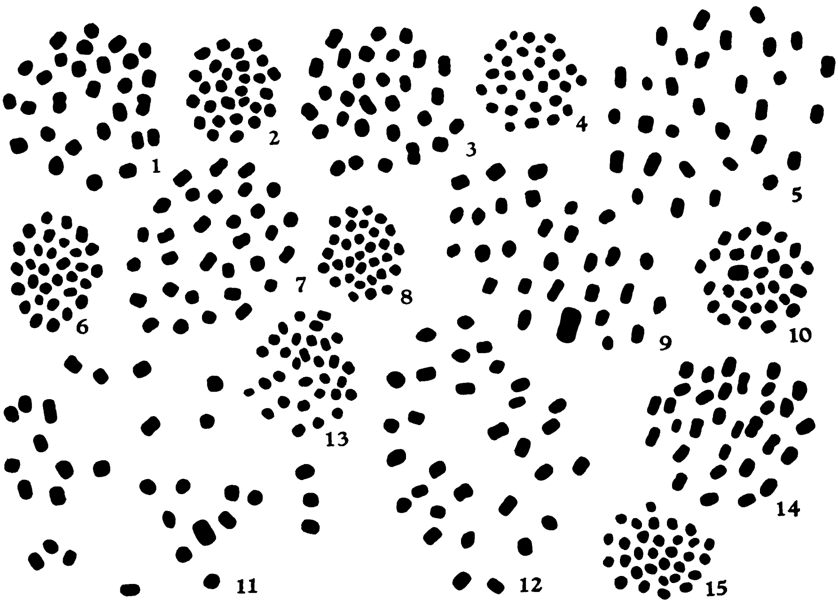
2) *Deilephila elpenor lewisii* Butler (Beni-suzume) (Figs. 3, 4)

The chromosomes were studied in larvae of the I- and II-color forms. The haploid number of chromosomes was ascertained to be 29 in both primary and secondary spermatocytes. The same haploid number was reported by Kernewitz (1915) and Federley (1916) in *Deilephila* (=*Chaerocampa*) *elpenor* from Europe.

3) *Spilarctia infernalis* Butler (Kurobane-hitori) (Figs. 5, 6)

4) *Arctia caja phaeosoma* Butler (Hitoriga) (Figs. 7, 8)

Species 3) and 4) belong to the Arctiidae. The haploid number of chromosomes was determined as 31 in both species of *Spilarctia infernalis* and *Arctia caja phaeosoma*.



Figs. 1–15. Haploid chromosomes, ca. × 1800. 1, 3, 5, 7, 9, 11, 12, 14, Primary spermatocytes. 2, 4, 6, 8, 10, 13, 15, Secondary spermatocytes. 1, 2. *Marumba gaschkewitschii echephron*, n, 28. 3, 4. *Deilephila elpenor lewisii*, n, 29. 5, 6. *Spilarctia infernalis*, n, 31. 7, 8. *Arctia caja phaeosoma*, n, 31. 9, 10. *Phragmatobia fuliginosa amurensis*, n, 29. 11–13. *Seudyra subflava*, n, 31. 14, 15. *Apatele incretata*, n, 31.

The same haploid number was reported in *Spilarctia imparilis* (Saitoh 1959a). Previously, Beliajeff (1930) and Kernewitz (1915) reported the same haploid number (n, 31) for *Arctia caja*.

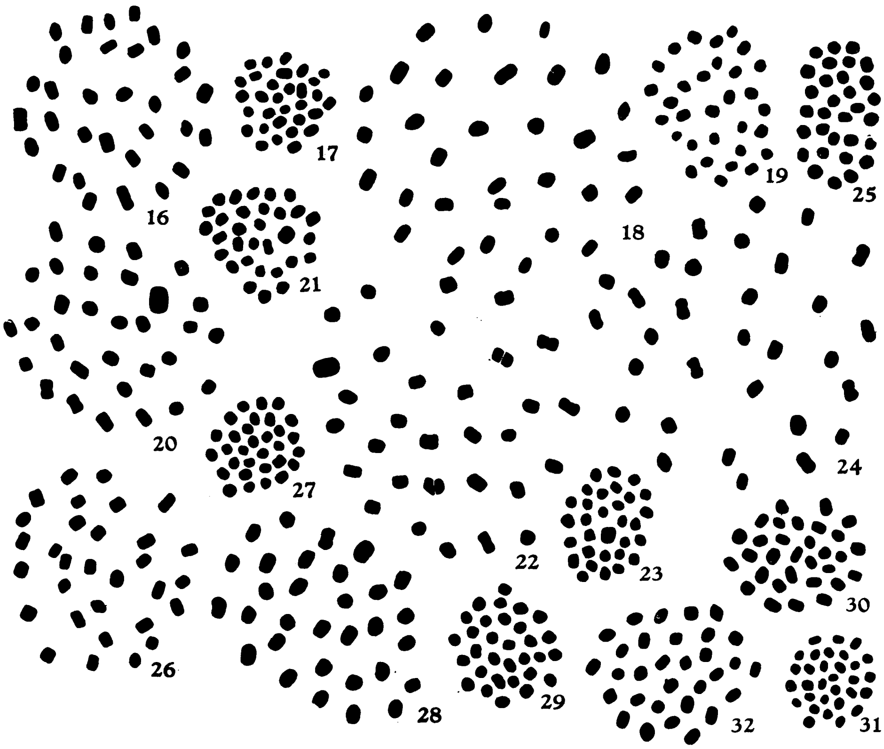
5) *Phragmatobia fuliginosa amurensis* Seitz (Ama-hitori) (Figs. 9, 10)

This species is also a member of the Arctiidae. Chromosome count indicated the occurrence of 29 chromosomes in the meiotic metaphases I and II. One of the 29 chromosomes is outstandingly large in size, being clearly distinguishable from other elements in the polar as well as side views.

Working with the chromosomes of *Ph. fuliginosa* from Europe, Seiler (1913, 1914, 1917, 1925) reported the occurrence of 28 and 29 haploid chromosomes. The author wishes to offer a discussion on the chromosomes again in comparison with Seiler's studies, after the completion of studies with fixed material of the present form.

6) *Seudyra subflava* Moore (Tobiiro-toraga) (Figs. 11–13)

This species is a member of the Agaristidae. The study was made with the material from young pupae. Primary and secondary spermatocytes showed 31 haploid chromosomes at metaphase. Some primary spermatocytes contained one chromosome of remarkably large size (Fig. 11). As described below, a chromosome of similar nature was found in a duplicated primary spermatocyte (Fig. 59).



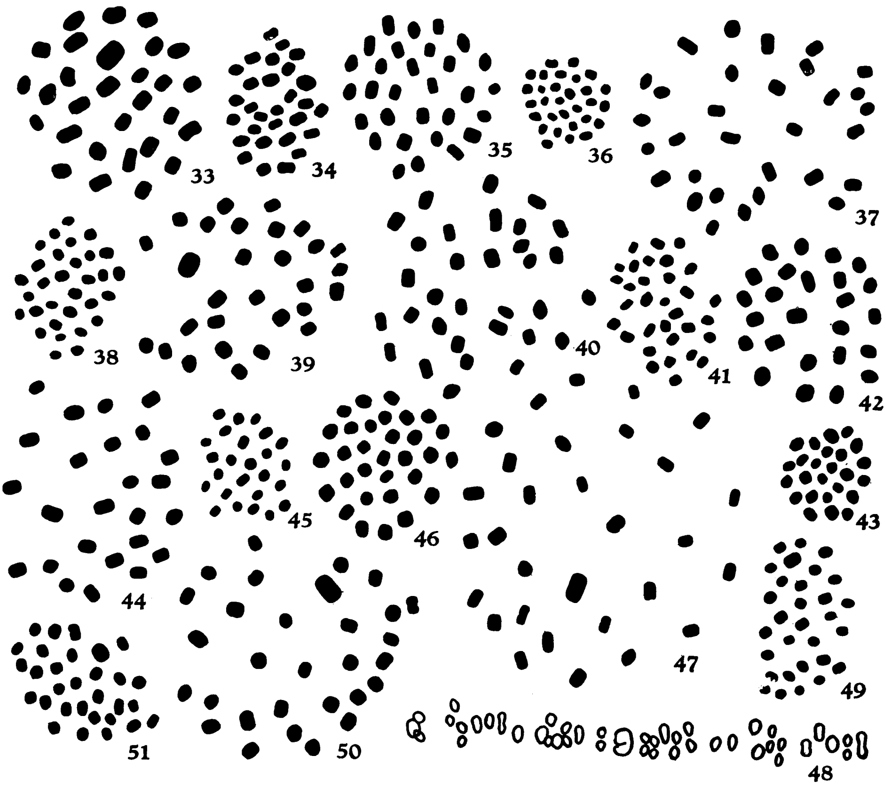
Figs. 16–32. Haploid chromosomes, ca. ×1800. 16, 18, 20, 22, 24, 26, 28, 30, 32, Primary spermatocytes. 17, 19, 21, 23, 25, 27, 29, 31, Secondary spermatocytes. 16, 17. *Amphipoea burrowsi*, n, 31. 18, 19. *Cosmia camptostigma*, n, 31, 20, 21, *Plusia peponis*, n, 31. 22, 23. *Plusia intermixta*, n, 31. 24, 25. *Adris tyrannus amurensis*, n, 31. 26, 27. *Plusiodonta casta*, n, 31. 28, 29. *Calpe aureola*, n, 31. 30, 31. *Anomis commoda*, n, 31. 32. *Dichromia trigonalis*, n, 31.

7) *Apatele incretata* Hampson (Ringo-kemmon) (Figs. 14, 15)
8) *Amphipoea burrowsi* Chapman (Miyama-shôbu-yotô) (Figs. 16, 17)
9) *Cosmia camptostigma* Ménétriès (Shiraobi-kiriga) (Figs. 18, 19)
10) *Plusia peponis* Fabricius (Uri-kin-uwaba) (Figs. 20, 21)
11) *Plusia intermixta* Warren (Kiku-kin-uwaba) (Figs. 22, 23)
12) *Adris tyrannus amurensis* Staudinger (Akebi-konoha) (Figs. 24, 25)
13) *Plusiodonta casta* Butler (Madara-eguriba) (Figs. 26, 27)
14) *Calpe aureola* Graeser (Figs. 28, 29)
15) *Anomis commoda* Butler (Oo-aka-kiriba) (Figs. 30, 31)

16) *Dichromia trigonalis* Guenée (Taiwan-kishita-atsuba) (Fig. 32)

The above ten species (Nos. 7–16) all belong to the Noctuidae. In *Apatele incretata* and *Anomis commoda*, young pupae furnished testicular materials for study. Although these noctuid species are represented by nine different genera, they show uniformly the same number of chromosomes, 31, in haploid. The haploid complements of *Plusia peponis* and *P. intermixta* each contain one chromosome, remarkably large in size.

Three Japanese noctuids have hitherto been subjected to chromosome study; they showed the haploid number of 31 without exception (Saitoh 1959a). Makino's list (1956) shows, besides 31, the haploid numbers of 29, 30 and 32 in the noctuid moths so far studied.



Figs. 33–51. Haploid chromosomes, ca. × 1800. 33, 35, 37, 39, 40, 42, 44, 46, 47, 48, 50, Primary spermatocytes. 34, 36, 38, 41, 43, 45, 49, 51, Secondary spermatocytes. 33, 34. *Harpyia lanigera*, n, 29. 35, 36. *Clostera anachoreta*, n, 30. 37, 38. *Malacosoma neustria*, n, 31. 39. *Calospilos sylvata fulvobasalis*, n, 29. 40, 41. *Elcysma westwoodii westwoodii*, n, 32. 42, 43. *Illiberis psychina*, n, 25. 44, 45. *Illiberis nigra nigra*, n, 25. 46. *Syllepte derogata*, n, 31. 47–49. *Archips breviplicanus*, n, 30. 48. Side view. 50, 51. *Adoxophyes orana*, n, 30.

17) *Harpyia lanigera* Butler (Nakaguro-mokume) (Figs. 33, 34)

Species 17) and 18) are members of the Notodontidae. In both meiotic divisions of *Harpyia lanigera*, 29 haploid chromosomes were counted. Both polar and side views showed clearly that the haploid complement contains one chromosome of large size.

18) *Clostera anachoreta* Fabricius (Tsumaaka-shachihoko) (Figs. 35, 36)

The haploid number of chromosomes was 30 in both primary and secondary spermatocytes. The same condition was found by Federley (1913, 1953) to occur in the same species from Europe.

According to Federley (1913, 1953), the chromosome numbers (n) of five European species of *Clostera* are as follows: n, 23 for *pigra*; n, 25, for *anastomosis*; n, 29 for *curtula*; n, 30 for *anachoreta* and n, 30 for *apicalis*. The Japanese specimens of *Cl. anastomosis tristis* observed by the present author (Saitoh 1959a) were found to be the same as the European counterpart, *Cl. anastomosis*, in having 25 haploid chromosomes.

19) *Malacosoma neustria* L. (Obi-kareha) (Figs. 37, 38)

This species belongs to the Lasiocampidae. The haploid number of chromosomes was ascertained to be 31 in both meiotic divisions, which agrees with that observed by Beliajeff (1930) for Russian specimens

20) *Calospilos sylvata fulvobasalis* Warren (Hime-madara-edashaku) (Fig. 39)

The chromosomes, 29 in number, were observed in primary spermatocytes of this geometrid species. One of them is remarkably large in size. It is of cyto-taxonomical interest to make a comparative study of chromosomes in this genus, because the genus *Calospilos* comprises allied species.

21) *Elcysma westwoodii westwoodii* Snellen van Vollenhoven (Usuba-tsubamega) (Figs. 40, 41)

This species is a member of the Zygaenidae. It has 32 haploid chromosomes in both primary and secondary spermatocytes.

22) *Illiberis psychina* Oberthür (Ume-sukashi-kuroba) (Figs. 42, 43)

23) *Illiberis nigra nigra* Leech (Ringo-hamaki-kuroba) (Figs. 44, 45)

Both *Il. psychina* and *Il. nigra nigra* belong also to the Zygaenidae and have the same number of chromosomes (n, 25) in spermatocytes.

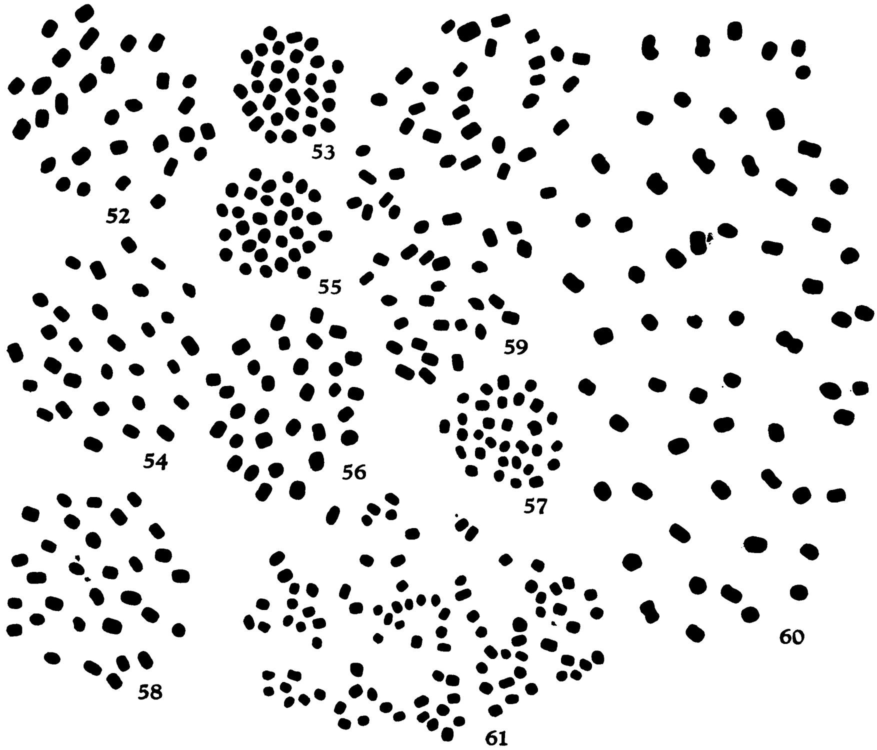
24) *Syllepte derogata* Fabricius (Wata-no-meiga) (Fig. 46)

This is a species of pylaridid moths. It was found in the primary spermatocytes to have 31 haploid chromosomes.

25) *Archips breviplicanus* Walsingham (Ringo-mon-hamaki) (Figs. 47–49)

26) *Adoxophyes orana* Fischer von Röslerstamm (Ko-kakumon-hamaki) (Figs. 50, 51)

The above two species are members of the Tortricidae. They are serious pests of apple trees. Their chromosome numbers are identical with each other, being n, 30, in both meiotic divisions. Further, the haploid complements of these two species contain in each one chromosome of considerably large size.



Figs. 52–58. Haploid chromosomes, ca. ×1800. 52, 54, 56, 58, Primary spermatocytes. 53, 55, 57, Secondary spermatocytes. 52, 53. *Yponomeuta polistictus*, n, 30. 54, 55. *Yponomeuta kitabatakei*, n, 30. 56, 57. *Yponomeuta malinellus*, n, 31. 58. *Yponomeuta vigintipunctatus*, n, 31.

Figs. 59–61. Polyploid chromosomes, ca. ×1800. 59. *Seudyra subflava*, 62 chromosomes. 60. *Adris tyrannus amurensis*, 62 chromosomes. 61. *Illiberis psychina*, 95 chromosomes.

27) *Yponomeuta polistictus* Butler (Ooboshi-ô-suga) (Figs. 52, 53)

28) *Yponomeuta kitabatakei* Moriuti (MS.) (Tsuru-umemodoki-suga) (Figs. 54, 55)

29) *Yponomeuta malinellus* Zeller (Ringo-suga) (Figs. 56, 57)

30) *Yponomeuta vigintipunctatus* Retzius (Benkeisô-suga) (Fig. 58)

The above four species are members of the Yponomeutidae. Chromosome counting has made it clear that *Yp. polistictus* and *Yp. kitabatakei* each has 30 haploid chromosomes, while *Yp. malinellus* and *Yp. vigintipunctatus* are characterized by 31 haploid chromosomes.

Beliajeff (1930) and Regnart (1933) observed 31 haploid chromosomes in *Yponomeuta* (= *Hyponomeuta*) *evonymella*.

Addendum : In a single cell of *Seudyra subflava* and in two cells of *Adris tyrannus amurensis*, a duplicated haploid number of chromosomes showing 62 was observed (Figs. 59, 60). Further, a single cell showing 95 chromosomes (Fig. 61) was found in *Illiberis psychina* which is characterized by n, 25. Each of these cells is apparently larger in size than the normal primary and secondary spermatocytes bearing the usual haploid chromosomes.

Table 1. Chromosome numbers of 30 species of moths observed in this study

Species	Haploid chromosome numbers
Sphingidae	
Marumba gaschkewitschii echephron	n, 28 ♂ (I, II)
Deilephila elpenor lewisii	n, 29 ♂ (I, II)
Arctiidae	
Spilarctia infernalis	n, 31 ♂ (I, II)
Arctia caja phaeosoma	n, 31 ♂ (I, II)
Phragmatobia fuliginosa amurensis	n, 29 ♂ (I, II)
Agaristidae	
Seudyra subflava	n, 31 ♂ (I, II)
Noctuidae	
Apatele incretata	n, 31 ♂ (I, II)
Amphipoea burrowsi	n, 31 ♂ (I, II)
Cosmia camptostigma	n, 31 ♂ (I, II)
Plusia peponis	n, 31 ♂ (I, II)
Plusia intermixta	u, 31 ♂ (I, II)
Adris tyrannus amurensis	n, 31 ♂ (I, II)
Plusiodonta casta	n, 31 ♂ (I, II)
Calpe aureola	n, 31 ♂ (I, II)
Anomis commoda	n, 31 ♂ (I, II)
Dichromia trigonalis	n, 31 ♂ (I)
Notodontidae	
Harpyia lanigera	n, 29 ♂ (I, II)
Clostera anachoreta	n, 30 ♂ (I, II)
Lasiocampidae	
Malacosoma neustria	n, 31 ♂ (I, II)
Geometridae	
Calospilos sylvata fulvobasalis	n, 29 ♂ (I)
Zygaenidae	
Elcysma westwoodii westwoodii	n, 32 ♂ (I, II)
Illiberis psychina	u, 25 ♂ (I, II)
Illiberis nigra nigra	n, 25 ♂ (I, II)
Pyralididae	
Syllepte derogata	n, 31 ♂ (I)
Tortricidae	
Archips breviplicanus	n, 30 ♂ (I, II)
Adoxophyes orana	n, 30 ♂ (I, II)
Yponomeutidae	
Yponomeuta polistictus	n, 30 ♂ (I, II)
Yponomeuta kitabatakei Moriuti (MS.)	n, 30 ♂ (I, II)
Yponomeuta malinellus	n, 31 ♂ (I, II)
Yponomeuta vigintipunctatus	n, 31 ♂ (I)

(I) : Primary spermatocyte. (II) : Secondary spermatocyte.

Summary

The chromosomes of the haploid group were studied in male germ-cells of thirty species of Japanese moths with the application of the acetic dahlia squash method.

For morphological details of chromosomes, one may refer to Figures 1 to 58. The chromosome numbers here established are shown in Table 1.

References

Beliajeff, N.K. 1930. Z.I.A.V. **54** : 369–399.

Federley, H. 1913. Z.I.A.V. **9** : 1–110.

——— 1916. Öfv. Finska Vetensk. Soc. Förh. 58 A, **12** : 1–17.

——— 1953. Z. Lepidopt. **3** : 1–32.

Kernewitz, B. 1915. Arch. Naturges. 81A : 1–34.

Makino, S. 1956. A review of the chromosome numbers in animals. 2nd ed., Hokuryûkan, Tôkyô.

Regnart, H.C. 1933. Proc. Univ. Durham Phil. Soc. **9** : 79–83.

Saitoh, K. 1959a. Jap. Jour. Genet. **34** : 84–87.

——— 1959b. Annot. Zool. Japon. **32** : 89–93.

Seiler, J. 1913. Zool. Anz. **41** : 246–251.

——— 1914. Arch. Zellf. **13** : 159–269.

——— 1917. Sitzungsber. Ges. Naturf. Fr. Berlin, **2** : 107–113.

——— 1925. Arch. Jul. Klaus-Stiftg. **1** : 63–117.