

Notes on the Spermatogenesis of the Wild and the Domesticated Silkworms.

By

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Although the spermatogenesis of some lepidoptera has been lately studied with especial reference to the chromosomes by the late Miss STEVENS ('05), MUNSON ('06), Miss DEDERER ('07) and Miss COOK ('10), yet that of the silkworm has not been undertaken since the appearance of TOYAMA'S papers ('94 a and b). What one finds in the later literature regarding the germ-cells of the silkworm is limited to fragmentary notes by LA VALETTE ST. GEORGE ('97), HENNEGUY ('98) and MEVES ('03) on structures other than the chromosomes. Such paucity of works on the spermatogenesis of the silkworm is rather remarkable, since in most countries the material can be obtained without difficulty.

As there are quite a number of varieties in the domesticated silkworm, I thought that they would be an excellent object for the study of correlation between their morphological features and the chromosomal characters. So I undertook a comparative study of spermatogenesis of the wild silkworm (*Theophila mandriana*) and of the following seventeen varieties of the domesticated silkworm (*Bombyx mori*):

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|------------------------------|---|-----------------|
| 1. Dainyorai | } | Japanese races. |
| 2. Aojiku | | |
| 3. Koishimaru | | |
| 4. Araya | | |
| 5. Watako | | |
| 6. Seihaku | | |
| 7. Shirojima × Kurojima | } | Corean races. |
| 8. Kasasagi | | |
| 9. Corean No. 1 (dark brown) | | |
| 10. Corean No. 1 (green) | | |

11. Shin-en	}	Chinese races.
12. Ryūkaku		
13. Birōdo		
14. Chinese	}	Turkish races.
15. Bagdad		
16. Bas-Alps	}	European races.
17. Italian No. 1		

As fixing fluids acetic-sublimate and FLEMMING'S solution were used. The latter preserves excellently both the cilia and the V-shaped centrioles of the primary spermatocyte, which were described and figured by MEVES ('97) and HENNEGUY ('98).

It is interesting to note that the testes of all the yellow cocoon races are yellow as are also their silk-glands and body-fluid. In those races, moreover, the testes grow slower than in the white cocoon races, so that the larvae of the former yield testes of suitable stages for the study, when they have grown to a size much larger than those of the latter.

I experienced some difficulty in getting the material of the wild silkworm. A large percentage of its larvae was found to be infested by the maggot (*Ugimia sericaria*), and only a few individuals could be obtained, that were free from the parasites and yielded good testes for my purpose.

Besides the testes, young ovaries were cut into sections in order to study the oogonial division.

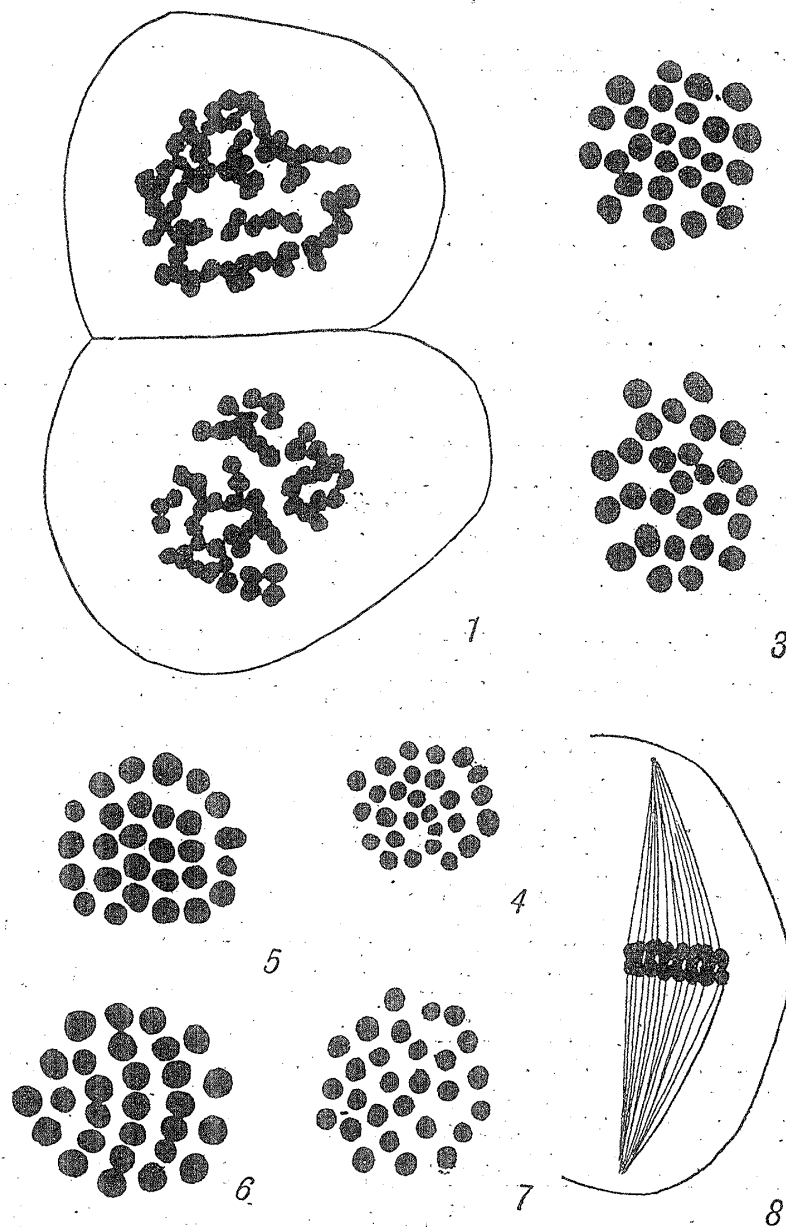
Here I must thank Professor TOYAMA of the Agricultural College and Mr. HAYASHI of the Tokyo Sericultural Institute for the kindness shown me in many ways, especially in providing me with the material.

Results.

As will be seen from the appended figures, all the chromosomes of the silkworms look almost alike, there being found no perceptible differences both in shape and size. A constant mode of arrangement of the chromosomes at the metaphase cannot be detected. Of the seventeen varieties, that came under my examination, I could find no

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All the figures were drawn with the camera at the level of table and with Zeiss apochromat 1.5mm. oil immersion objective and No. 18 compensating eye-piece, which combination gives an enlargement of 4800 diameters.—Fig. 1, metaphase of spermatogonial division in the domesticated silkworm ("Shirojima" × "Kurojima"); polar view.—Figs. 2 and 3, equatorial plates of first spermatocyte-division in the wild silkworm (27 chromosomes).—Fig. 4, second spermatocyte-division in same (27 chromosomes).—Fig. 5, first division in the domesticated silkworm, race "Italian No. 1" (28 chromosomes).—Fig. 6, same, race "Kasasagi".—Fig. 7, second division in same, race "Birōdo".—Fig. 8, same, race "Kasasagi"; side view.

difference in their chromosomal characters. This seems rather remarkable in view of the fact that the larvae are so divergent in external characters. It may, therefore, be concluded that among varieties of the silkworm there is no morphological correlation between external features and chromosomes. Thus the primary object of the present study was frustrated. Nevertheless, I may mention the two following facts as worth noting.

1. The haploid number of chromosomes in the domesticated silkworm is 28, contrary to TOYAMA'S statement. This was determined by counting the chromosomes at the metaphase of the first and the second spermatocyte division (figs. 5, 6 and 7). The unreduced number, therefore, must be 56. During spermatogonial divisions the chromosomes cannot be exactly counted owing to their crowded state, but they number unquestionably between 50 and 60, and decidedly not 28 as TOYAMA has stated ('94b, p. 132). There occurs apparently the same number of chromosomes in the equatorial plate during the division of oogonia and of the follicle cells of both the testis and ovary. It need hardly be mentioned that the second spermatocyte division is of the ordinary type, contrary to TOYAMA'S observation ('94b p. 137). That author thought that each of the 28 bivalent chromosomes does not divide, but half of them go to one pole and the remaining to the other; thus reducing the number to 14. It is a rather singular coincidence that MUNSON ('06) also observed a similar mode of division in *Papilio rutulus*. As a matter of fact, each of the chromosomes becomes constricted into two, as is seen in the side-view shown in fig. 8, each spermatid receiving 28 chromosomes. I have no evidence to decide which of the two spermatocyte divisions is reducing.

2. In the wild silkworm known to systematists as *Theophila anandriana* or *Bombyx mandriana*, the haploid number of chromosomes is 27 (figs. 2, 3 and 4). The unreduced number should then be 54, though for the same reason as mentioned above, the exact number of the chromosomes in the diploid group cannot be made out.

By comparing various characteristics of the wild and domesticated silkworms, SASAKI ('98) came to the conclusion that the former should be taken for the ancestral form, from which the various races of the ordinary silkworm were derived. If so, in the course of domestication the wild form must have acquired two additional chromosomes. But when and how these two came into existence is still an open question. Not unlikely ancient people took hold of a mutant from the wild *Theophila* and succeeded in producing from it the races better fitted for their need.

It will be of great interest to study the chromosome groups in the cross of the wild and domesticated silkworms. Male *Theophila* is known to come sometimes from the mulberry bush to mate with female *Bombyx* moth and, as I was told, the rearing of the cross is not a difficult task. It is highly probable that in the germ cells of the cross, one chromosome of the domesticated silkworm will not find its mate at synapsis and will appear as an accessory or heterotropic chromosome.

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