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LARVAL DEVELOPMENT OF *SESIA SININGENSIS* (HSU) IN NORTHERN CHINA (LEPIDOPTERA: SESIIDAE)

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ABSTRACT.– The eight larval instars of *Sesia siningensis* (Hsu) were determined by systematic sampling and rearing in the field. The rate of growth of the larvae was studied by means of zero mark, and succession between groups of larvae of different years was observed by field sampling.

KEY WORDS: biology, Cossidae, *Cossus*, group succession, growth rhythm, immatures, larvae, life history.

Research on larval instars of sesiid borers is very difficult. Little information on their development is available because of the longer life cycle and their reclusive behavior. Tsai *et al.* (1974) examined the larval instars of *Cossus cossus* (Linnaeus) (Cossidae) by rearing them in the laboratory. They did not finish that experiment completely. The food quality did not fully meet the physiological needs of the larvae. As a result, growth stagnated or was abnormal, and the rearing period was excessive. In 1984, the number of larval instars of *Sesia siningensis* (Hsu) were noted, but not described in any detail (Xu *et al.*, 1984). Therefore, in this paper we describe the reliability of a method for determining instars of borers, usuing *S. siningensis* as an example. Arita *et al.* (1994) described and illustrated the mature larva and pupa of *S. siningensis*.

To study wood borers, which have extended life cycles, it is necessary to understand accurately the growth rhythm of larvae through each year; *S. siningensis* was observed during 1987-90.

Material and Methods

1. Larvae were repeatedly collected from poplar trunks which were infested with borers during this research. The larval head widths from hatchlings to fully grown larvae were measured and recorded on a coordinate figure. A series of successive peaks are shown. The boundaries of various peak areas are the lowest points between two successive peaks on the abscissa. This demonstrates the disparity value of the mean head width from adjacent areas. These peak areas of head width should corresponded to the number of larval instars.
2. Healthy larvae of varying sizes were returned into inoculate holes on the poplar tree separately after measuring the head widths. Once a week, the feces were cleaned from these holes into plastic bags. In the frass, we checked for head capsules and determined their width.
3. Poplars of appropriate age (about 10 years) were selected. New boring points of early borer stages were located on the trunks and marked from June to September. Then, they were sampled in groups before they overwintered in early and mid October of the 1st year and 2nd year. The head width of each sampled larva was measured. This method is called "zero mark." During the adult emergence period, we examined once a day for pupal skins protruding at the marked points. Healthy larvae of 2nd year sampling were reared separately on other trees. Through the adult emergence period during the 3rd year, we examined the pupal skins at the inoculate holes once a day.
4. Before larval overwintering, a large number of larvae of varying sizes was collected at random in the field and measured individually.

Results and Analysis

1. The distribution changes on the larval head widths: according to the measurements of 408 larvae of *S. siningensis,* there are eight peak areas successively on the distribution curve (Fig. 1 and Table 1).
2. The results of rearing on the trees: 21 larvae were successively reared through 1-2 additional instars (16 molted once, 5 molted twice), providing 26 additional measurements (Table 2). Thus, it is shown, for the most part, that the head width after each molt corresponds to the next peak area in about 92.3% of the total, slightly beyond in only 7.69% (Table 3).

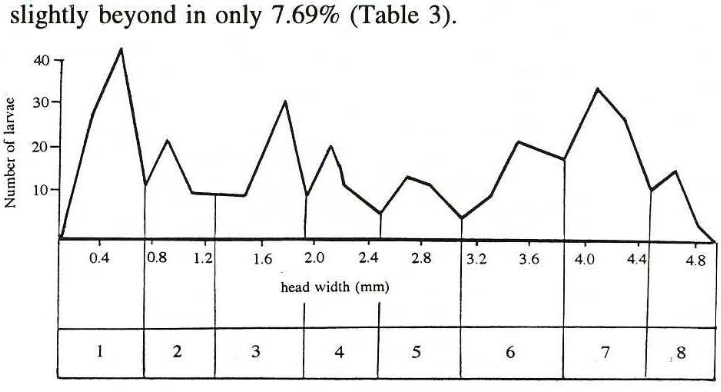

Fig. 1. Distribution of larval head widths from hatching to last instar.

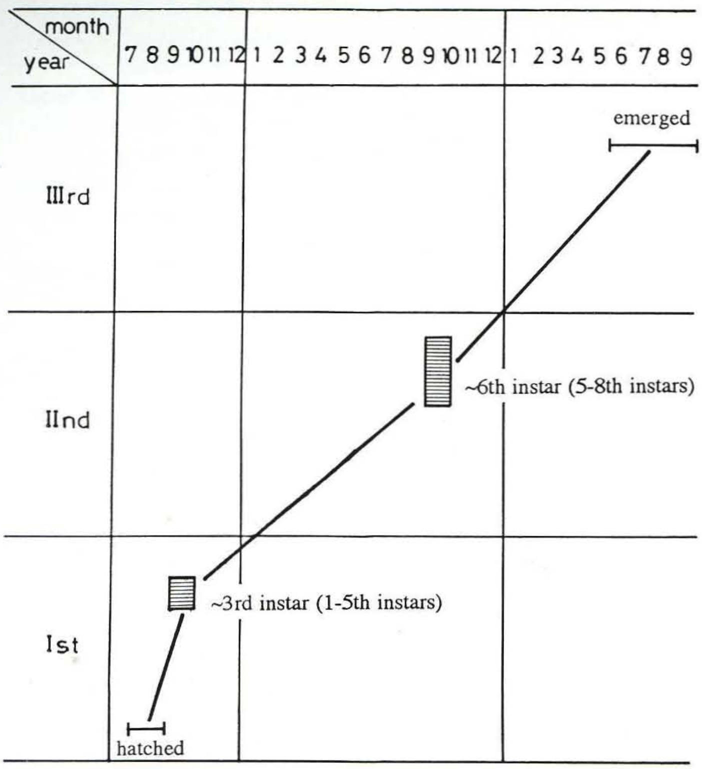

Fig. 2. The rhythm of larval growth (Xining, China).

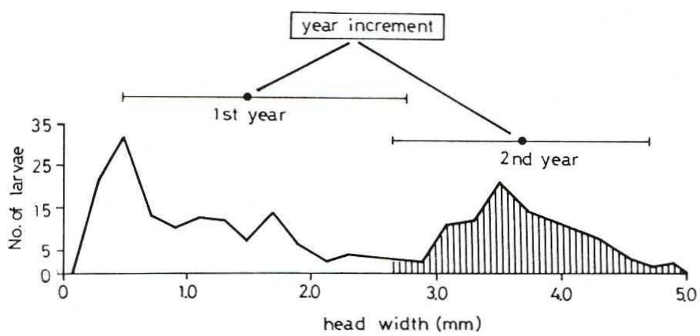

Fig. 3. The survey of larval year group before their overwintered (October 1989, Xining, China).

It is, thus, clear that the changes between the peak areas of widths compared with the molting larvae are nearly identical. Therefore, we consider that the number of peak areas on the distribution curve of head widths should be equal to that of the number of larval instars. We conclude that the larval development of *S. siningensis* involves eight instars.

3. The rate of growth of the larvae (growth rhythm): the growth of larvae is relatively slow from the early boring stage to overwintering (1-5 instars) in the 1st year (Table 4). The mean of head width is only 1.44mm (0.45-2.70mm), indicating about 3rd instar. In the 2nd year up to October, the increments vigorously. The mean of head widths is 3.17mm (2.61-4.68mm), mostly 6th instar (5-8 instars). From late May to late September of 3rd year, adults emerged (Fig. 2).

On the basis of Table 4, the rate of growth of larvae beginning at the hatching stage is illustrated in Fig. 2. It is clear that *S. siningensis* takes two years to complete its life cycle, or it may extend over three years in Xining, China.

TABLE 1. Larval head width distribution for *Sesia siningensis* (1978-80)

head width group (mm)	mid-value of width group (mm)	No. of larvae sampled	peak area of head width(mm)	mean value of head width (mm)	increment of mean value (mm)
0.21-0.40	0.3	27			
0.41-0.60	0.5	42	1	0.457±0.014	
0.61-0.80	0.7	10			0.516
0.81-1.00	0.9	23	2	0.973±0.028	
1.01-1.20	1.1	9			
1.21-1.40	1.3	10			0.615
1.41-1.60	1.5	10	3	1.624±0.025	
1.61-1.80	1.7	30			
1.81-2.00	1.9	8			0.552
2.01-2.20	2.1	21	4	2.170±0.027	
2.21-2.40	2.3	10			
2.41-2.60	2.5	7			0.590
2.61-2.80	2.7	14	5	2.766±0.031	
2.81-3.00	2.9	12			
3.01-3.20	3.1	5			0.834
3.21-3.40	3.3	10			
3.41-3.60	3.5	23	6	3.600±0.027	
3.61-3.80	3.7	21			
3.81-4.00	3.9	19			0.567
4.01-4.20	4.1	36	7	4.167±0.019	
4.21-4.40	4.3	29			
4.41-4.60	4.5	11			0.487
4.61-4.80	4.7	18	8	4.650±0.014	
4.81-5.00	4.9	3			
		$\overline{x}$			0.670

TABLE 2. Larval exuviation records for *Sesia siningensis* (1978-80)

Larvae sampled	Head width during inoculation (mm)	After exuviation Head width (mm)	Increment (mm)
1	1.71	2.42	0.72
2	0.36	0.72	0.36
3	0.45	0.99	0.54
4	0.45	0.99	0.54
5	0.36	0.90	0.54
6	2.43	3.33	0.90
7	1.17	1.89	0.72
8	1.62	2.34	0.72
9	2.97	3.78	0.81
10	2.97	3.96	0.99
11	2.16	2.97	0.81
12	3.15	4.05	0.90
13	2.52	3.42	0.90
14	1.35	2.25	0.90
15	2.07	2.97	0.90
16	2.16	3.06	0.90
17	0.81	1.62	0.81
18	2.61	3.24	0.63
19	2.79	3.24	0.45
20	2.97	3.60	0.63
21	2.52	3.33	0.81
6	3.33	3.87	0.54
15	2.97	3.69	0.72
16	3.06	3.69	0.63
18	3.24	3.96	0.72
20	3.60	4.32	0.72
		$\overline{x}$	0.72

TABLE 3. Comparisons between peak areas and exuviation changes of head width in *Sesia siningensis* (1978-80)

peak area	1	2	3	4	5	6	7	8
head width (mm)	0.3-0.7	0.7-1.3	1.3-1.9	1.9-2.5	2.5-3.1	3.1-3.9	3.9-4.5	4.5-4.9
	0.36	0.72						
	0.36	0.90						
	0.45	0.99						
	0.45	0.99						
		0.81	1.62					
		1.17	1.89					
exuviation			1.35	2.25				
change			1.62	2.34				
of head width			1.71	2.42				
(mm)				2.07	2.97	3.69		
				2.16	3.06	3.69		
				2.16	2.97			
				2.43		3.33 3.87		
					2.52	3.33		
					2.52	3.42		
					2.61	3.24		
					2.79	3.24	3.96	
					2.97	3.78		
					2.97		3.96	
					2.97	3.60	4.32	
						3.15	4.05	

TABLE 4. Survey results for larval growth of *Sesia siningensis* (1978-80) (sampled larvae are reared again in the tree during the second winter)

Yr	Head width before overwintering or pupation (mm)	Instar	Larval samples	Average for larvae sampled (mm)	Mean head width (mm)	Number of emergences
1st	0.45-0.72	1	5	39	1.44	0
	0.81-1.08	2	15			
	1.35-1.89	3	5			
	1.98-2.34	4	9			
	2.52-2.70	5	4			
2nd	2.61-3.06	5	2	35	3.71	0
	3.15-3.87	6	19			
	3.96-4.41	7	13			
	4.68	8	1			
3rd	2.61-3.06	5	2	28	3.66	28
	3.15-3.87	6	19			
	3.96-4.41	7	6			
	4.68	8	1			

4. The year-group succession of the larvae: From larval hatching to adult emergence, the larval development rewuires at least one year. Therefore, adults are present each year, due to the succession between different year-groups.

The head widths of 256 larvae sampled at random from the field before larval overwintering (1979) were divided into two groups on the abscissa. Because the head widths of the smaller group of the 1st year larvae are identical, we call this group the "1st year group." Since the size of the larger group of the 2nd year larvae are similar, it is called the "2nd year group" (Fig. 3). The larval group before pupation in the 3rd year is called the "3rd year group. "

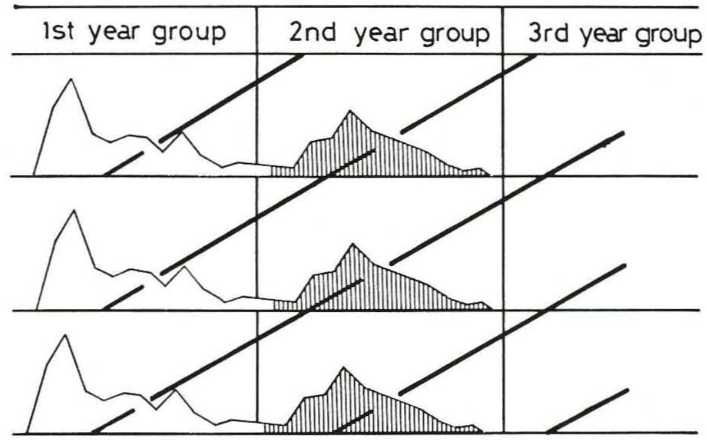

Fig. 4. Succession by year groups for *Sesia siningensis* (Xining, China).

Fig. 4 is derived from computations in Fig. 3. It clearly illustrates the succession process between these year-groups of larvae from year to year.

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LITERATURE CITED

Arita, Y., Z.-G. Xu, and Y.-Q. Liu
1994. Descriptions of immature stages of *Sesia siningensis* (Hsu) (Lepidoptera: Sesiidae). *Trans. Shikoku Ent. Soc.* (Matsuyama), 20:117-123.

Tsai, C.-S., C.-K. Hsu, and H.-F. Lu
1974. A preliminary study on the wood moth *Cossus cossus* L. in Chinghai. *Acta Ent. Sinica* (Beijing), 17:385-395. [In Chinese; English abstract]

Xu, Z.-G., J. Li, Y. Cai, H. Wu, and X. Gu
1984. Bionomics and control measures of the poplar-trunk clearwing (*Sphecia siningensis* Hsu). *Scient. Silvae Sinicae* (Beijing), 20:165- 170. [In Chinese; English abstract]

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BOOK REVIEWS

A PHYLOGENETIC ANALYSIS OF THE MAJOR LINEAGES OF THE CRAMBIINAE AND OF THE GENERA OF CRAMBINI OF NORTH AMERICA (LEPIDOPTERA: PYRALIDAE)

by Bernard Landry

1995. Associated Publishers, Gainesville, Florida, USA. 15 x 23 cm, 242 pp. Cloth cover, $45.00. ISBN: 1-56665-056-9.
Available in the USA from Flora & Fauna Books, P. O. Box 15718, Gainesville, FL 32604.

This work provides a significant generic revision of the North American Crambiinae, one of the more economic groups of Pyralidae. Two new tribes are described, along with 2 new genera, and 3 new species are also described. Several genera and 1 tribe have revised status. A revised species list is also included for the Nearctic Crambinae, although all species are only listed alphabetically. The character analysis used only adult characters. The tribes are all redefined and diagnosed, and included genera are noted for the world fauna of each tribe. A key to Nearctic genera is provided for the tribe Crambini. The Crambini genera are each discussed in detail. Larvae, when known, are noted for each of the genera discussed. The work is carefully done, well illustrated and well worth having for reference to this important group of pyralids.

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SWALLOWTAIL BUTTERFLIES: their Ecology and Evolutionary Biology

edited by J. Mark Scriber, Yoshitaka Tsubaki, and Robert C. Lederhouse

1995. Scientific Publishers, P. O. Box 15718, Gainesville, FL 32604. 21 x 28 cm, 459 pp (incl. 32 color plates). Cloth, $65.00 ISBN: 0-945417-89-6.

The 35 chapters in this remarkable compendium of current research on swallowtail butterflies worldwide cover a diverse range of topics, from chemical ecology to their evolution, and even an article about butterfly postage stamps. The volume is the result of a 1992 conference in Yokohama, Japan, attended by a host of specialists from around the world. The 42 authors of the included articles are specialists in all aspects of insect biology and swallowtails, bringing together their expertise in a unique and important summary of current knowledge of these well-known butterflies. Anyone interested in swallowtails cannot fail to miss having this volume for reference and frequent perusal of the various fascinating subjects. Although some articles are quite technical, there is information available for anyone interested in the biology and systematics of these butterflies worldwide.

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THE OWLET MOTHS OF OHIO. Order Lepidoptera, Family Noctuidae

by Roy W. Rings, Eric H. Metzler, Fred J. Arnold, and David H. Harris

1992. Ohio Biological Survey, c/o Ohio State University, 1315 Kinnear Rd., Columbus, Ohio 43212-1192. 21 x 28 cm, 219 pp, (incl. 8 halftone plates and 8 color plates). Soft cover, $20.00 ISBN: 0-86727-110-8. *Bulletin Ohio Biol. Survey* (n.s.), no. 9(2).

This book on the owlet moths is part of a new series on the fauna of Ohio, following a similar work on the butterflies of Ohio. The work represents the first major new illustrated work on Noctuidae since the time of J. B. Smith. Other than Kimball's illustrated catalog of Lepidoptera for Florida and Covell's moth guide for eastern North American species, there have been few works available that the amateur could turn to to identify owlet moths. The present work covers many species also found in other areas of the eastern United States and Canada.

The 8 full-size color plates in this large format book provide excellent illustrations for 238 species of Noctuidae. The illustrations also include 8 halftone plates showing photographs of eggs and larvae of several species. The book as a whole treats 708 species recorded for Ohio. Each species is treated with a uniform text resulting in a kind of illustrated catalog, giving basic information on current status in Ohio, the history of collection dates, host data if known, and a brief note on the original description or identification guidelines. Each species also has a small Ohio distribution map, showing the counties of recorded occurrence, and a bar-graph showing flight periods for northern and southern Ohio. The end of the book has a section on species that could become endangered, followed by other sections on special Ohio habitats, migrant species, species recorded in error in the past, and hostplants. There is an index to recorded hostplants, a glossary, a bibliography, and an index to species.

The illustrations, distribution and hostplant data of this book, provide an excellent compendium on this important group of moths, and at a modest price. It will be of use to anyone from most areas of eastern North America interested in these moths, since few of the species treated are restricted to the Ohio Valley.

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