37. *On the Developmental Characteristics of the Silkworm Embryo.*

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Introduction:—The rate of early development of the embryo, that is, from the wintering stage (Fig. 1) to the elongated stage (Fig. 2) occupying about one-third the entire embryonic period, varies not only with the race of the silkworm, but with the season in which the eggs are laid. On the contrary the rate of later development, namely, from the elongated stage to the time of hatching (Fig. 3), which takes up about two-thirds the entire embryonic period does not differ very much. The wintering eggs laid in August and October usually develop into the elongated stage in the spring of the following year much earlier than those produced in June and July.

Fig. 1.
Embryo at winter-
ing stage.

Fig. 2.
Embryo at elongated
stage.

Fig. 3.
Embryo before
hatching.

Experiments:—In order to ascertain the rate of embryonic development under natural conditions in the spring of the following year, experiments were first made with the wintering eggs using such races as Japanese No. 1, Chinese No. 4, European No. 7 (all univoltine races), and Japanese No. 107 (bivoltine race). Eggs were laid in June, August, and October. The rates of development of each batch of eggs that were laid during these three months, together with those laid in October and kept at a temperature of 25° C for periods ranging from 10 to 50 days from the dates they were laid, were observed at natural temperature in the spring of the following year. The rates for their various stages of development for 1932 are shown in Table 1.

TABLE 1.

Race	Eggs laid in Incubation	Controls			Experimentals (eggs laid in October kept at 25° C) for				
		June	August	October	10 days	20 days	30 days	40 days	50 days
Japanese No. 1	Date elongated stage was reached	IV-15	IV-8	IV-5	IV-6	IV-8	IV-15	IV-17	IV-20
	Date hatched	V-15	V-9	V-7	V-7	V-7	V-10	V-8	V-8
	Days required for "later stage"	30	31	32	31	29	25	21	18
Chinese No. 4	Date elongated stage was reached	IV-14	IV-9	IV-5	IV-5	IV-7	IV-16	IV-19	IV-23
	Date hatched	V-15	V-11	V-9	V-7	V-8	V-15	V-17	V-13
	Days required for "later stage"	31	32	34	32	31	29	28	20
European No. 7	Date elongated stage was reached	IV-19	IV-16	IV-5	IV-14	IV-16	IV-19	IV-27	IV-28
	Date hatched	V-19	V-17	V-9	V-15	V-14	V-12	V-15	V-13
	Days required for "later stage"	30	31	34	31	28	23	18	15
Japanese No. 107	Date elongated stage was reached	IV-9	IV-6	IV-2	IV-5	IV-8	IV-9	IV-14	IV-18
	Date hatched	V-10	V-7	V-6	V-7	V-9	V-8	V-12	V-8
	Days required for "later stage"	31	31	34	32	31	29	28	20

Roman numerals indicates months.

It will be seen from the above table that the period of embryonic development required for reaching the elongated stage at natural temperature varied with race, and with the season in which the eggs were laid. In the controls as to races the difference was a matter of only a few days, while there was a disparity of as much as nearly 10 days regarding the season of egg-laying. On the other hand the duration of development in the stages subsequent to the elongated embryo did not show much difference. For example the eggs of the Japanese No. 1 laid in June developed to the elongated stage on April 15, while those laid in October already reached that stage on April 5. In contrast with this, the later stages to hatching, in the former case, took 30 days, while in the latter 32 days.

When the eggs laid in October and kept at 25° C for from 20 to 30 days soon after they were laid, the elongated stage was reached nearly at the same time as that of the June eggs. When kept at 25° C for from 40 to 50 days the development to the elongated stage

was retarded still more than in the eggs laid in June, that is, the earlier embryonic stage became noticeably longer. In other words, the developmental period from the elongated stage to hatching is considerably accelerated.

Further experiments were carried out in constant temperature rooms. Each batch of eggs similarly treated as just mentioned, together with the embryos in the wintering stage, were kept at 0° C from February to April of the following year. In the middle of April the temperature was raised to 10°–15° from 0° C in order to compare the length of time it takes from the wintering stage to the elongated stage and from the latter to hatching. The results are shown in the following table.

TABLE 2.

Race	Eggs laid in Incubation	Controls			Experimentals (eggs laid in October kept at 25° C) for				
		June	August	October	10 days	20 days	30 days	40 days	50 days
Japanese No. 1	Days required for early embryonic stage	13	8	4	5	8	13	15	18
	Days required for later embryonic stage	28	31	36	35	33	28	26	24
	Days required for entire embryonic stage	41	39	40	40	41	41	41	42
Chinese No. 4	Days required for early embryonic stage	12	8	4	6	7	13	15	18
	Days required for later embryonic stage	29	34	38	35	34	29	27	25
	Days required for entire embryonic stage	41	42	42	41	41	42	42	43
European No. 7	Days required for early embryonic stage	15	13	6	8	14	17	22	28
	Days required for later embryonic stage	29	32	39	37	29	26	22	17
	Days required for entire embryonic stage	44	45	45	45	43	43	44	45
Japanese No. 107	Days required for early embryonic stage	10	7	4	4	6	8	14	17
	Days required for later embryonic stage	28	31	36	36	35	33	27	25
	Days required for entire embryonic stage	38	38	40	40	41	41	41	42

Similar to the previous experiments the rate of development of the embryo at a constant temperature of from 10° to 15° C varies in the earlier stage as shown by the controls and the experimentals, while in the later stage it accelerates as much as it regarded in the earlier stage, until the whole period of the embryo is not much different.

Conclusion:—Interesting is it to note that the more retarded the development of the embryo in the earlier stage, the more accelerated it is in the later stage, with the result that the total period of embryonic development under constant temperature becomes almost the same, irrespective of the season in which the eggs are laid. This shows a species characteristic in connexion with the development of the embryo. The rate of embryonic development in the earlier stage must be under the influence of temperature for a certain length of time immediately after egg-laying. But, if so, why is it that, when the earlier stage is retarded, the development of the embryo in the later stage is accelerated? This phenomenon is undoubtedly due to some hereditary cause in connexion with the development of the embryo. Now, the slight difference in the length of developmental period in the different races may be due to the action of certain genes. At all events, crossing experiments with the various races should solve the problem. It should, however, be emphasized here that the length of the entire embryonic period is almost constant, lasting for about forty days at a temperature of from 10° to 15° C, notwithstanding the great difference in the rate of embryonic development both before and after the elongated stage. I hesitate to regard that such a phenomenon as the constant duration of embryonic development will be mendelized, ascribing it to the mere expression of genes. But from the viewpoint of the organism as a whole, I should regard it rather as predisposition to species-specificity in embryonic development on the part of the silkworm.