Seasonal Occurrence of *Pieris rapae* (L.) (Lepidoptera: Pieridae) in Southwest Virginia[1]

David N. Gaines and L. T. Kok

Department of Entomology
Virginia Polytechnic Institute and State University
Blacksburg, VA 24060-0319 USA

J. Entomol. Sci. 30(2): 262-272 (April 1995)

ABSTRACT In Virginia, *Pieris rapae* (L.) phenology is not well established because earlier studies focused on its occurrence within the growth period of a particular crop. In this study, conducted in 1989 and 1990, we sampled multiple crops in both spring and fall plantings and these data were compared with those from earlier studies to obtain an overall pattern of seasonal occurrence. In 1989, spring crops of broccoli, cabbage, and kale were planted in field plots in Montgomery Co., VA, and sampled weekly for the eggs and larvae of *P. rapae.* In 1990, both spring and fall crops were planted and sampled. Four *P. rapae* generations (egg count peaks) were observed in 1989 and 1990, but comparison of data from both years suggested a fifth generation was possible in this region. When these data are compared with egg count data from seven previous years (1981-1988; 1985 not included), evidence indicates a first generation in mid-May, and consistent second and third generations in mid-June and mid-July, respectively. The June and July generations were always well defined by high egg and larva counts per plant. Less predictable are the fourth and fifth generations which may both occur in August or one generation each in August and September. When fourth and fifth generations occur in early and late August, a sixth generation may occur in late September. The regular occurrence and size of the second and third generation can facilitate the planning and implementation of biological or other control measures for *P. rapae* in this region.

KEY WORDS *Pieris rapae*, imported cabbageworm, generations, broccoli, cabbage, biological control.

The imported cabbageworm, *Pieris* (= *Artogeia*) *rapae* (L.), a native of the Palearctic region, was introduced into North America about 1860 and has since spread throughout much of the continent (Harcourt 1963). *Pieris rapae* is among the most important pests of *Brassica* crops in Virginia and other regions within the United States (Latheef and Irwin 1982, Lasota and Kok 1989). The larvae consume the plant leaves, reducing plant vigor and growth, and their presence in harvested heads of broccoli and cabbage render them unsalable. The most damaging life stage is the fifth instar which consumes the most leaf area (Harcourt 1963).

Foraging *P. rapae* females demonstrate host plant preferences for oviposition. Preferences are based on plant age, plant group (e.g., the broccoli or cabbage groups within *Brassica oleraceae*), and cultivars (Fox 1974, Jones and Ives 1979,

[1] Accepted for publication 19 December 1994.

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-06

Chamberlin 1983, Vail et al. 1991, Gaines 1992). Larger, preheading or mature plants are preferred over seedlings or senescent plants because these plants tend to offer more leaf area and shelter than seedlings, and a higher quality larval food than senescent plants (Jones and Ives 1979).

Pieris rapae eggs are laid typically on the underside of a host plant leaf. Five instars and a pupal stage occur before adult emergence (Richards 1940). At temperatures of 16.5° and 22.0°C, mean times for: egg development were 8.0 and 4.3 days; larval stage (instars 1-5) were 25.5 and 14.6 days; and pupal stage were 15.3 and 8.0 days, respectively (Jones and Ives 1979). Thus, the entire development cycle, from egg to adult is 27 to 49 days within this temperature range. Populations tested in Great Britain (Richards 1940), British Columbia, Canada, and Canberra, Australia all had similar developmental rates (Jones and Ives 1979). Adult females may live for as long as 20 days and lay more than 300 eggs (Richards 1940).

Pieris rapae overwinter as pupae and emerge as adults in the spring. In the British Isles, *P. rapae* oviposition activity commences in mid-April, and three full generations and a partial fourth generation may occur per year (Richards 1940). The seasonal activity and number of generations of *P. rapae* vary considerably across the United States because of the broad range of latitudes, climates, and elevations. Parker (1970) recorded as many as six distinct generations per year in Missouri, with the first generation occurring between early April and late May and the sixth generation starting in late September. In southwest Virginia, adult *P. rapae* were observed foraging in early April (Chamberlin 1983, Lasota and Kok 1989), and newly laid eggs were observed as late as mid-October (Gaines 1992). Two to four distinct generations were reported per year on broccoli and cabbage (Chamberlin 1983, Lasota 1985, Vail 1988, McDonald 1990, Gaines 1992). However, none of these studies involved sampling throughout an entire plant growth season (April-October) because *Brassica* crops at an attractive age for oviposition were not continuously present. Clark and Clark (1951) indicated that *P. rapae* may have three to eight (usually four to six) broods per year in Virginia, with fewer broods in the cooler mountainous regions; adults first appear in the third week of March and forage as late as mid-October.

Pieris rapae is common throughout Virginia, especially in proximity to cultivated *Brassica* crops (Clark and Clark 1951). In the absence of cultivated crops, wild Brassicaceae species such as yellow rocket (*Barbarea vulgaris* R. Br.) serve as an alternate food for *P. rapae. Barbarea vulgaris* is important because it is common and is available from early spring to July; new rosettes become available as food in late summer or autumn (Root and Tahvanainen 1969).

This paper shows the seasonal occurrence and abundance of *P. rapae* in southwest Virginia and provides evidence that its early summer generations are relatively consistent and predictable. Such information is needed for timely application of pest control measures.

Materials and Methods

In 1989 and 1990, *Brassica* field crops planted at the Virginia Polytechnic Institute and State University (VPI) research farm at Whitethorne, Montgomery Co. (elevation ≈ 518 m) were sampled for eggs and larvae of *P. rapae* to determine its seasonal occurrence. Seedlings of broccoli (cv. 'Premium Crop'), cabbage (cv. 'Rio

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-06

Verde') and kale were planted to provide a diverse habitat and source of food for the insects. The broccoli and cabbage cultivars were selected because they were among several long season cultivars which are highly attractive to *P. rapae* (Chamberlin 1983, Vail et al. 1991). In the 1989 spring planting, broccoli and kale were planted on 30 April, and cabbage was planted 6 wk later on 14 June to extend the field sampling into September. No fall crops were sampled. In 1990, all three crops were planted in both spring and fall on 30 April and 8 August, respectively (broccoli, cabbage, and kale planted concurrently at each planting date).

The field design was a randomized complete block, replicated six times. Plot size was 3 × 7.5 m, and each plot contained 75 plants in three rows spaced 1 m apart (25 plants per row, spaced 0.25 m apart within row). Ten plants in the central row of each plot (excluding three plants at each end) were randomly selected and flagged. These 60 flagged plants from each crop were thoroughly inspected weekly for *P. rapae* eggs and larvae. Larvae were counted as small larvae (instars 1-3) and large larvae (instars 4-5). Because *P. rapae* eggs may develop in as little as 4.3 days at temperatures approximating the average mid-summer temperatures of this region, some eggs laid in the 7-day interval between sampling dates may have hatched before being counted. However, few eggs were missed during the cooler months and, based on our experience, it is likely that most of the eggs were counted during the warmest months (July and August).

Crops were sampled starting from 1-3 wk after planting. Sampling of the kale plots was discontinued in July 1989 due to the difficulty in detecting insects on its convoluted leaves. However, kale sampling was resumed on a limited basis in 1990; only five plants per plot were sampled and only large larvae were counted. Sampling of spring crops continued until mid-August or early September each year when the senescing plants no longer attracted *P. rapae* oviposition over one or two sampling periods. The 1990 fall crop was sampled until the first freezing temperatures which occurred in early November.

Data showing oviposition peaks observed in Montgomery Co., VA between 1981 and 1990, with the exception of 1985, were arranged for comparison (Fig. 4). These egg count data were collected in plots of broccoli or cabbage by Chamberlin (1983), Lasota (1985), Vail (1988), McDonald (1990), and Gaines (1992). Egg count peak dates were determined from the data of each author. We designated oviposition peaks as either major or minor peaks. Major peaks were prominent and clearly represented discrete generations. Minor peaks could represent periods when gravid *P. rapae* encounter favorable weather for oviposition (*P. rapae* oviposit most on warm sunny days) (Gossard and Jones 1977), but may also represent generations, or the tail ends of generations when they occurred on a first sample data. Generally, minor peaks were not indicated when they were < 20 days from a major peak, and in a cluster of minor peaks, the most prominent was selected. In one case (fall 1984), Lasota (1985) indicated a single late September generation, but we believe there were two generations (one in late August and one in late September). The late-August peak became apparent when Lasota's two samples per week were averaged and plotted as one sample per week. Data from her larvae counts also support this conclusion. In addition, data from Missouri (Parker 1970) are included for comparison.

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-06

Results and Discussion

Pieris rapae had similar seasonality patterns during June and July in 1989 and 1990 (Fig. 1). Mean weekly *P. rapae* egg counts (Fig. 1) show distinct population peaks around mid-June and mid-July each year. Two distinct peaks also occurred each year in counts of small and large larvae (Figs. 2 and 3, respectively). The 1990 peaks were about one week earlier than the corresponding 1989 peaks, possibly because of warmer weather during the spring of 1990. In both years the mid-July peak was the largest of the season. A third distinct peak occurred in August of 1989, but was not seen during 1990. In the fall of 1990, *P. rapae* oviposition peaks occurred in early and late September, which had slightly above normal temperature (Fig. 1). The fall oviposition peaks are small (fewer eggs per plant), broader and less distinctive than in the spring. This continuous oviposition activity was due to partial overlapping of generations; adults of each succeeding generation emerged over a longer time period as the season progressed because of developmental rate differences influenced by local microclimate or food quality differences. The timing of oviposition peaks was generally the same for the three crops in 1989, and for broccoli and cabbage crops in 1990 (Fig. 1); except for the June peaks, large larval peaks were also the same for all three crops in 1990 (Fig. 3).

There were three distinct oviposition peaks seen in 1989 (Fig. 1), but four generations may have been observed that year. Eggs were first detected in mid-May 1989, and although few were seen, they may represent part of an oviposition peak or generation (see enlarged inset, Fig. 1). Only five eggs were counted, and in the following weeks, one small larva and one large larva also were observed (Figs. 2 and 3). Following these observations, no eggs or larvae were recorded until the second week of June. Few eggs were counted in mid-May, probably because the newly-planted seedlings were too small to attract ovipositing *P. rapae.* Also, the early season population density of *P. rapae* adults in general was relatively low, and eggs were probably distributed among the wild Brassicaceae, *B. vulgaris* and *Sisymbrium officinale* (L.) (hedge mustard), which are common at Whitethorne. The latter is a large plant which is abundant from spring until July and produces new rosettes in the fall; we have found numerous *P. rapae* eggs on this plant in May and June. No data are available on the development rate of *P. rapae* on wild Brassicaceae, but it is evident that these wild hosts support *P. rapae's* first generation. If the eggs and larvae observed in mid-May 1989 are part of a generation, the mid-August oviposition peak becomes a fourth generation.

No oviposition peak was detected in May 1990, possibly because sampling commenced after mid-May. There were four distinct generations (peak egg and large larva counts) during 1990 (Figs. 1 and 3). In August, low *P. rapae* oviposition on the sample plants may have been due to the badly deteriorated spring crops and the small size of the newly-planted fall crop seedlings. However, there appears to be greater oviposition activity in the fall seedlings than in the aging spring crops, suggesting that gravid adults were present and active in the field (Fig. 1). With an inter-generation interval of 27-49 days, it is likely that an August generation followed the observed mid-July generation. The period between the oviposition peaks observed in mid-July and early September was about 50 days (Fig. 1), but intervals between any generations in July and August would probably be < 30 days because of the heat; the normal average temperatures (30 year mean temperatures based on

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-06

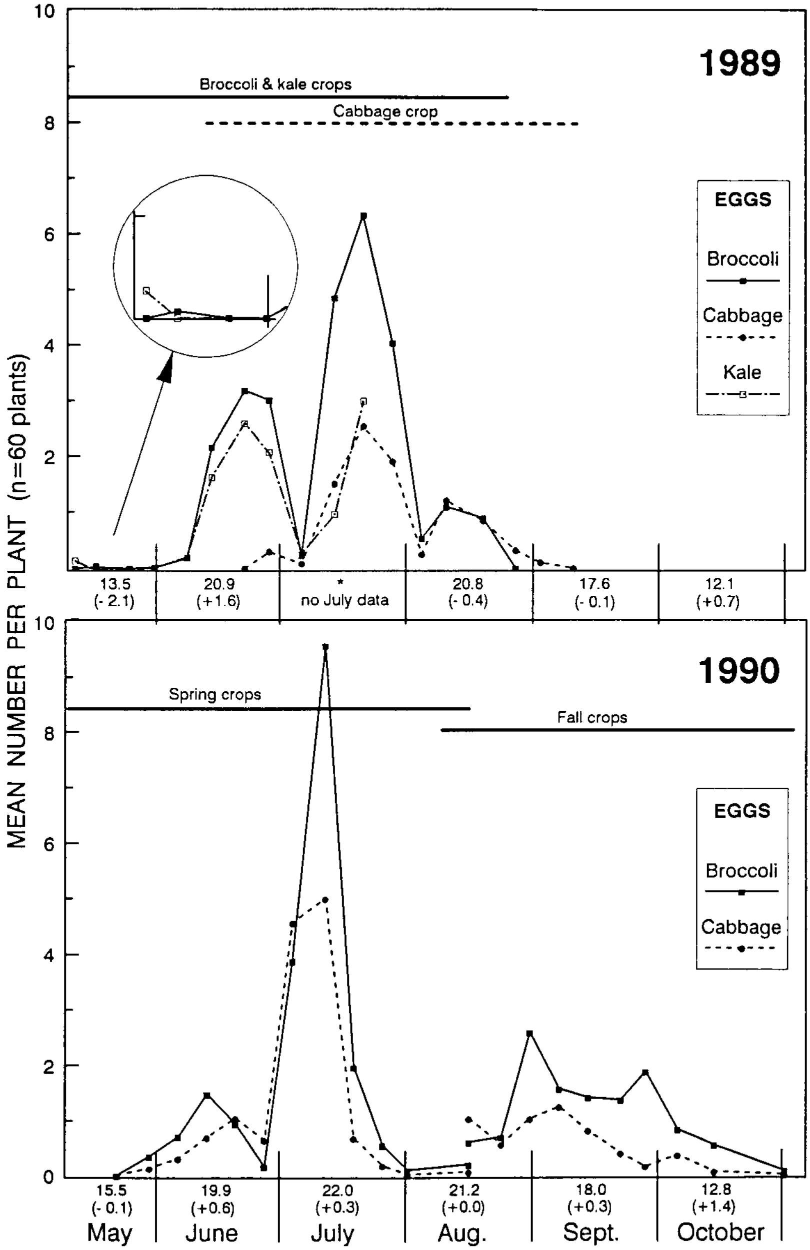

Fig. 1. *Pieris rapae* egg counts from broccoli, cabbage and kale in 1989 and 1990 (kale sampling was discontinued after 21 July 1989). Included for each year are average monthly temperatures (°C) with departures from normal (NOAA 1989 and 1990).

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-06

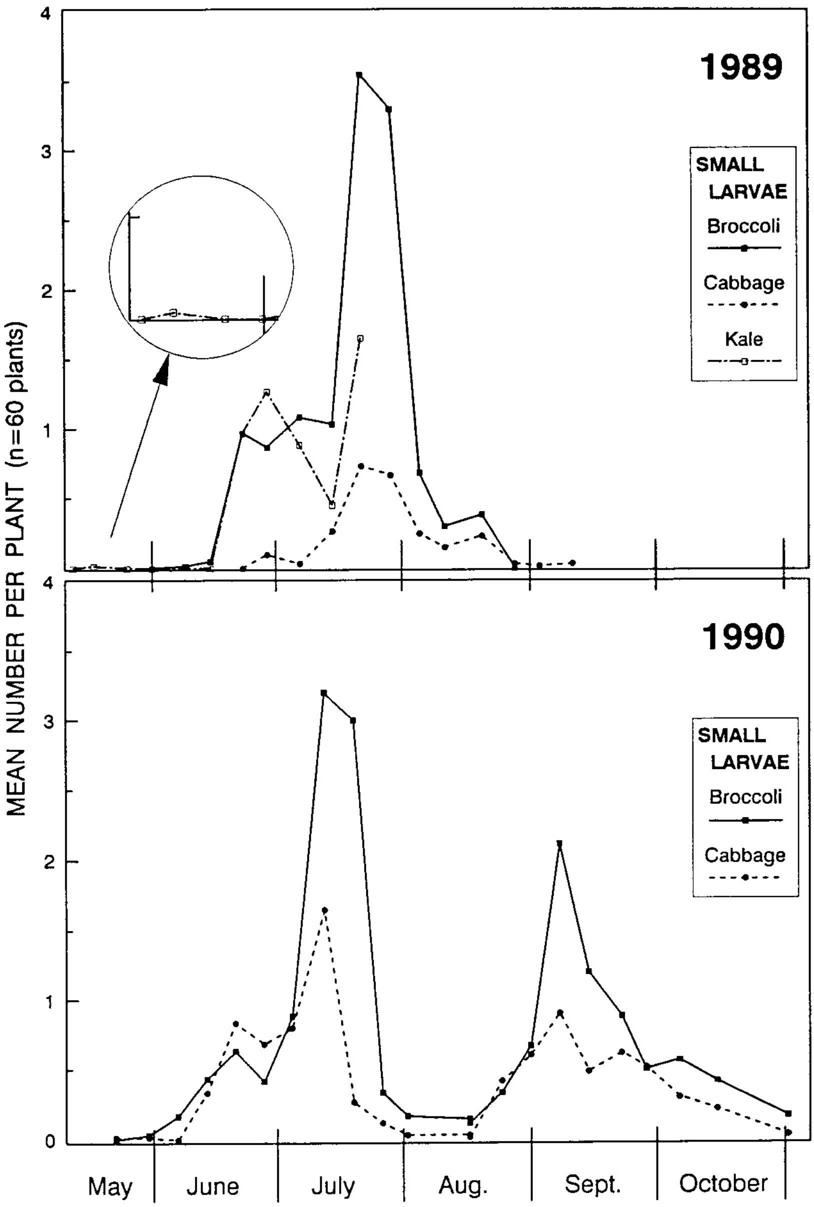

Fig. 2. *Pieris rapae* small larvae (instars 1-3) counts from broccoli, cabbage and kale in 1989 and 1990 (kale sampling was discontinued after 21 July, 1989).

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-06

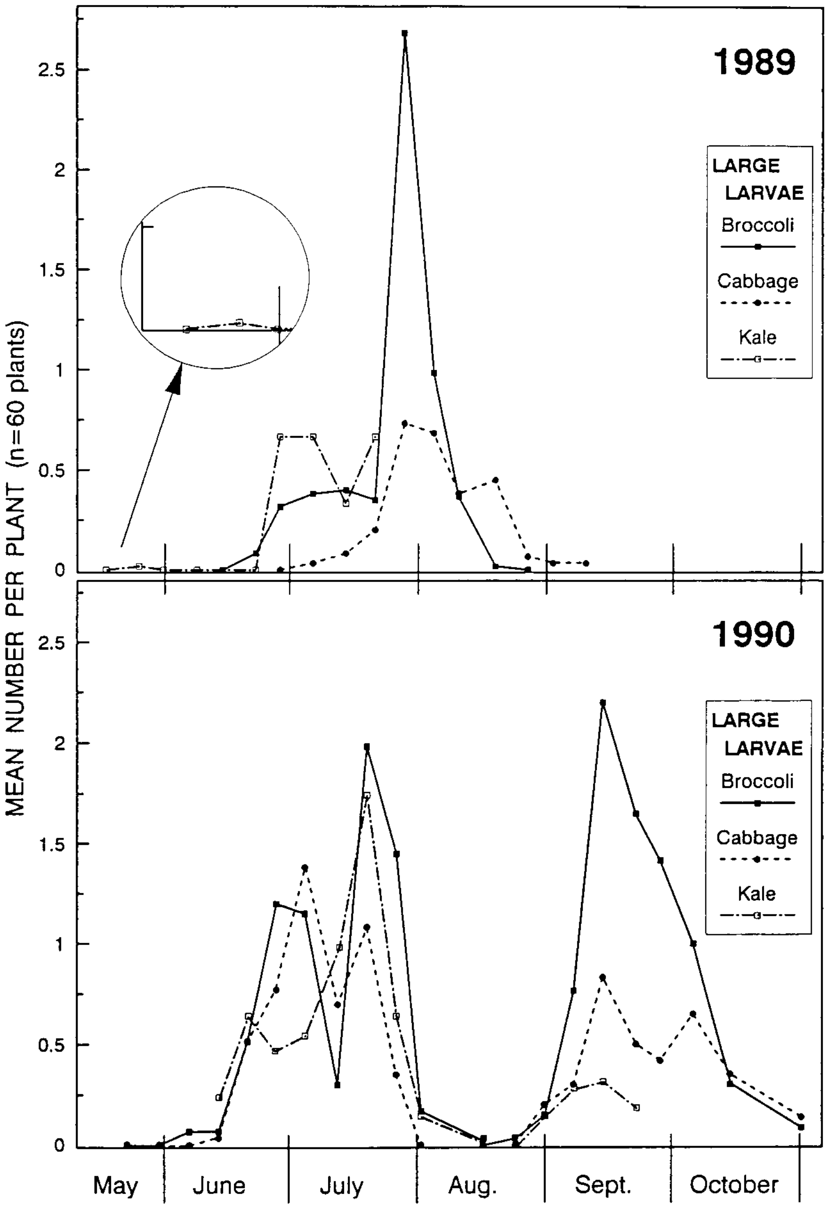

Fig. 3. *Pieris rapae* large larvae (instars 4-5) counts from broccoli, cabbage and kale in 1989 and 1990 (kale sampling was discontinued after 21 July 1989, but was resumed, for large larvae only, in 1990 from 13 June to 22 September and 5 plants per plot were sampled).

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-06

1951 - 1980 data for Blacksburg, VA) for July and August are 21.7° and 21.2°C, respectively (Fig. 1, NOAA 1990). Thus, any generation occurring after mid-July would probably be seen by mid-August (as in 1989), particularly if an extended period of high temperatures and low precipitation occurred after mid-July. Few wild Brassicaceae are present in mid-August, but the presence of foraging *P. rapae* suggests that oviposition is possible during this period. The generation peaks occurring in early and late September 1990 may represent third and fourth generations, but these peaks could also represent fourth and fifth generations, if the hypothesized August generation is included. The addition of an early May generation (not detected in 1990 because of late initiation of sampling) would make six generations.

The occurrence of at least five generations in this region is supported by data from earlier studies (Fig. 4). The dates of planting, the first and last dates of sampling, and egg count peaks are all indicated on Julian date scale. Although sampling did not commence until after mid-May in most studies, a first generation was observed in mid-May by Vail (1988), McDonald (1990), and Gaines (1992) (Fig. 4). Major peaks for the second and third generations were observed by all authors in mid- to late June and mid- to late July. Data for the period from late July to late August are scarce because it is a transition period between spring and fall crops. Only one major peak was observed in early to mid-August and it was considered to be a fourth generation (Figs. 1 and 4) (Gaines 1992). If this was a fourth generation, the fifth generation could be represented by major peaks observed in late August/early September (Lasota 1985, Gaines 1992) and a sixth generation could be represented by major peaks in late September (Lasota 1985, Vail 1988, McDonald 1990, Gaines 1992). The timing of the six generations on mixed crucifer crops in Missouri (Parker 1970), where generations start earlier and end later, generally conforms to this analysis.

Peak *P. rapae* oviposition should correspond to the time when the largest number of emerging females from a generation are gravid. However, the observed oviposition peaks may not exactly correspond to this event because of inclement weather (Biever et al. 1972), planting dates of *Brassica* crops (i.e., sample crop availability) and/or the interval between sampling dates. The June and July peaks occurred consistently within a two week period starting in the middle of each month, and when averaged across all years sampled, the peak dates for the June and July generations (Fig. 4) are 17 June and 17 July, respectively. In most years the greatest peak occurred in July, but the June peak was larger during several years. The mean period between the June and July peaks (Fig. 4) of 30.2 ± 4.5 days ($\overline{x} \pm$ sd; range = 21-37 days) falls within the 27 to 49 day development cycle determined for *P. rapae* at temperatures between 22° and 16.5°C (Jones and Ives 1979). The normal average temperature for June is 19.3°C (Fig. 1, NOAA 1990).

In summary, these data indicate five generations of *P. rapae* between early May and late September on host crops in this region. The second and third generations consistently occur within a two-week period starting in mid-June and mid-July, respectively, and egg counts are always large for these generations. There are few oviposition records from early to mid-August, but if a generation occurred at that time, there could be six generations from early May to late September. Identification of discrete late summer and early fall generations may be difficult because generation overlap makes them difficult to distinguish, and available wild hosts were not included in samples.

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-06

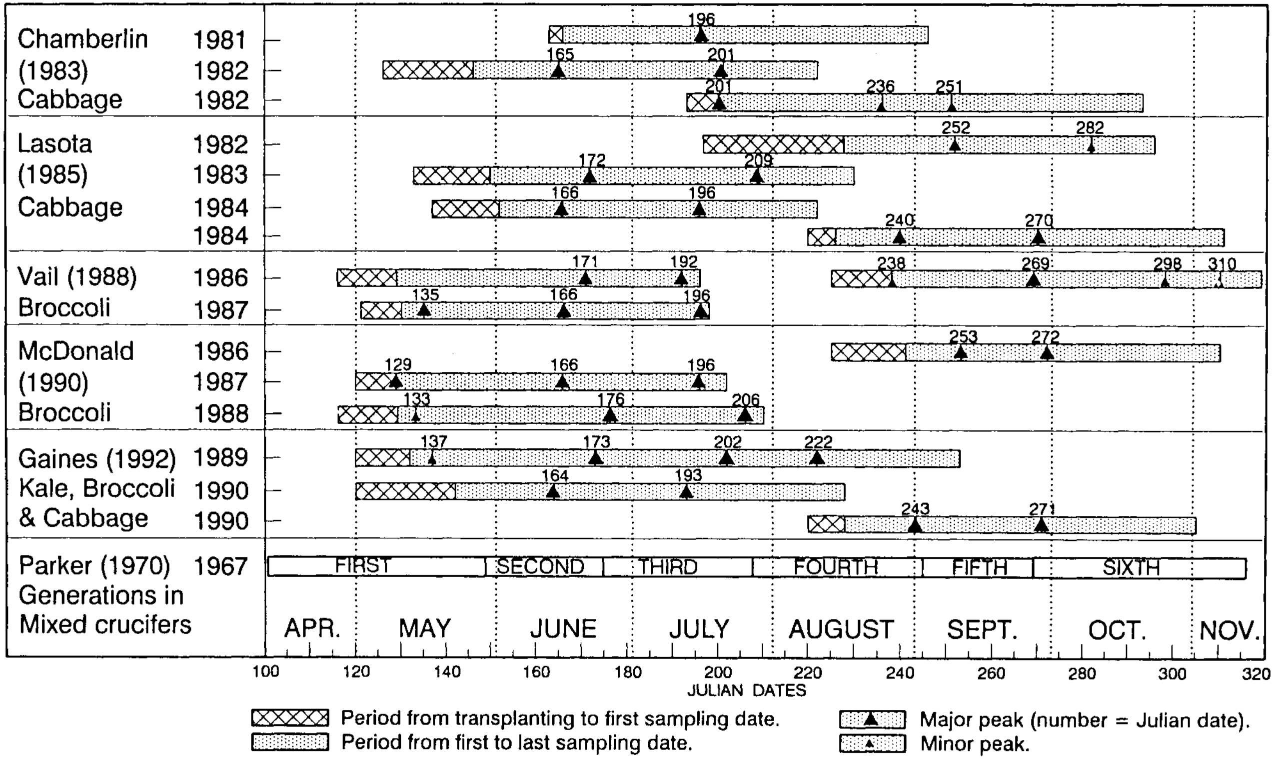

Fig. 4. Number of *Pieris rapae* generations per year (peaks in egg production) estimated from field data obtained by researchers in southwest Virginia since 1981 (compared with data from Parker (1970) in Missouri).

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-06

The predictable occurrence and size of the second and third generations could facilitate the planning and implementation of control programs against *P. rapae*. Applications of microbial or chemical insecticides to crops could be timed to coincide with peak occurrences of a target life stage. Parasites and predators could be reared with June or July inundative release dates in mind. The June and July generations are also good target dates for the introduction and establishment of exotic natural enemies. Natural enemies released during these periods would have a better chance of becoming established due to the high host (or prey) density and the occurrence of several subsequent generations.

Because southwest Virginia is a mountainous region, seasonal occurrence of *P. rapae* may differ from that of the Virginia piedmont and coastal plain. The elevation of Montgomery Co., VA ranges from ≈ 335 to 914 m (1100 - 3000 ft), but most agricultural land lies on a plateau between ≈ 518 and 670 m (1700 and 2200 ft). Elevation generally varies by < 100 m within a 5 km radius of Whitethorne and so, it has little effect on the range of local climate. However, topographic features may create local microclimates resulting from nocturnal convective air movements or differences in solar warming on north and south slopes, and these microclimates may produce a range of local *P. rapae* phenologies. Summers are relatively mild at this elevation and the growing season is several weeks shorter than in the piedmont. Thus, *P. rapae* generations may occur a few weeks earlier in the piedmont and there may be an additional generation per year. Further sampling will be required to determine the seasonal occurrence of *P. rapae* in other regions. A clear representation of the number of generations in a season could be obtained by sampling for eggs on early and late wild hosts and on a continuous supply of attractive crop plants. The latter would require planting at least three crops, in overlapping succession, between early April and September (Gaines 1992).

References Cited

Biever, K. D., D. L. Hostetter and P. E. Boldt. 1972. Reliability of climate simulation studies utilizing *Pieris rapae* (L.). Environ. Entomol. 1: 440-443.

Chamberlin, J. R. 1983. Seasonal abundance, parasites and varietal preferences of cabbage caterpillars in Southwestern Virginia. M. S. Thesis. Dept. of Entomol. V. P. I. & S. U. 96 pp.

Clark, A. H. and L. F. Clark. 1951. The butterflies of Virginia. Smithsonian Misc. Pub. Vol. 116, no. 7: 88-90.

Fox, C. J. S. 1974. Note on the ovipositing preferences of the imported cabbageworm, *Pieris rapae* (L.), on cole crops. Phytoprotection 55: 36-37.

Gaines, D. N. 1992. Seasonal abundance and biology of hyperparasites and their hosts associated with *Pieris rapae* (L.) (Lepidoptera: Pieridae) in the *Brassica* crop system. M. S. Thesis. Dept. of Entomol. V. P. I. & S. U. 118 pp.

Gossard, T. W. and R. E. Jones. 1977. The effects of age and weather on egg laying in *Pieris rapae* (L.). J. Appl. Ecol. 14: 65-71.

Harcourt, D. G. 1963. Biology of cabbage caterpillars in Eastern Ontario. Proc. Entomol. Soc. Ont. 93: 61-75.

Jones, R. E. and P. M. Ives. 1979. The adaptiveness of searching and host selection behaviour in *Pieris rapae* (L.). Austral. J. of Ecol. 4: 75-86.

Latheef, M. A. and R. D. Irwin. 1982. Seasonal abundance and parasitism of lepidopterous larvae on *Brassica* greens in Virginia. J. Georgia Entomol. Soc. 18: 164-168.

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-06

Lasota, J. L. 1985. Evaluation of the potential of *Pteromalus puparum* (L.) (Hymenoptera: Pteromalidae) for suppression of the imported cabbageworm and parasitism of the diamondback moth. Ph.D. Dissertation. Dept. of Entomol. V. P. I. & S. U. 112 pp.

Lasota, J. L. and L. T. Kok. 1989. Seasonal abundance of imported cabbageworm (Lepidoptera: Pieridae), cabbage looper (Lepidoptera: Noctuidae), and diamondback moth (Lepidoptera: Plutellidae), on cabbage in southwestern Virginia. J. Econ. Entomol. 82: 811-818.

McDonald, R. C. 1990. Impact of the microbial pesticide *Bacillus thuringiensis* Berliner subsp. *kurstaki* on Hymenopterous parasites of the imported cabbageworm, *Pieris rapae* (L.) (Lepidoptera: Pieridae). Ph.D. Dissertation. Dept. of Entomol. V. P. I. & S. U. 121 pp.

NOAA. 1989. National Oceanic and Atmospheric Administration. Climatological data for Virginia, Annual Summary, 1989. Vol. 99, no. 13.

NOAA. 1990. National Oceanic and Atmospheric Administration. Climatological data for Virginia, Annual Summary, 1990. Vol. 100, no. 13.

Parker, F. D. 1970. Seasonal mortality and survival of *Pieris rapae* (Lepidoptera: Pieridae) in Missouri and the effect of introducing an egg parasite, *Trichogramma evanescens.* Ann. Entomol. Soc. Amer. 63: 985-994.

Richards, O. W. 1940. The biology of the small white butterfly (*Pieris rapae*), with special reference to the factors controlling its abundance. J. Anim. Ecol. 9: 243-277.

Root, R. B. and J. O. Tahvanainen. 1969. Role of winter cress, *Barbarea vulgaris,* as a temporal host in the seasonal development of crucifer fauna. Ann. Entomol. Soc. Am. 62: 852-855.

Vail, K. M. 1988. Broccoli yield response to cabbage looper and varietal preferences of lepidopterous pests of broccoli. M. S. Thesis. V. P. I. & S. U. 132 pp.

Vail, K. M., L. T. Kok and T. J. McAvoy. 1991. Cultivar preferences of lepidopterous pests of broccoli. Crop Prot. 10: 199-204.

http://prime-pdf-watermark.prime-prod.pubfactory.com/ | 2025-02-06