Parowan, July 16, 1919; Richfield, July 1926 (Knowlton); Richmond, June 1929 (Knowlton).

67. XYLOTA BATON Walker

Utah.

68. XYLOTA FLAVITIBIA Williston

Mesa Verde National Park, Colorado, June 1927 (Tanner).

69. EUMERUS STRIGATUS Fallén

Lewiston, August 24, 1925 (Knowlton); Wellsville (R. Christensen).

70. SPILOMYIA INTERRUPTA Williston

Aspen Grove, Timpanogos, July 1927 (Tanner); Provo (Tanner).

Note: Mr. Knowlton authorizes me to include six additional species taken by me in Utah in July 1922. *Chilosia petulca* Will., Vivian Park, Park City; *Syrphus intrudens* O. S., Mount Timpanogos; *Mesogramma marginata* Say, White Pine Lake, above Logan; *Sphærophoria sulphuripes* Thom., Salt Lake City; *Polydontomyia curvipes* Wied., Salt Lake City.—E. P. Van Duzee.

THE SYNCHRONIZATION OF LIFE HISTORIES

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In the temperate regions, where insects have been most extensively studied, there is in nearly all cases a very definite synchronization in the development associated with the winter rest. This is so evident that we all expect an insect in the spring to appear suddenly and all the individuals to be in the same stage of development, while in the fall there may be specimens in different stages of development, and if more than one brood, we expect to find it in every stage. In some species there is a total mortality in the fall for every stage but one, and in this surviving stage the growth during the cooler weather, either fall or spring, brings most, or all, to a molt or other point of physiological reversal which they cannot pass till the warmer weather of spring. These two causes, acting together, brings the species to a very complete synchronization.

The fundamental thing in the seasonal adjustment of an insect is the mechanism for this developmental synchronization. Below I have attempted to tabulate the outstanding features of this process:

SYNCHRONIZATION

Cause—differential
lethal—
thermal (heat, cold)
dryness
nutritional
dimorphic
Type—mono
bi
di (morphic)
Season—vernal
summer
autumnal
Stage—egg: after maturation
after embrionation
larva: any stadium, particularly (initial, penult, ultimate)
before feeding
before molting
pupa: before adult formation
before emergence
imago: before sexual maturity
between ovipositions

Certain insects in the tropics and parasites on warm-blooded animals may be beyond the influence of seasonal changes, but even in the tropics most insects have accomplished some sort of adjustment associated there with the dry and rainy season rather than with heat and cold.

The length of life of various species vary between seventeen years in a cicada and scarcely as many days in some aphids, and within the same species the different forms of the honey bee may range from perhaps eight years for the queen and in summer perhaps ten weeks for the worker. The great majority of insects, however, are annual brooded with the total length of the life of a generation only a little over twelve months and with each generation completely separated from the preceding and following generation. This we have come to look upon as the normal condition of insect life.

In the case where the life is more than one year, it can be measured by year units, being two or three or four years, and not two and a half, nor any other fraction. Sometimes a species may have individuals requiring two and others taking three years. Some individuals of an annual species may sleep

over to a second summer. There is in all these cases a single seasonal synchronization period which, if passed without the effective reaction, will transfer the individual along to the next period one year later unless it dies in the interim.

Some species may have two or even more synchronizations operating on different stages of the same insect, so that an adult and a larva may both hibernate, the former giving rise to a spring generation and the latter to a fall generation; both remaining quite distinct, or with considerable shifting of individuals from one series to the other.

Where the species has more than one brood a year, there may be two periods of synchronization almost equally effective; for example, the double migration of many aphids show in connection with the wing production in midsummer and fall, resulting in the bringing together of the progeny of three or more generations into a flying swarm of insects, all in precisely the same developmental stage.

More commonly, however, the species proceeds from a synchronized condition in the spring to complete overlapping (what are called "partial broods") in the fall, all to be returned to the synchronized condition by the next spring.

There are two periods in each stadium, one just preceding, and the other just following the molt, where there is a sudden complete change in the physiological activity of every tissue in the body. Normally these changes come in orderly procession, but there may be an interval between the stopping of one function and the starting of the next, so that the entire organism, or nearly all of it, may be brought to a standstill. These potential resting intervals are the points at which the synchronization may be accomplished. Failure or inability of any tissue to stop at one of these intervals is the usual condition making effective the lethal causes mentioned in the table above.

In attempting to classify the life histories, it is necessary to determine the precise stage and season at which synchronization occurs, together with its type and cause. The number of broods is very inadequate without this additional data.