EXPERIENCES FROM BREEDING *APATURA IRIS* (L.) NYMPHALIDAE IN SWITZERLAND FROM 1982 TO 2002

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Abstract

Details are described of the breeding protocol, seasonal distribution of early stages, parasitism and pattern of emergence of *Apatura iris* (L.) in the neighbourhood of Basel, Switzerland from 1982 to 2002. Early stages are most readily found in the first three weeks of August. Eggs are laid between the leaf edges and the midrib. Males emerged significantly earlier than females. Emergence dates are related to spring temperatures; emergences have occurred earlier in the season year on year correlating with increasingly warmer springs. There was a gradual decrease in the numbers of imagines observed in the wild over the 21 years, possibly due to a decrease in the numbers of *Salix caprea* plants. Parasitism by *Psilomastax pyramidalis* Tischbein 1868 (Ichneumonidae), is discussed.

Introduction

The following observations on the purple emperor, *Apatura iris*, were made in the neighbourhood of Basel, Switzerland, from 1982 until 2002. Ova and first and second instar larvae were collected in the wild and bred on sallow, *Salix caprea* (L.) in the author's gardens. The resulting imagines were released back into the woods that had been the source of the ova and larvae. This account outlines the protocol for breeding the butterfly and the findings over this 21 year period.

Searching for ova and larvae

Ova and larvae were searched for on *Salix caprea* in several woods around Basel in north-west Switzerland and just over the border in France, a few kilometres west of Basel, from July until October each year. Usually, the shaded side of the bushes were searched and only the branches within reach at full stretch were examined. Of 175 eggs noted over 11 years, 161 were placed between the leaf edge and midrib, and only 14 on the midrib; based on the area of leaf available to ovipositing females, there is a bias in egg-laying on the midrib (c^2_1 = 10.03, P = 0.0015). No distinction was noted as to which side of the midrib, right or left, was used (c^2_1 = 0.2, P = 0.66) and all eggs were laid on the upper leaf surface.

Heslop et al (1964), and Friedrich (1977) report that most success is to be had by searching sallows in shady positions along the rides or edges of woods. Heslop et al (1964) reports report that mature female sallows are favoured. For practical reasons, I invariably searched relatively young sallows (three to four years old) that were not more than a few metres high and I did not differentiate between males and females. Although the shady side of a bush yielded the best results, it was possible to find larvae on the west and south facing sides, provided the leaves were well within the bush, and therefore mostly shaded from the sun by the surrounding foliage. Willmott (1987) has referred to favoured breeding areas in woods, where most of the larvae could be located. In my experience, the greatest number are to be found in areas of woods where the sallows occurred in clumps of at least six, rather than on solitary bushes. In particular, the best areas were those where general tree felling had taken place three to five years previously, and which had been invaded by pioneering sallow. Morris (1938) states that sallows in young birch and ash plantations are favoured because the foliage of the latter is comparatively sparse, giving some shelter but not keeping out too much sunshine. There are several reports of varieties of *Salix* other than *S. caprea* being used; I have found larvae and eggs on *S. cinerea* and *S. alba,* but never very many.

Although larvae may be found throughout the year apart from during the flight period, experience indicates that the period before winter hibernation is best, with the first three weeks of August presenting the highest yields (Fig 1). This is probably due to increased losses due to insect and bird predation as time goes on (Warren 1992). The sharp drop in yield from the third to the last week in August is noteworthy.

Breeding

August until November

Salix caprea was planted in the gardens of the houses I occupied, but was never allowed to grow very high; this was achieved by frequent cutting back throughout the growing season, so that the bushes were never more than about 2.5 metres high and 2 metres in girth. Pruning was managed to achieve a wide canopy, tapering down towards the ground, so that the leaves of the lower branches, used by the larvae, were shaded.

Plate L. Freshly emerged adult of *Psilomastax pyramidalis* Tischbein on pupa of *Apatura iris* (L.).

Table 1. Incidences of parasitism (*Psilomastax pyramidalis*).

YEAR	NUMBER OF PUPAE	NUMBER PARASITIZED	% PARASITIZED	PARASITIZED PUPAE IN ORDER OF EMERGENCE (JUNE)
1993	31	5	16	2nd, 3rd, 14th,15th,16th
1994	10	0	0	
1995	27	0	0	
1996	5	0	0	
1997	14	0	0	
1998	20	2	10	1st, 2nd
1999	18	3	17	1st, 3rd, 12th
2000	17	2	12	6th, 7th
2001	13	2	15	4th, 9th
2002	14	3	21	1st, 2nd, 7th
TOTALS*	**169**	**17**	**11**	

*from 1982 until 1992, 50 pupae were brought through and none were parasitised.

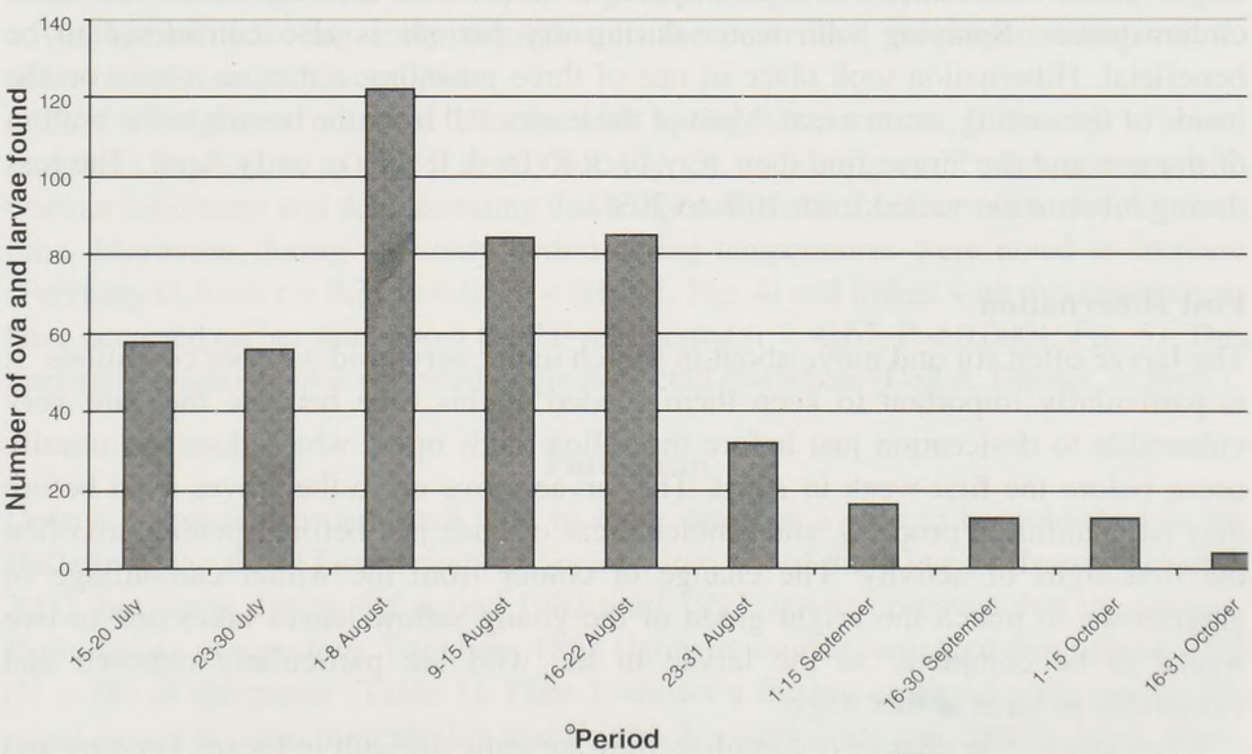

Fig. 1. The timing in observations of larvae found in woodland near Basel 1982 –2002.

For optimum control while they were still very small, larvae were kept, immediately after collection, in small, closed, glass or plastic bottles, outside in a shaded position, until the first week in September. Sallow leaves were renewed every three to four days. The larvae were carefully transferred to the fresh leaves by means of a small soft-haired paintbrush. The bottles were carefully cleaned and dried on the inside every three days. Twice every day, larvae, which had wandered onto the walls of the vessels, were transferred back to leaves. At the beginning of September, the larvae, usually second instar, were transferred to the leaves of a growing *Salix* bush in the garden. Only branches low down on the bush, facing north or north-east and in the shade, were used for the transfer in order to avoid exposing the larvae to the afternoon sun. The branches containing the larvae were enclosed in small mesh nylon netting. Before transferring larvae to a branch, the leaves and branches were very carefully examined for predatory insects, particularly ants, spiders, beetles, and earwigs, and these were all removed. I had not considered that ants would be a problem until, on one day, I observed an ant carry away a stiff first instar larva.

It was not usually necessary to carry out any further transfers before hibernation took place in November, since eating is slow during this phase. The larvae do not grow much during these three months, achieving a maximum length of about 10 mm. This contrasts starkly with the post hibernation period, when they almost quadruple in size in just six weeks.

Winter Hibernation

When the leaves fall, there is a risk that the larvae may be sometimes exposed to bright winter sunshine, so it is important to provide artificial shade in these circumstances. Spraying with water during dry periods is also considered to be beneficial. Hibernation took place in one of three positions: either on a bud, on the inside of the netting; or on a leaf. Most of the leaves fall from the branch to the bottom of the net, and the larvae find their way back to fresh leaves in early April. The loss during hibernation varied from 10% to 20%.

Post Hibernation

The larvae often stir and move about in March under very mild weather conditions. It is particularly important to keep them shaded at this time because they are very vulnerable to desiccation just before the sallow buds open, which does not usually occur before the first week in April. The larvae move on to the leaves even before they have unfurled properly, and nibbled areas of buds just before opening are often the first signs of activity. The change of colour from the winter camouflage of grey/brown to match the bright green of the young sallow leaves takes one to two weeks to be complete, so the larvae in the wild are particularly exposed and vulnerable to birds at this stage.

When this colour change is complete, they are quite difficult to locate. Feeding and growth is rapid from early April, and the larvae have to be moved to new branches about every ten days until pupation takes place sometime during the last two weeks in May. Normally, some 10% of larvae during this stage develop a black colouration, which spreads from the rear, and eventually consumes the whole body. This is presumably a fungal disease.

Pupal Period

The time between a larva moving to the underside of the leaf and the moment of pupation lasts from three to five days. After moving to the leaf underside, the colour gradually changes from bright green to a very pale green and, just before pupation, to an almost translucent hue. The actual pupation process, observed from beginning to end only on one occasion, took one hour. The mean time spent as a pupa was 19 days for females (range 14-31 days, n = 88), and 21 days for males (range 14 –28 days, n = 114). This does not include parasitised pupae, or second-generation examples (see below). A tendency exists for the earlier the pupation date, the longer the pupation period; this is significant only for the females (males: r = -0.08, P = 0.28; females: r = -0.29, P = 0.0001) Some 28 pupae failed to develop into imagines; 18 of these were parasitised (see below).

Emergence

From a total of 274 ova and 476 larvae collected, 202 perfect imagines emerged (27%). The mean period over which emergence took place was 14 days (range 5 to 27 days). Males emerge before females (Fig. 2), an observation which agrees with the general experience of observations in the field for many species (Morbey & Ydenberg, 2001). Specimens bred in captivity appeared to emerge earlier than first observations in the wild, by approximately one week, on average. This may be due to the somewhat more sheltered environment in captivity (sallow enclosed in fine mesh nets, thus reducing wind chill factor slightly) though it may well be owing to the advantage of detecting early eclosions in the controlled conditions compared to observations made in woodlands.

First emergences correlate closely with spring temperatures (February to June: Pearson r = -0.42 to –0.80, P < 0.0001; Fig. 3), indicating earlier emergences with warmer conditions and demonstrating that temperature plays a clear role in development time. Moreover, during the study period spring temperatures were noted to increase (February to June: r = 0.31 to 0.64, P < 0.0001; Fig. 4) and linked with this emergences have occurred earlier throughout the 21-year period (r = -0.67, P < 0.0001; Fig. 5). This important relationship is explored in greater detail elsewhere (Dell & Dennis, in prep.).

Parasitism

Details on parasitism are dealt with in more detail in a note to be published in the *Bulletin of the Basel Entomological Society*. In 6 out of the 10 years, from 1993 until 2002, but never during the period 1982 until 1992, it was observed that the parasite *Psilomastax pyramidalis* Tischbein 1868 (Ichneumonidae) emerged from about 15% (N = 18) of the pupae (Table 1). Plate L shows a freshly emerged wasp on the *iris* pupal case. On consulting Heslop and Friedrich's works (loc cit), and Dr Mark Shaw, it was clear that parasitism of the ova, larva and pupa of *A. iris* is rare. It is probable that the female wasp lays her eggs in ova or first and/or second instar *A. iris* larvae in the wild, before they are collected. The questions as to why, during my studies, this phenomena was only encountered after 1993, and also why it was more frequent than had been previously reported, remain unanswered.

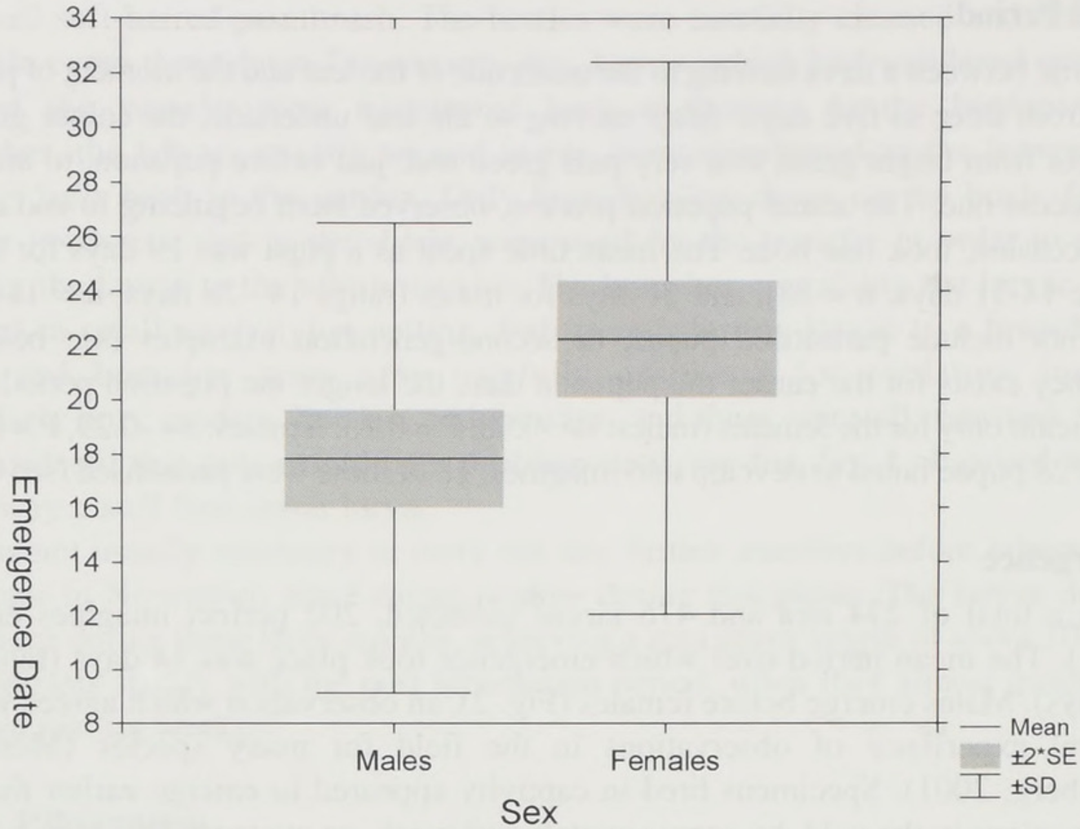

Fig. 2. Emergence times (days after May 31) of male and female *A. iris* near Basel between 1982 and 2002. SE is standard error and SD is standard deviation.

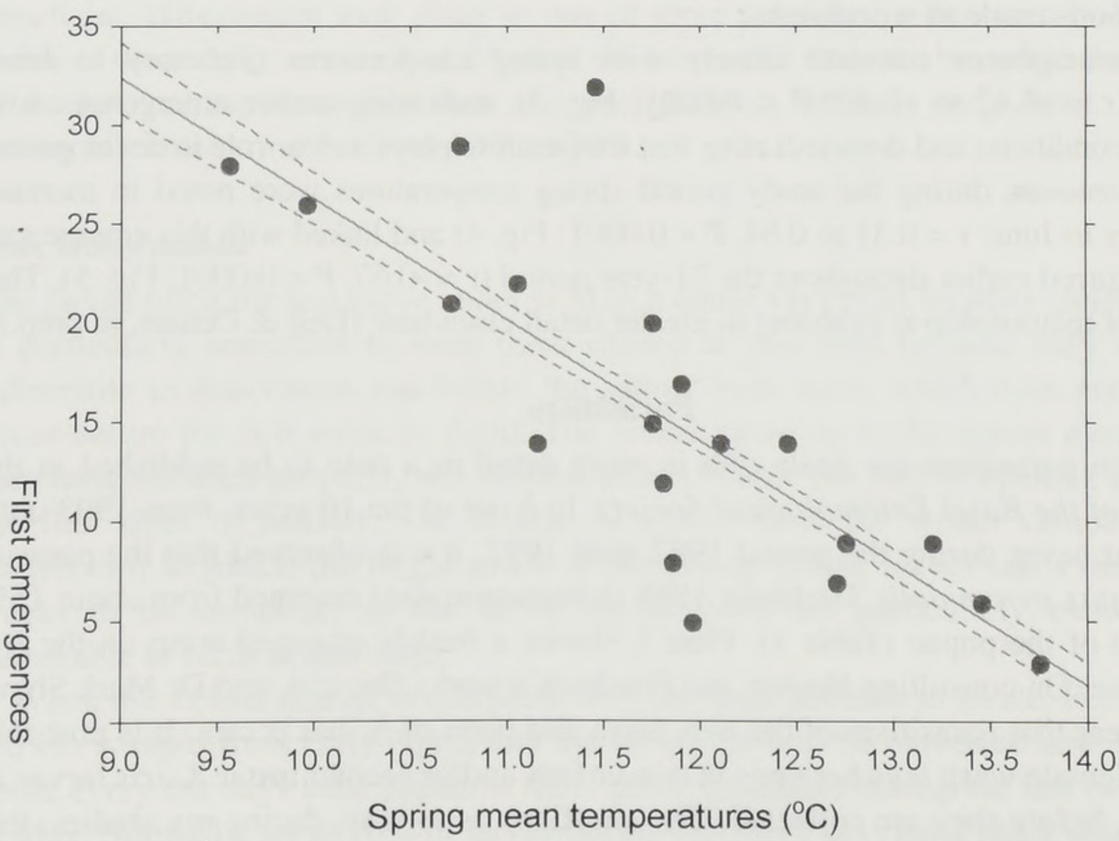

Fig. 3. The relationship between first emergence dates (days after May 31) of *A. iris* and spring temperatures (average of April and May means).

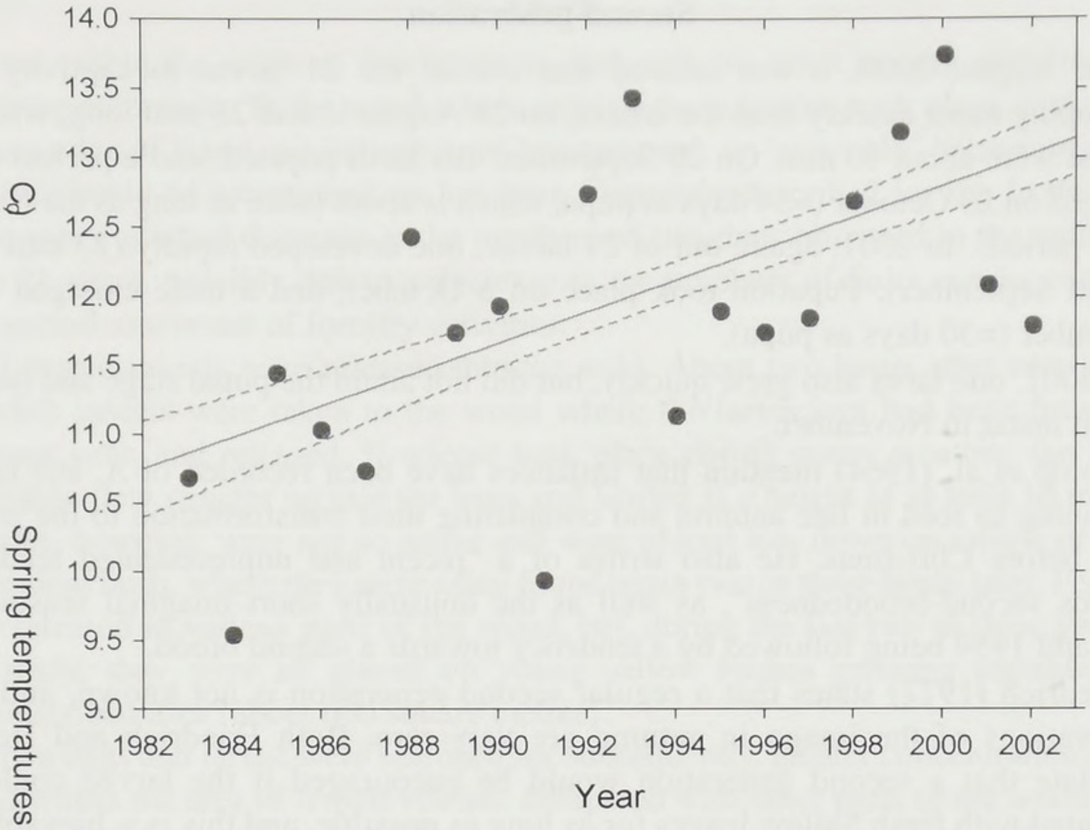

Fig. 4. Relationship between spring temperatures (average of April and May) and year for the period 1982 and 2002.

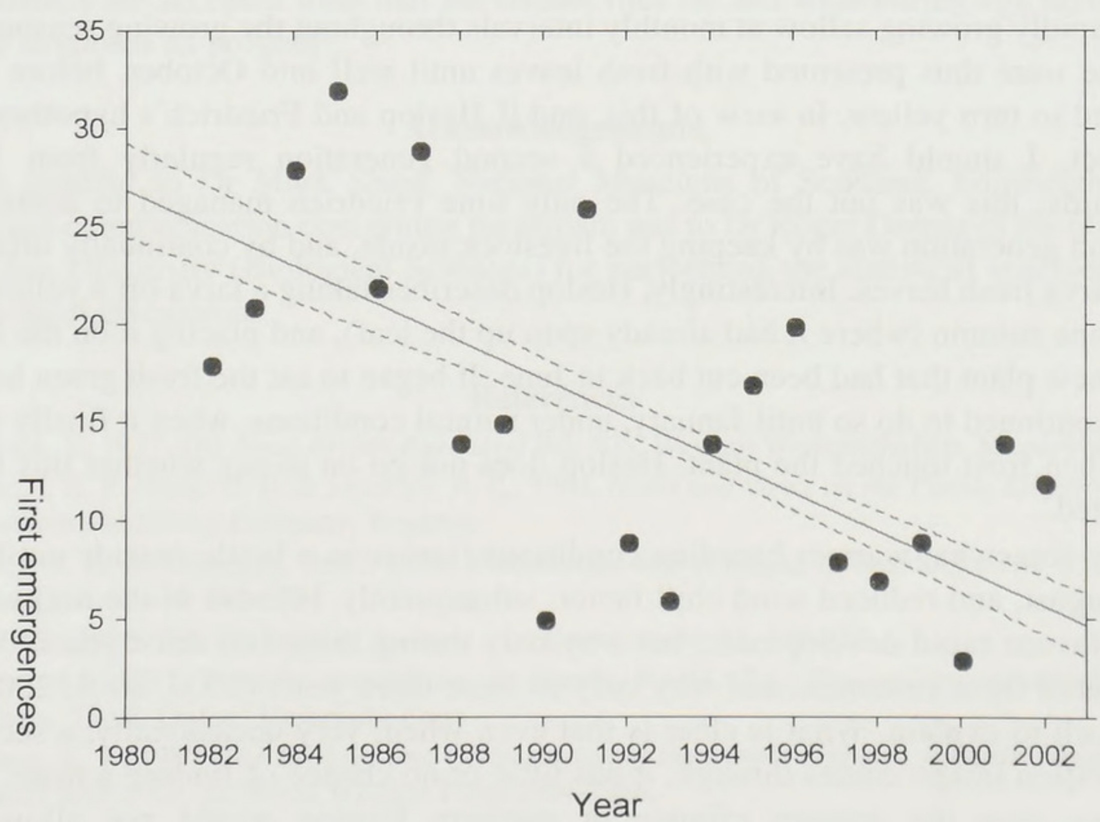

Fig. 5. Relationship between first emergences (days after May 31) and year for the period 1982 and 2002.

Second generation

In late August 2000, it was noticed that one of the 21 larvae in captivity was developing more quickly than the others; on 28 August it was 23 mm long, whereas the rest were about 10 mm. On 20 September, this larva pupated, and a perfect male emerged on 23 October (=34 days as pupa, which is about twice as long as the normal pupal period). In 2001, again, out of 29 larvae, one developed rapidly (23 mm long on 2nd September). Pupation took place on 6 October, and a male emerged on 4 November (=30 days as pupa).

In 2002, one larva also grew quickly, but did not attain the pupal stage and died in the 4th instar in November.

Heslop et al. (1964) mention that instances have been recorded of *A. iris* larvae continuing to feed in late autumn and completing their transformation to the imago stage before Christmas. He also writes of a "recent and unprecedented tendency towards second-broodedness", as well as the unusually short imaginal seasons of 1949 and 1959 being followed by a tendency towards a second brood.

Friedrich (1977) states that a regular second generation is not known, and that observations of the imago in autumn are very rare. Both Friedrich and Heslop speculate that a second generation would be encouraged if the larvae could be presented with fresh Sallow leaves for as long as possible, and this is achievable by cutting back the bush in May, when fresh shoots will be produced, which would last longer as green leaves into the autumn. In the wild, sallow leaves tend to turn yellow from late September. Since, in my small garden, it was necessary to cut back the rapidly growing sallow at monthly intervals throughout the growing season, the larvae were thus presented with fresh leaves until well into October, before they started to turn yellow. In view of this, and if Heslop and Friedrich's hypothesis is correct, I should have experienced a second generation regularly from 1982 onwards; this was not the case. The only time Friedrich managed to achieve a second generation was by keeping the livestock inside, and by continually offering the larva fresh leaves. Interestingly, Heslop describes taking a larva off a yellowing leaf one autumn (where it had already spun up the leaf), and placing it on the sprig of a new plant that had been cut back in June. It began to eat the fresh green leaves and continued to do so until January, under natural conditions, when it finally spun up when frost touched the plant. Heslop does not go on to say whether this larva pupated.

My somewhat warmer breeding conditions (larvae in a bottle outside until end of August, and reduced wind chill factor, subsequently, because of the net) would also favour rapid development, but why only during these last three years? What triggered these instances, and why only in these three years (2000, 2001, 2002) is difficult to explain. What is clear is that even when, very occasionally, a second-generation imago comes through, it has little or no chance of finding a mate, and, in any case the autumn climate in northern Europe would not allow the development of larvae from second generation pairing to the normal hibernation stage.

Adults

It is not within the scope of this report to deal with the adult insect, apart from the following comments. In the wood where most of the activities took place, just on the western edge of Basel, no indication of 'master tree', or 'assembly' behaviour of the imagines could be ascertained, as has been frequently described for *iris* in the U.K. There was a gradual decrease in the numbers of imagines observed in the wild over these 21 years, possibly due to a decrease in the numbers of *Salix caprea* over this time period as a result of forestry activities.

All reared insects were released into the wild. About two hours after emergence, the adult insects were taken to the wood where the larvae/ova had been found the previous year, and released. If release took place during sunny weather, the males invariably flew straight up into the trees and landed at a height of at least 10 metres. Females, however, were not so active and were placed low down on sallow or other convenient bush, where they were often found again two or three hours later. Females were released in various parts of the wood, but, during the last two to three years of this study, they were all placed on young sallow bushes growing together in a circumscribed area (about 600 square metres).

When eggs and larvae were searched for subsequently, greater concentrations were found within the area of female release, compared with other parts of the wood. This suggests that the females are relatively immobile before mating and up to the time of egg laying, and lay a large proportion of their eggs within the vicinity of emergence. Clearly, more work would have to be carried out to substantiate this, since it contradicts the accepted truth that the female flies far and wide during egg laying in order to spread its progeny.

Acknowledgements

I am grateful to Dr Mark Shaw, National Museums of Scotland, Edinburgh, for personal communication concerning parasitism and to Dr Roger Dennis of the Oxford Brookes University (Biological Sciences) for performing the statistical analyses and for helpful discussions

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