fusions effected by nuclei from the pollen-tube. In spite of the absence of fertilization the egg develops into an abortive embryo in which the divisions show five chromosomes; in other words, the embryo is haploid. This embryo does not attain any considerable size and ultimately aborts. The endosperm, which is diploid as a result of its method of origin, forms in the usual manner and first contains a large central cavity around which are rapidly dividing cells. After the abortion of the haploid embryo and after the endosperm has reached considerable degree of development, a diploid embryo makes its appearance in the micropylar region of the endosperm and is continuous with the endosperm tissues. This is the embryo which perpetuates the plant. Frequently with the abortion of the haploid embryo the whole seed aborts. In other cases the seeds may reach a certain size without any embryos in them at all and in a number of instances what appear superficially to be seeds, even when relatively mature, do not contain an embryo. In certain cases all the seeds in an ovary may be in this condition. In all the mature seeds examined by the present writers in the following species of Trillium embryos produced from the endosperm were found to be present: *T. grandiflorum, T. erectum, T. undulatum* and *T. sessile.*

It would appear from the abnormal method of reproduction in Trillium that too great importance can not be attached to the reproductive chromosomes of the anthers and their behavior.

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THE ROLE OF ARRHENOTOKY IN THE ADAPTATION OF INSECTS

THE sperms of Hymenoptera appear to be only female-producing. The lack of male-producing sperms is correlated with the production of males from unfertilized eggs, a form of parthenogenesis known as arrhenotoky. Since the production of females in arrhenotokous Hymenoptera only takes place after mating and since oviposition in many species occurs as readily before as after mating, a preponderance of males might be expected. Actually, however, arrhenotokous Hymenoptera as a rule produce more females than males.

This preponderance of females is possible because of the presence in insects of a mechanism for the storage and conservation of sperms. This mechanism consists of a spermatheca (sperm reservoir), the spermathecal gland, the sperm duct and associated nerves and muscles. The primary function of this mechanism is to discharge a limited number of activated sperms upon each egg as it passes down the oviduct. When a species produces males from unfertilized eggs this mechanism automatically becomes the means of controlling the proportion of the sexes. When it functions females are produced; when it fails to function males are produced.

The fact that, in the Hymenoptera in general, there is a preponderance of females shows that mating usually occurs before oviposition and that the spermatheca contains sufficient sperms to fertilize most of the eggs. Since male progeny also are produced by the female before its supply of sperms is exhausted, it is evident that some stimulus other than the mere passage of the egg through the oviduct is needed to cause the discharge of sperm in Hymenoptera. This operation appears to be dependent on two sets of reflexes: one involving the spermathecal gland (the stimuli originating externally); the other the spermathecal muscles (the stimuli originating internally with the movement of the eggs through the oviduct). The glandular reflex apparently serves to activate the stored sperms; the muscular reflex apparently synchronizes the discharge of sperms with the expulsion of the egg. Lack of fertilization results either from inadequate stimulation, an excessive rate of oviposition or lack of sperm.

Since in the Hymenoptera the activation of sperms is a result of environmental stimulation, it is evident that the environment controls the sex ratio in most species. As a result of such control extreme variability characterizes the sex ratio in this group of insects.

The fact that, in general, there exists a preponderance of females indicates a remarkable adaptation to environment.

In this connection it is interesting to note a phenomenon which occurs in a few species of Hymenoptera and is correlated with the preponderance of females. This is intra-specific hyperparasitism: a phenomenon also dependent on arrhenotoky. In this type of parasitism all the males, in most species, are the progeny of unmated females and in pure cultures are obligatory parasites of the immature stages of the female. The females are obligatory parasites of scale insects and mealy bugs. Male hyperparasitism, however, is not necessarily entirely intra-specific. In at least one species the male appears to be an obligatory inter-specific hyperparasite, rarely, if ever, parasitizing the immature female of its own species. Such a species would be unable to reproduce in pure cultures. The hyperparasitic males develop under diverse environmental conditions. In extreme cases the males develop only ectoparasitically in a dry environment, whereas the female develops endoparasitically in a fluid environment. The adults of both sexes frequent like environments.[1]

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[1] *Ann. Ent. Soc. of Amer.*, 32: 11–26, 1939; *Univ. of Calif. Publ. in Ent.*, 6: 401–422, 1937.