THE INSTARS OF PHYMATA AND SINEA (PHYMATIDAE, REDUVIIDAE: HEMIPTERA)[1]

W. V. BALDUF,
Urbana, Illinois

INTRODUCTION

The data on instars presented below were secured as by-products of my study of the weight patterns of *Phymata pennsylvanica americana* Melin and *Sinea diadema* Fabr. in relation to differences in the amounts and kinds of food administered. These studies extended over the years 1942 to 1945. The bugs were caged and fed individually, and kept at 80° Fahrenheit and approximately 80 per cent relative humidity. In this manner, I reared 14 series of *Phymata,* which yielded 176 adults—100 males and 76 females; and 19 series of *Sinea,* from which 127 males and 90 females were secured. Many other individuals failed to become adults, due to insufficient food and to accidents in molting or handling.

The tabulated data, given below, concern the duration of (a) the five instars that usually compose the nymphal stage of these predatory bugs, and (b) the nymphal stage as a whole. Duration in each species is stated in two forms, first (Tables I and II) in terms of days, both the average and the extreme numbers being given, and second (Tables III and IV) in terms of per cents that express the relative value of each instar in the total nymphal period. The durational records for the individual bugs on which these averages, extremes and per cents are based were taken daily, not hourly, as should perhaps have been done. As a result, the records contain errors varying from one to 24 hours. However, some records were quite precise because they chanced to be taken when the bugs were exuviating.

The series of *Phymata* and *Sinea* are arranged in the tables on the basis of the over-all duration of the nymphal life, the shortest being placed first, followed by the successively longer series. This gradation is correlated, in a cause-effect relation, with the amount of *Drosophila melanogaster* L. and *Musca domestica* L. permitted in the plans of the feeding experiments previously reported in other articles. That is, the more adequate the diet, the more rapid or the shorter the nymphal development. In the case of *Phymata* series number 7 (Table I) miscellaneous insects swept from vegetation in the field were substituted for *Drosophila* and *Musca.*

DISCUSSION

The tabulated data afford a basis for consideration of four aspects of instars. First to be treated is the variability in duration of (a) any one instar and (b) the entire nymphal stage under differing amounts of diet but somewhat uniform temperature and humidity. Reference to Table I will show that the total nymphal life of *Phymata* varied from 34 to 185 days, while the five instars exhibited spreads of 6 to 25, 5 to 34, 5 to 58, 6 to 39, and 8 to 34 days, respectively. The total nymphal life of *Sinea* (Table II) varied in length from 28 to 108 days, while the five instars ranged from 5 to 18, 4 to 13, 4 to 21, 5 to 33, and 7 to 48 days, respectively. It will be noted that the spreads given for *Phymata* are decidedly more extreme than those for *Sinea.* However, these figures are not to be accepted as signifying the full potential innate capacities for variation in the two species. They only reflect the ranges obtained incidental to my experiments under unequal

[1]Contribution No. 279 from the Entomological Laboratories of the University of Illinois. Supporting funds were appropriated by the Research Board of the Graduate School.

dietaries. It may be stated with certainty that *Sinea* could be made to vary much more extensively than the above numbers indicate, if determination of its ability to vary were made the prime object of future experiments. Moreover, it is probable that *Phymata* could effect a greater range in time of development if tested further, particularly under a variety of temperatures.

TABLE I

THE INSTARS OF *Phymata*. DURATION IN DAYS

Series	Adults Reared		Average and Extreme Duration in Days							
	Males	Females	First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Nymphal Stage	Nymphal Males	Nymphal Females
1	7	3	7.40 6–8	5.50 5–6	5.60 5–7	7.00 6–8	10.90 10–12	36.40 34–41	35.86 34–38	37.66 34–41
2	11	7	10.28 8–16	6.55 5–10	6.50 5–8	7.00 6–8	10.55 10–12	40.88 36–48	40.45 36–42	41.57 38–43
3	4	3	7.43 7–9	5.71 5–7	6.43 5–8	7.43 7–8	14.86 13–16	41.86 37–44	41.25 37–44	42.66 41–44
4	8	5	10.15 7–14	6.38 4–8	6.15 5–7	7.31 6–8	12.92 11–14	42.91 35–48	42.50 35–48	43.60 43–48
5	15	3	10.61 7–15	7.11 5–10	6.28 5–8	7.33 6–11	10.61 9–13	41.94 36–48	42.00 36–48	41.67 41–43
6	15	5	9.70 8–14	8.20 5–11	5.70 5–6	7.25 6–9	12.00 10–14	42.85 39–47	41.87 39–45	45.40 44–47
7	7	9	10.50 6–16	7.00 5–11	6.88 5–9	8.56 7–17	11.44 8–14	44.38 38–56	44.29 41–48	44.66 38–56
8	6	6	12.08 9–14	7.50 5–10	7.66 6–10	8.50 7–10	13.00 11–16	48.74 43–56	48.00 43–56	49.17 45–52
9	8	7	11.21 9–13	7.73 7–9	7.60 6–10	9.47 8–11	13.80 10–17	49.81 46–56	48.50 46–52	51.43 47–56
10	5	7	14.75 11–19	8.91 7–11	9.08 8–11	9.50 8–12	15.33 14–16	57.57 53–67	56.60 55–58	58.28 53–67
11	6	7	15.16 9–24	10.23 6–14	13.07 9–11	11.62 10–13	11.77 16–23	61.85 58–78	66.33 58–78	67.14 62–77
12	5	5	16.20 12–20	15.40 10–22	14.70 12–16	18.60 14–22	23.30 18–28	88.20 79–103	85.40 79–92	91.00 85–103
13	3	8	20.27 13–25	23.20 12–37	27.82 20–40	26.36 16–42	40.54 32–63	138.19 114–176	133.67 121–152	139.88 117–176
14	0	1	20.00	34.00	58.00	39.00	34.00	185.00	.....	185.00

The second aspect concerns the differences in duration of growth between the two sexes of the species. With several exceptions in the case of *Sinea*, the reared series of the two bugs indicate that the females required a significantly greater number of days for their total nymphal growth, and therefore also for the several component instars, than the males (Tables I and II). This intersexual difference in time required to attain adulthood appears to be hereditary and

TABLE II

THE INSTARS OF *Sinea*. DURATION IN DAYS

SERIES	ADULTS REARED		AVERAGE AND EXTREME DURATION, IN DAYS							
	Males	Females	First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Nymphal Stage	Nymphal Males	Nymphal Females
1	8	3	7.18 5–9	4.36 4–5	4.36 4–5	5.73 5–68	8.36 8–9	30.00 28–33	30.1 28–31	29.7 29–30
2	4	5	8.10 7–9	4.44 4–5	4.77 4–7	5.77 5–9	9.33 9–11	32.41 30–41	31.00 30–34	33.60 30–41
3	6	3	8.66 6–12	4.77 4–6	5.00 4–6	6.11 5–10	9.11 8–11	33.65 29–41	35.00 29–41	31.00 29–32
4	8	7	7.53 6–9	5.40 4–8	4.93 4–6	6.27 5–12	9.60 7–18	33.73 28–51	31.13 28–36	36.71 31–51
5	7	8	7.53 6–9	5.73 4–7	5.40 4–8	6.86 5–15	9.80 8–13	35.32 30–51	35.14 30–48	35.50 30–51
6	4	4	6.87 6–9	6.00 5–7	5.75 4–8	6.87 6–10	10.25 8–21	35.74 30–51	36.25 30–51	35.25 33–37
7	10	4	8.00 6–12	5.36 4–8	5.21 4–6	6.64 5–12	11.21 9–25	36.42 29–58	36.7 29–58	35.75 33–39
8	8	6	8.50 6–15	5.50 5–8	5.36 4–7	6.64 5–11	12.86 8–31	38.86 30–64	40.50 30–64	36.66 31.46
9	7	2	7.22 6–9	6.11 4–8	6.22 4–8	8.44 6–14	13.33 8–25	41.32 30–58	43.86 35–58	41.50 30–53
10	10	4	10.43 8–17	7.79 6–9	5.86 5–7	9.21 6–15	12.50 8–19	45.79 37–60	47.30 39–60	42.00 37.46
11	7	7	9.43 5–13	7.50 5–10	6.14 5–8	8.64 5–16	14.71 9–26	46.42 30–63	41.86 30–51	51.00 39.63
12	13	6	10.53 7–15	7.15 4–9	6.26 4–10	8.79 5–13	13.89 8–31	46.62 32–69	43.92 32–55	52.50 46–69
13	8	8	10.10 7–12	7.25 6–8	6.25 5–8	10.00 5–16	14.12 9–22	47.72 35–60	46.25 35–60	49.25 44–58
14	9	9	11.55 9–18	7.61 5–9	6.17 5–7	9.94 7–12	16.67 11–24	51.94 46–58	50.67 46–58	53.20 48–55
15	2	2	6.00 5–7	8.00 7–9	10.00 8–12	14.00 11–21	18.25 13–24	56.25 49–72	50.00 49–51	62.5 53–72
16	1	0	11.00	8.00	14.00	7.00	22.00	62.00	62.00	00.00
17	10	1	10.18 8–12	9.09 7–12	10.82 9–14	15.36 10–22	25.36 15–40	70.81 52–95	70.60 52.95	63.00 .....
18	2	4	11.00 9–14	8.40 5–11	13.00 7–18	16.80 11–22	21.00 19–23	70.20 55–82	55.00 55–55	80.30 79–82
19	3	7	12.10 10–16	10.30 8–13	12.40 5–21	19.80 10–33	27.00 19–48	81.60 50–108	80.33 64–89	82.14 59–108

associated with the normal difference in bodily bulk, the females of both species being the larger. The data for *Phymata pennsylvanica* are to be taken as the more nearly correct, for the reason that the performance of this species is more

TABLE III

Phymata. Duration of Instars, in Per Cents

Series	What Per Cent Each Instar Contributes to the Duration of the Entire Nymphal Life				
	First	Second	Third	Fourth	Fifth
1	20.35	15.11	15.38	19.23	29.95
2	25.14	16.02	15.90	17.12	25.80
3	17.75	13.64	15.36	17.75	35.49
4	23.65	14.87	14.33	17.03	30.11
5	25.27	16.95	14.91	17.48	25.30
6	22.63	19.14	13.30	16.92	28.00
7	23.62	15.77	15.50	19.29	25.78
8	24.78	15.38	15.72	17.44	26.67
9	22.51	15.52	15.26	19.01	27.71
10	25.62	15.48	15.77	16.50	26.63
11	24.51	16.54	21.46	18.72	19.30
12	18.37	17.46	16.66	21.09	26.42
13	14.67	16.79	20.13	19.08	29.34
14	10.81	18.38	31.35	21.08	18.38

TABLE IV

Sinea. Duration of Instars, in Per Cents

Series	What Per Cent Each Instar Contributes to the Duration of the Entire Nymphal Life				
	First	Second	Third	Fourth	Fifth
1	23.93	14.53	14.53	19.10	27.87
2	24.99	13.70	14.71	17.80	28.79
3	25.73	14.17	14.86	18.16	27.07
4	22.32	16.01	14.61	18.59	28.46
5	21.32	16.22	15.29	19.42	27.75
6	19.22	16.79	16.09	19.22	28.68
7	21.97	14.72	14.31	18.23	30.78
8	21.82	14.15	13.79	17.09	33.09
9	17.47	14.78	15.05	20.42	32.26
10	22.78	17.01	12.79	20.12	27.30
11	20.31	16.16	13.23	18.61	31.69
12	22.59	15.34	13.42	18.86	29.79
13	21.16	15.19	13.10	20.95	29.59
14	22.24	14.65	11.89	19.14	32.09
15	10.66	14.22	17.78	24.89	32.44
16	17.74	12.90	22.58	11.29	35.48
17	14.38	12.84	15.28	21.69	35.81
18	15.67	11.91	18.52	23.93	29.91
19	14.83	12.62	15.20	24.26	33.09

nearly normal in captivity than that of *Sinea*, *Phymata* being decidedly more efficient in capturing both the small *Drosophila* and the larger *Musca*, and therefore comes closer to realizing its inherent potentialities for growth.

The third topic suggested by the tabulated data concerns the question whether the instars of these insects possess what may be described as an ideal durational pattern, and, if so, what are its characteristics? by "ideal durational pattern" I mean (a) the most rapid development on the one hand, and (b) the most prolonged development of which the species is capable under a given set of environmental and hereditary conditions. Such a pattern implies that not any one or two, but *all* the instars of the nymphal life are completed in (a) the least amount of time or (b) the maximum amount of time possible for the species. It represents, on the one hand, the irreducible minimum, and, on the other, the inextensible maximum time period in which the species can complete its growth from the event of hatching to transformation to the adult form. The value of the pattern is not fixed, set or absolute, for it changes with alteration of the environment, particularly food, temperature and relative humidity, and the peculiar combination of hereditary traits possessed by the individuals subjected to experimentation.

What actual values enter concretely into the composition of these ideal patterns of instars in the cases of *Phymata* and *Sinea?* Too few data are at hand to permit further consideration of the maximum pattern, which is secured by use of the most attenuated diet and the most adverse temperatures and humidities the species can tolerate and still grow to adulthood. However, the data provided in the most adequately nourished series of *Phymata* (Ser. 1, Table III) affords some idea of the features that possibly characterize the ideal minimum developmental pattern of this species. Expressed in terms of per cents and round numbers, this pattern is 20, 15, 15, 20, and 30 for the five instars, respectively. Here the first and fourth instars are of equal duration, as are also the second and the third, while the fifth is equal to the second and the third combined, and one-half longer than either the first or fourth.

It will be observed from series 1 to 6, Table IV, that the minimum pattern for *Sinea* conforms in some respects to that of *Phymata* just described, but differs from it in others. While the second and third are approximately equal and also the shortest of the five instars, and the fifth required about as much time as the second and third combined, the fifth is relatively shorter than either the first or the fourth. Are these differences between the minimum patterns of the two species inherent and characteristic, or are they results of unequal dietaries? I am inclined to the latter view for the following reasons.

First, the proportionately greater duration of the first instar of *Sinea* may arise from a degree of ineptitude in capturing *Drosophila* and also may be due to a supply of nutrient known to be carried over into the nymph from the egg, and which effects a delay in growth and thus a prolongation of the instar. On the other hand, the relatively greater length of the fifth instar is probably the result of (a) the inability of the nymphs in that stadium to secure enough *Drosophila* and (b) their disposition to avoid the boisterous *Musca*, with the consequence that *Sinea* fails to ingest sufficient food to meet its needs for maximum growth and to realize its ideal time pattern under the captive conditions imposed.

The fourth feature of instars indicated by the tabulated data relates to the number of instars that composes the total nymphal stage. In the course of rearing 393 adult bugs individually, I had an opportunity to determine the number of growth periods with considerable precision. Despite the extreme variation secured in length of nymphal stages due to the great range of dietary imposed on the several series of *Phymata* and *Sinea*, only one individual positively departed from the usual number of five instars by adding a sixth. The exception was a male *Sinea* that was provided a maximum number of *Drosophila* each day throughout his nymphal life. The duration of the total nymphal period was not significantly increased by the added instar, it being 49 days. Seven other males, of the same series and dietary, completed their five instars in an average of 44 days, with

extremes of 35 and 58. That is, the addition of an instar had the effect of abbreviating the inter-molt periods rather than increasing the length of the over-all nymphal stage.

In conclusion, I should like to suggest further studies on the question of insectan instars. Does the pattern generally follow a common design, in which the first and last instars are longer than the intermediate ones? What underlying structures or processes, possibly such as cuticular characters, glandular functions, cell division and rate of ingestion, determine the relative per cent of time each instar consumes in the course of nymphal growth?