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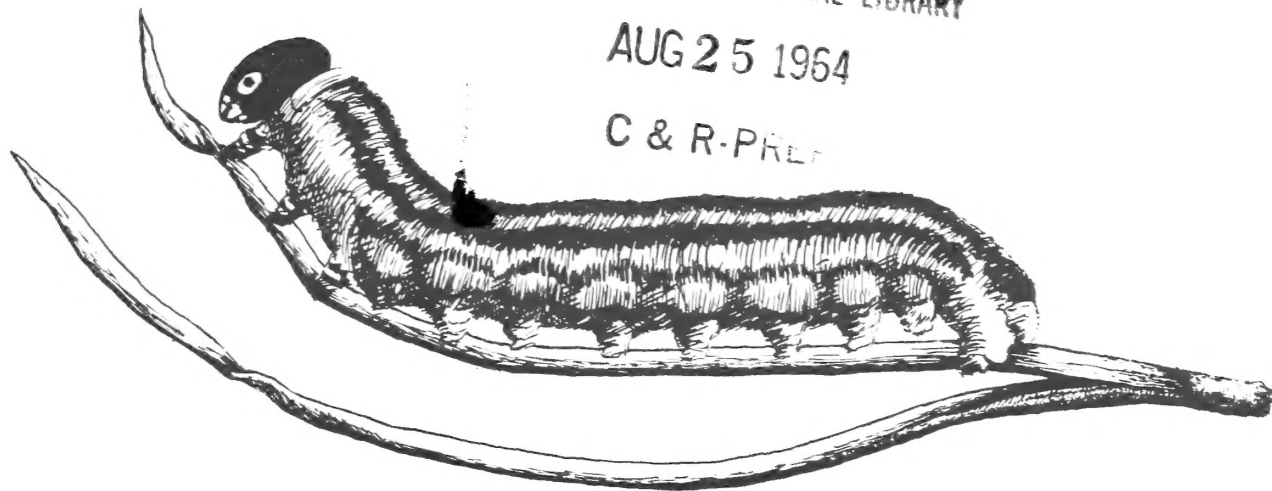
Studies on the Life History of the Virginia Pine Sawfly

(*Neodiprion pratti* Dyar)

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Studies on the Life History of the

Virginia Pine Sawfly,

Neodiprion pratti Dyar

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The Virginia pine sawfly, *Neodiprion pratti*, has been abundant in Maryland throughout the past 10 years (Freeman and Morris 1962). Because of its availability and because it represents an important group of forest pests, it was selected as a principal test insect for physiology studies, which were initiated at the Forest Insect Laboratory, Beltsville, Md., in 1962. In order to utilize this sawfly as a test insect, information on certain aspects of the life history was needed. Past reports (Schaffner 1943 and Hetrick 1956) gave only a brief account of the life history. Recently, a more detailed account was published (Morris, Schroeder, and Bobb 1963).

The present paper describes life history studies conducted during 1962 and 1963. Major objectives of the studies were to (1) find methods for separating the larval instars; (2) determine the intraspecific variation in larval color pattern; (3) determine the field occurrence of the various stages at Beltsville; (4) determine whether cocoon size could be used for sexing; and (5) determine whether eggs pass through diapause.

METHODS

The head capsule widths of about 2,000 larvae and prepupae were measured and frequency histograms were plotted. Over 100 larvae were reared individually, and daily observations were made of each larva. As the larvae reached the prepupal stage, they were placed in separate containers with moist sand to allow them to spin cocoons; after 2 days, each cocoon was collected, measured (to nearest 0.5 mm. in length and width), and stored individually. Development within the cocoons was followed with periodic X-radiograms, which were taken with a General Electric (Maxima R100) X-ray Unit at 15 kilovolts, 5 milliamps and 10 seconds, using Kodak no-green, X-ray film.

Adult characteristics, particularly colors, were examined and an attempt was made to correlate them with markings of the larvae from which they had matured. The sex of each adult was compared with the size of its respective cocoon. Several workers (Kapler and Benjamin 1960, Benjamin 1955, and Dahlsten 1961) have reported that the female cocoons of several species of *Neodiprion* are longer than those of the respective males. In such species, cocoon size is an easy method for sexing and can be used for determining the sex ratio.

The occurrence of the various stages under field conditions at Beltsville was followed for 1½ years. Larvae were collected twice a week throughout the feeding period. Eggs were collected in October 1962, shortly after being laid; they were brought into the laboratory and held at room temperature (65° to 70° F.) in order to determine whether hatching would occur without exposure to low temperatures.

RESULTS AND DISCUSSION

Larval Head Capsule Measurements

Figure 1 shows the distribution of head capsule widths of 1,830 larvae (feeding instars). The first and second instars are discrete, but a slight overlap exists between the third and fourth instars and a wider zone of overlap exists between the fourth and fifth instars. Figure 2 shows the considerable overlap of head capsule width distributions that existed between prepupae that passed through only four feeding instars and those that passed through five. In estimating the means and standard deviations, the lowest frequencies under each peak (fig. 1) were used as the range limits for that instar. The mean range, standard deviation, and sample size of each instar are given in table 1. These values are quite similar to those reported by other workers for this species (table 2).

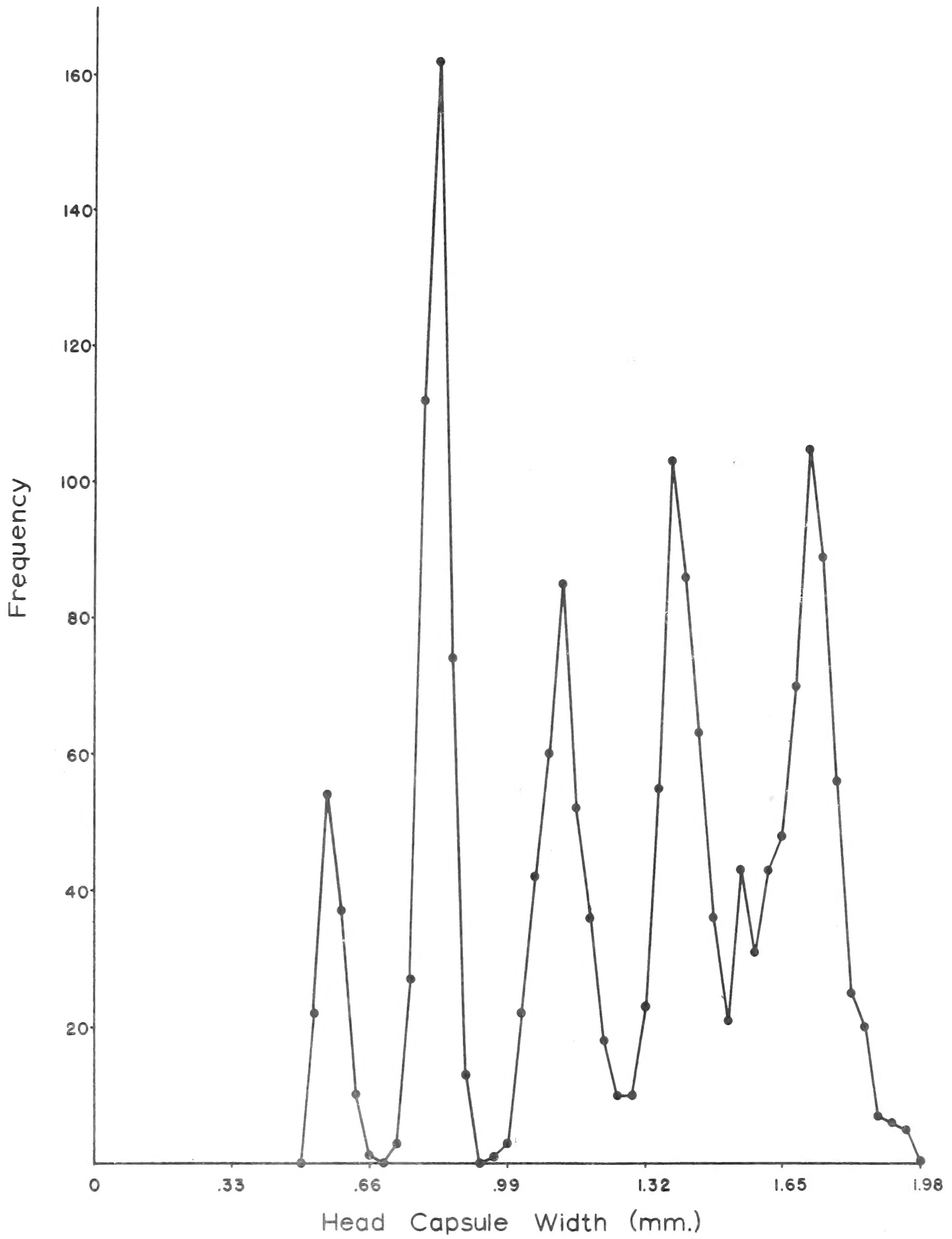


FIGURE 1.—Head capsule width distribution of 1,830 larvae (five feeding instars).

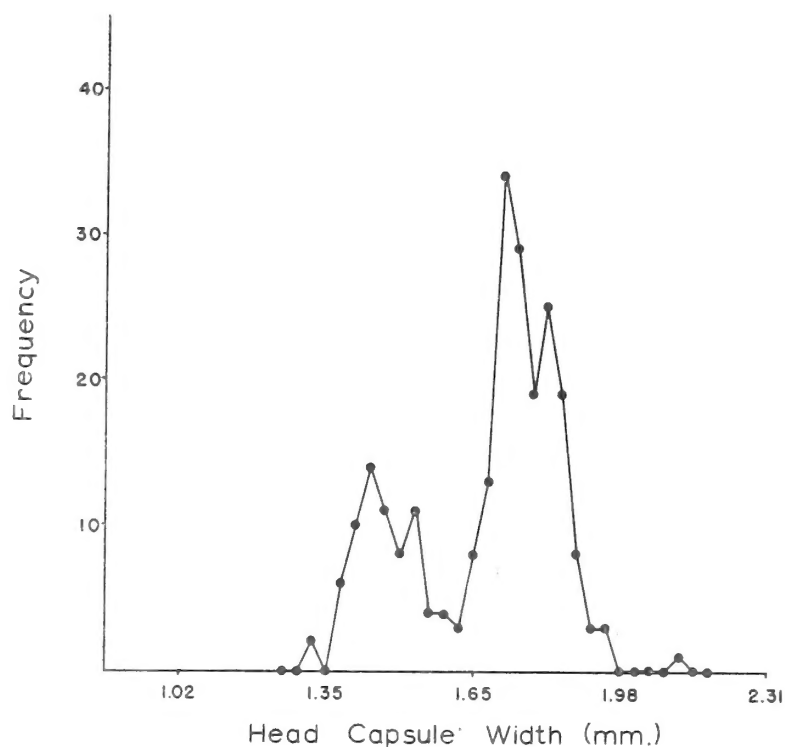


FIGURE 2.—Head capsule width distribution of 238 prepupae.

The instar of most larvae and prepupae can readily be determined from head capsule width; however, within certain ranges, the overlap is too great to use this character as a sole criterion of instar.

Larval Color Patterns

General descriptions of the larval markings of this species have been reported under several synonyms: *Neodiprion banksianae* Roh. (Atwood and Peck 1943); *N. dyari* Roh. (Craighead 1950, Peterson 1948, p. 264); *N. pratti pratti* Dyar (Ross 1955, Hetrick 1956); *N. pratti paradoxicus* Dyar and *N. pratti banksianae* (Ross 1955). The following descriptions of larval color patterns characterize the variations observed in local populations. They are based primarily on daily records kept on 110 individually reared larvae. The terminology used is that of Middleton (1921). Colors of the larval markings were often deceiving, and caution had to be used in describing them.

TABLE 1.—Head capsule widths of larvae of *Neodiprion pratti* (Dyar) (Beltsville)

Feeding instar	Larvae measured	Head capsule widths		
		Mean	Range	Standard deviation
	<i>Number</i>	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>
1 -----	124	0.57	0.43-0.69	0.03
2 -----	391	.82	.73- .92	.03
3 -----	329	1.12	.96-1.25	.06
4 -----	403	1.41	1.29-1.52	.05
5 -----	583	1.71	1.55-1.95	.09
Fifth instar prepupae ----	73	1.46	1.29-1.62	.09
Sixth instar prepupae ----	165	1.77	1.62-2.11	.08

TABLE 2.—Comparison of average head capsule widths of *Neodiprion pratti* larvae obtained by different workers

Feeding instar	Present work	Ghent (1956)	Morris et al. (1963)
	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>
1 -----	0.57	0.58	0.61
2 -----	.82	.84	.90
3 -----	1.12	1.15	1.14
4 -----	1.41	1.44	1.45
5 -----	1.71	1.73	1.74
Fifth instar prepupae ----	1.46	—	1.44
Sixth instar prepupae ----	1.77	—	1.73

In general, the larval integument is yellow and is figured with various black markings. Green materials in the gut give a light green appearance to the body and to the light black stripes or spots; this is particularly apparent toward the ends of the larval stadia when the markings are usually faded. Markings that appeared light green to the naked eye were actually light black when viewed with a dissecting microscope.

First Instar

The recently hatched larva of the Virginia pine sawfly is about 3.5 mm. in length, and it has a white head capsule, black eye rings, and brown mouth parts. Within a few hours the head capsule and sclerotized parts of the thoracic legs turn black. Such color changes are also characteristic for recently molted larvae of each feeding instar. Dark circumvential lines run, approximately, from one spiracular line over the tergum to the opposite spiracular line, giving a gray cast to the tergum. The subspiracular part of the body is a light, yellow green. Within a few days the dark lines fade away, and the entire body appears yellow green. At this time the position of each spiracle on the abdominal segments is denoted by a pair of small, black atrial lips. No spines are present on the tergum, preepipleurites, or postepipleurites during this stadium.

Second Instar

Recently molted second instar larvae are about 4 mm. in length. The tergum has a gray-green cast, which is divided by a faint yellow, median-dorsal line. In some larvae, two narrow stripes are apparent on each side of the median-dorsal line, but often these are blended together into one gray-green area as described above. Each segment is figured with three rows of short, black spines, which run from one spiracular line over the tergum to the opposite spiracular line. The center row ends just above each spiracle, and there are one or two spines just anterior to the ends of the posterior row so that it appears to end in a double row on each side. Numerous spines are present on the epiproct. There is a group of four to seven spines on each preepipleurite. The same pattern of spines is also characteristic for the subsequent feeding instars. The atrial lips of the spiracles are less distinct than in the first instar. At the end of the stadium the larvae are about 7 mm. long, and the markings described above are either faint or absent.

Third Instar

Larvae in this instar bear two light black, subdorsal stripes (often appearing green to the naked eye), one stripe on either side of the

median dorsal line. A light, black supraspiracular stripe is also present on each side and joins the subdorsal stripe in the tenth abdominal segment. The tracheal trunk connecting the spiracles appears as a white line. At first all four of these stripes are distinct, but after 24 to 28 hours the subdorsal and supraspiracular stripes blend together in the second through fourth or fifth abdominal segments. There are usually two small, gray spots on the epiproct, one on either side of the median dorsal line. On some larvae these spots are fused. The integumental spines are larger and darker than in the second instar. Gradually the stripes and spots fade and frequently disappear. Larvae increase to about 11 mm. in length by the end of the stadium.

Larger Feeding Instars

The markings of fourth and fifth instar larvae are quite variable but, within each instar, two general types or patterns are apparent; these types are hereafter referred to as spotted and striped. At Beltsville, in 1962 and 1963, about 75 percent of the mature larvae were of the spotted type and 25 percent were striped.

FOURTH INSTAR.—These larvae are usually about 11 to 12 mm. long at the beginning of the stadium, and they are either striped or spotted, as follows:

1. *Striped larvae*: These larvae have a subdorsal stripe and a supraspiracular stripe on either side of the body, which extend from the prothorax to the tenth abdominal segment. Some larvae have spots (one per segment) along the spiracular level from the mesothorax to the eighth abdominal segment; in other larvae these spots may be joined into a narrow spiracular stripe. Such spiracular markings are absent in most striped, fourth instar larvae. Spots on the postepipleurites of abdominal segments one through eight are common; these are almost joined and often appear as a postepipleural stripe. In some striped larvae postepipleural markings are very faint, and in others they are entirely missing. A few larvae have faint spots above and below the preepipleurites, but these are not common. On each side of the epiproct is a black spot; on some larvae, these are fused into a single dark area.

2. *Spotted larvae*: These larvae have a subdorsal stripe almost always present on either side of the median dorsal line. Supraspiracular markings are quite variable. In recently molted larvae, a faint supraspiracular stripe is sometimes present, but later this breaks into individual spots. The supraspiracular spots on the mesa and metathoracic segments are sometimes joined, but separate spots occur on the abdominal segments. Frequently only one or a

few of these spots are present, and on some larvae they are entirely missing. Postepipleural spots on abdominal segments one through eight are usually faint or absent. Black or gray spots on the epiproct are characteristic but often very faded by the end of the stadium. No difference could be found between fourth instar larvae that were destined to become prepupae and those which would pass through an additional feeding instar.

FIFTH INSTAR.—These instars are usually 15 to 17 mm. long at the beginning of the stadium and increase to about 22 mm. before molting. Like fourth instar larvae, they are either striped or spotted (fig. 3) as follows:

1. *Striped larvae*: Prominent, dark subdorsal and supraspiracular stripes are present on each side of the body. Spiracular spots are usually present on abdominal segments one through eight; they are commonly fainter than the stripes; and on some larvae are joined into a faint, narrow spiracular stripe. Postepipleural spots are elongate and almost joined and occur on abdominal segments one through eight. Small postepipleural spots sometimes are present on the thoracic segments, and faint spots are sometimes evident around each preepipleurite. Two large black areas cover most of the epiproct; on some larvae, these are fused into a single marking (fig. 3, C).

2. *Spotted larvae*: Subdorsal stripes are almost always present on these larvae. The occurrence of supraspiracular spots is quite variable, but some are usually present. Some larvae have separate supraspiracular spots on the mesa and metathorax and abdominal segments one through nine.

Often, the supraspiracular spots on the thorax (mesa and meta) and first abdominal segment are joined into a short line, and the other abdominal spots are separate. Frequently the supraspiracular spots on abdominal segments two through five are very faint or missing and in some larvae only one or a few such spots are present (fig. 3A, B). Postepipleural spots are usually present on abdominal segment one through nine but are typically faint and much smaller than on striped larvae. Two relatively large black areas, occasionally fused, are always present on the epiproct.

Prepupae

Prepupae that form from the larvae that pass through only four feeding instars are smaller than those from larvae passing through five feeding instars. Inasmuch as the two size ranges overlap, many prepupae cannot be placed into either of the two categories on the basis of size alone. Furthermore, no differences in markings were found that could be used either to separate prepupae in these two categories, or to separate prepupae that formed

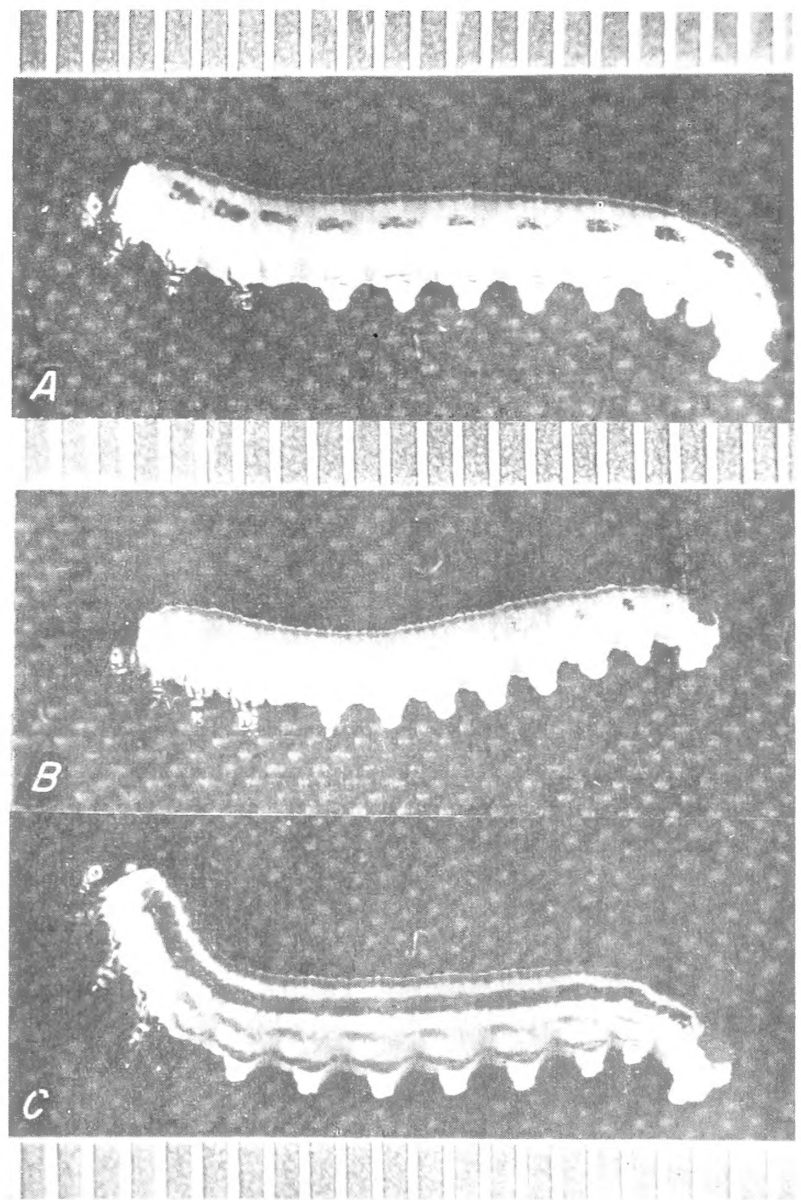


FIGURE 3.—Typical color patterns for fifth instar *Neodiprion pratti* larvae at Beltsville: (A), Spotted larva with full complement of supraspiracular spots; (B), spotted larva with only a few supraspiracular spots; and (C), striped larva. (Each division on the scale represents 1 mm.)

from spotted larvae from those that formed from striped larvae.

The head capsule of a prepupa is pale green to light gray; the eyes are pale; the eye rings are black and the mouth parts brown. The atrial lips of the spiracles are whitish. The unfigured areas of the dorsum are usually pale green but, on some larvae, a pinkish cast is apparent. The sternum is lighter than the dorsum and often appears yellow. No dark pigmented areas on the thoracic legs occur as in the feeding instars. A very narrow subdorsal stripe is present on each side of the median-dorsal line; it is broken into short sections in the anterior part of the body (anterior from fourth abdominal segment), and is joined into a continuous line from the fifth abdominal segment posteriorly. The supraspiracular stripes are relatively broad and are formed from single spots on each segment that are joined together by narrower intersegmental

pigmented areas. The supraspiracular spots on the thoracic segments are occasionally separate.

All the subdorsal and supraspiracular stripes blend together from the seventh through the tenth abdominal segments, giving a dark appearance to the posterior part of the body. The epiproct is entirely black. Prepupae have the same pattern of integumental spines that occurs in the second through the fifth feeding instars.

Significance of the Different Larval Color Patterns

Larval colonies collected in the Beltsville area are either of the spotted or striped type. Although the majority of individuals in a given colony are of the same pattern, frequently, a few larvae of the other pattern are also present. This indicates that the variations in larval color patterns at Beltsville are intraspecific and that the spotted and striped types cannot be divided into subspecies. Wallace (1963) points out that the situation at Beltsville is particularly complicated because it is in a zone where *pratti* and *paradoxicus* (subspecies as proposed by Ross 1955) come together, and that under epidemic conditions it is harder to understand than under endemic conditions. The possibilities are that the present epidemic is subsiding, inasmuch as the intensity of defoliation in Maryland and Virginia dropped to a low level in 1962 (Anonymous 1963). If so, before too many years endemic populations should be available for study.

Also noteworthy at the present time is that a great shortage of information exists on the geographic distribution of larval types particularly in the Southern and Northeastern States (Wallace 1963). Moens and Atwood (1963) have made crosses between adults of *Neodiprion pratti* derived from populations of spotted and striped larvae; they conclude that the allele for the spotted pattern is incompletely dominant over the allele for the striped pattern. In any event the validity of dividing *N. pratti* into subspecies is not yet known, and more complete data on geographic distribution is needed.

Field Occurrence of Stages at Beltsville

Eggs.—In 1962 the first eggs were detected in the field on October 19th. Egg samples were collected from that time until April 1963.

Larvae.—The occurrence of larval instars in the field during the 1962 and 1963 seasons is shown in figures 4 and 5. The earlier occurrence of the first instars in 1963 was caused by 1 week of above-normal temperatures in March. By the end of May of 1962 and 1963, all larvae had dropped to the ground.

Cocoons.—The development of the prepupa and pupa was not studied under field conditions. Morris et al. (1963) report that *Neodiprion pratti* remained in the prepupal stage until the latter part of September in Virginia, and then transformed to the pupa. They also report that from 1.6 to 1.9 percent of the prepupae examined were in diapause at that time and remained in the prepupal stage.

Adults.—Adults emerged in late October and November of 1962. This agrees with the report of Hetrick (1956).

Relationship Between Sex and Number of Feeding Instars

Hetrick (1956) and Morris et al. (1963) report that female larvae pass through five feeding instars and males only four. In these studies, this was found to be true of most larvae; however, individual rearings revealed that some females passed through only four feeding instars and then transformed to prepupae. These adult females were the same general size as males and emerged from male-sized cocoons. No males were formed from larvae that passed through five feeding instars.

Correlation Between Cocoon Size and Sex

The variation in cocoon size, particularly length, was large, and great overlap was observed between the sexes. Male cocoons varied from 5.5 to 7.5 mm. in length (average 7.0) and 3.0 to 3.5 mm. in diameter; females varied from 7.0 to 10.0 mm. in length (average 9.0) and 3.5 to 4.5 mm. in diameter. Thus, even though female cocoons are generally larger than male cocoons, cocoon size is only of limited use for sexing.

Egg Diapause

No egg diapause occurs in *Neodiprion pratti* populations in the vicinity of Beltsville, Md. Morris et al. (1963) also report the lack of egg diapause for *N. pratti* populations in Virginia. Egg samples collected in October 1962 and held at room temperature began hatching after 26 days. The length of time until hatch, at room temperature, decreased gradually with subsequent egg collections. For example, in April 1963 field-collected eggs hatched in less than 24 hours; within the next few days, hatching was observed in the field. The accumulative effect of temperature was distinct; no attempt was made to find the lower developmental thresholds. These results are very interesting in that eggs of *N. pratti banksianae* in Canada experience diapause (Brygider 1952), and an exposure to cold temperature is required to fulfill this condition.¹

¹ Personal communication from C. E. Atwood and D. R. Wallace, 1963.

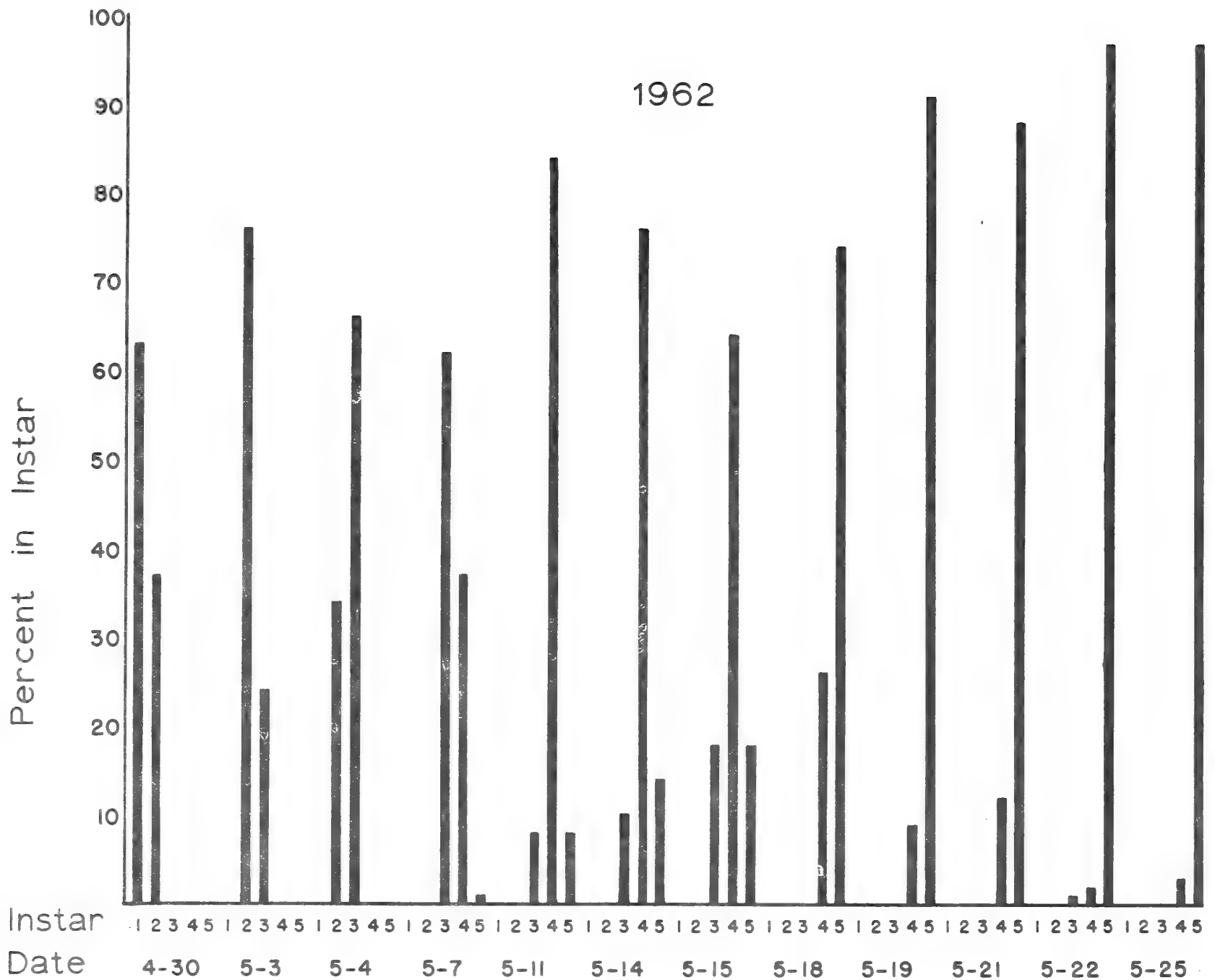


FIGURE 4.—Field occurrence of *Neodiprion pratti* larvae at Beltsville in 1962. At least 50 larvae (collected at random) were included in the sample for each date.

SUMMARY

1. Head capsule width can be used for determining the first three larval instars of most larvae of the Virginia pine sawfly. The overlap of these widths between large fourth and small fifth instar larvae is too great for separating those individuals.

2. Larvae collected at Beltsville, Md., may have either a spotted or a striped color pattern during the fourth and fifth feeding instars. These patterns, as well as the markings of the earlier instars and the prepupae, are described.

3. Variations in larval color patterns observed at Beltsville are intraspecific. Local populations cannot be classified as to subspecies at the present time.

4. The period of occurrence of each larval instar in the field in 1962 and 1963 is given. The total larval feeding period is about 1 month under field conditions.

5. Cocoon size is not an accurate method for sexing, although female cocoons are generally larger than male cocoons.

6. *Neodiprion pratti* eggs do not pass through diapause in the Beltsville area.

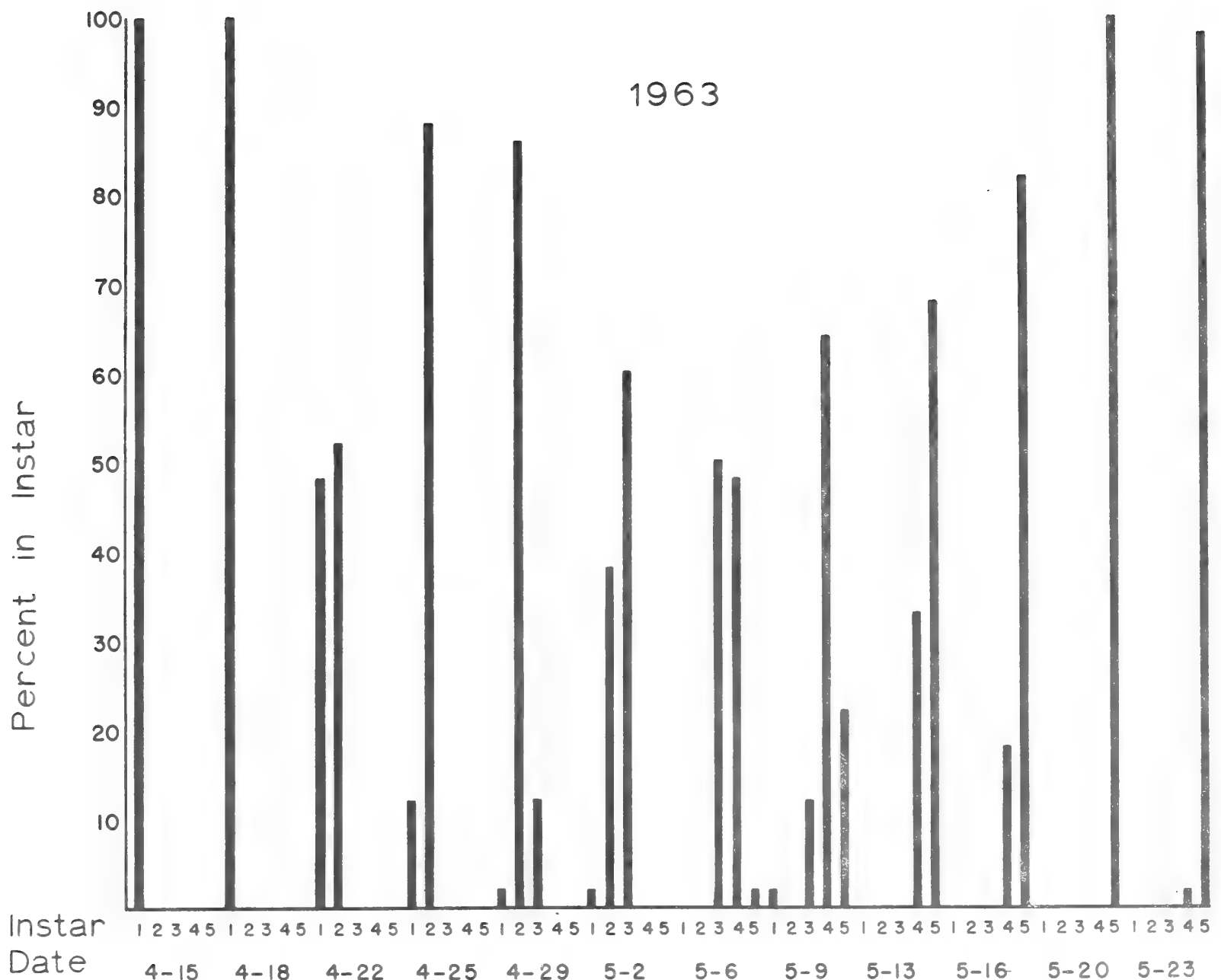


FIGURE 5.—Field occurrence of *Neodiprion pratti* larvae at Beltsville in 1963. Fifty larvae (collected at random) comprised the sample for each date.

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