

CONTRIBUTION TO THE EARLY STAGES OF *XYLENA EXSOLETA* L.(LEP.: NOCTUIDAE)

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THE HISTORY of *Xylena exsoleta* in Britain since the turn of the century is well documented (Lorimer, in Heath and Emmet, 1983). In modern times the moth has been recorded mostly from Scotland. In the spring of 1995, a pairing was made from moths at sugar in Banffshire. Eggs were laid in quantity, batches being distributed to colleagues and their acquaintances in both Scotland and parts of England. The fate of the numerous broods reared by the different persons in widely differing locations and on a range of host-plants is summarised in this paper. The opportunity to rear this fine insect prompted a review by GMH of literature references to larval descriptions and illustrations, which appear to have arisen during the 1880s and which have a uniformity about them that could suggest a common origin; no account could be found of the life-history or of rearing in captivity. Only one published record of the occurrence in Britain of the wild larva is known to us.

The Banffshire Site.

This consists of a mixture of wet and dry heathland, bog, marsh and sallow carr, on a gentle northerly slope at around 160m. It is surrounded by rather unintensive mixed farmland. *X. vetusta* Hb. is also present, and slightly the more numerous. In autumn, the main flight period of *exsoleta* at this locality extends from the last week in September to the middle of October. Extreme dates during the years 1990-95 were 17 September to 5 November, the latter being the only sighting of the month. Tutt (1901-05) gives several references to November as a good month for the moth, which may have been the case further south then. Sugaring is usually many times as productive as light trapping at this season, as neither *Xylena* species seems to fly much in autumn - identifiable individuals re-appear night after night at the same or an adjacent sugared post. Ripe blackberries are also visited.

Where *exsoleta* hibernates is not known. None has yet been found in various outbuildings used by *Aglaia urticae* L. and the large dense tussocks of tufted hair-grass and *Juncus* which cover parts of the site seem a more likely choice. In spring *exsoleta* re-appears during the first proper spell of mild weather; exceptionally, as early as 6 February as in 1993, but normally slightly before the first *Orthosia* species emerge. This is well before any sallow catkins show blossom, so sugar is again attractive, and *exsoleta* may attend in temperatures as low as 3°C. However, light trapping is equally effective now, though a high proportion of moths do not enter the trap itself

but settle on the ground some distance away. Latest sightings during 1990-95 were on 23 April; thus the flight period here is rather earlier than the "late March to May, exceptionally June" given in Heath and Emmet (1983).

In early April 1995, favourable weather produced up to five *exsoleta* per look at sugar, giving a rare opportunity to study the life history of this scarce and declining species. Two moths of each sex were placed in a large container, and supplied with willow catkins plus a variety of green and dead vegetation; they were fed each night with sugar solution, which they drank (and excreted) copiously. One pair was observed in copulation on 20/21 April, and egg-laying began two days later. Eggs were laid in prodigious numbers; Tutt (*loc. cit.*) states 1000-2000 per female. Most were laid in large batches, carefully packed well down inside old flowering heads of Soft Rush *Juncus effusus*. Dry seed-heads of Cocks-foot grass *Dactylis glomerata*, Self-heal *Prunella vulgaris* and Sneezewort *Achillea ptarmica* were also used, but no eggs were laid on the willow *Salix* catkins, green vegetation, crumpled paper tissue or on the sides and muslin top of the container. Eggs were small in relation to the size of the moth, and creamy white when first laid, but soon changing to a pinky brown which closely matched the colour of the old seed-heads. Once sufficient eggs had been obtained, the moths were released at the original site.

Accounts of Rearing

Eggs were distributed by RL to a number of colleagues in England and in Scotland; the fate of each batch is recorded here as far as we know of them.

1. By GMH in Norfolk.

Eggs hatched in around ten days. Recorded dates of moults of most advanced larvae reared by GMH in Norfolk were 13, 18, 23 and 28 May. Larvae were managed initially in batches of twenty in plastic boxes measuring 150 x 100 x 50 mm. Larvae on dock ate only the broadleaved *Rumex obtusifolia* but during the fourth instar the furthest developed attacked and devoured their smaller brethren, especially those in moult or newly moulted; this was attributed to food being allowed to remain long enough to go limp during the very hot weather at that time, so larvae were segregated into batches of four, six and fifteen depending on size and put into appropriately-sized containers; from that time dock was selected only from the most luscious and rapid growth, avoiding flat, pale leaves no matter how young. No further cannibalism occurred in any box.

Boxes of last instar larvae became heavy with condensation due mainly, it was thought, to the high moisture content of the dock, and for a while boxes were laboriously cleaned and dried and the paper lining and crumpled resting niches changed frequently. Later into the instar it was thought dampness might not be inappropriate for this larva of wet Scottish moorland, so condensation was allowed to accumulate and cleaned only at longer

intervals. Larvae appeared at the time no worse for this indifferent treatment and some colleagues had adopted a similar pattern.

Last instar larvae were far less irritable than those of second and third instars, when they readily thrashed about at disturbance or twitched violently if contacted by another larva. The larger larvae were indeed placid by contrast and when handled they displayed no such vigour and unlike so many other species they did not vomit then. They rarely curled up, being mostly laid stretched, and when replaced in their box they just rambled off. Their crotchets gave a grip that might feel sticky to human skin but which allowed the larva to be separated from its perch with no suggestion of damage. They fed by day and night. When approaching full-growth they were given fresh flowering shoots of sorrel *Rumex acetosa* and these were readily devoured.

As larvae appeared to be ready to prepare for pupation they were divided into three treatments, two smaller batches put into slightly moist peat to a depth of 100mm, and a larger batch of forty larvae into 40mm of peat over dried sharp sand that sloped from 110mm to none beneath peat. Larvae were introduced as they were judged to approach maturity, this being when they felt firm to the touch in contrast to their earlier rather soft, flabby feel. Larvae spent their first two days if not in constant motion then at least for much of that time, day and night, until they finally rested full length against the glass lid at the top of the wooden box. The earliest disappeared after 2-3 days, but thereafter it was not possible to record the time of individuals because of continued addition of larvae until 24 June, by which time all larvae had been judged to be fully grown. During the while that larvae were motionless the body colour changed from uniform pea-green to mottled yellow and green, with patches of alternating colours, not at all attractive and indeed suggestive of sickness (or as parasitism might appear in wild larvae). Also at this time larvae shortened in length to some three-quarters and with rings swollen, taut and wet they shortly disappeared into peat, having not eaten for several days. All larvae had gone into peat or were resting upon it by 28 June.

Examination of the pupating medium soon found corpses in blackened, rotting state both upon the surface of peat and below with no cocoon begun; others had made a cocoon but failed to pupate. Of a total of 72 mature larvae only 11 had pupated, being distributed through the three pupal batches with no one proving advantageous. One moth that emerged on 17 August was the sole survivor of the Norfolk attempt.

Most of the larval life of batches reared in England was passed under cool to cold conditions with temperatures around 10°C, but the remarkable heatwave of early May shot thermometers to 21°C and cooler sites had to be located: late May was extremely cold and the first two weeks of June quite the most dismal on record with indoor temperatures regularly no more than 10°C.

2. By Robert Harvey in Norfolk

Starting with around 100 eggs, larvae were fed throughout on dock leaves. Most larvae reached full growth but then suffered heavy losses after entering soil. 15 moths were reared, all of them from pupae formed in kitchen-roll paper that had not been available to the rest of the batch.

3. By RL in Banffshire

Eggs hatched in 10-12 days. The tiny larvae were extremely active for the first three days (in the wild this presumably ensures dispersal). They were kept in plastic boxes in an unheated room, exposed to normal daylight. Initially they were fed on potted clumps of grass, mainly *Poa annua*. Couch grass *Agropyron repens* was also eaten, but otherwise they would eat only meadow vetchling *Lathyrus pratensis* from a wide variety of herbaceous plants offered.

Once past the second instar the larvae stopped eating grasses; they were offered a wide selection of plants and shrubs picked at or near the original site of their parents. For a supposedly polyphagous species, *exsoleta* proved very choosy. The following plants were rejected or barely nibbled - chickweed, cranes-bill, bird's-foot trefoil, tufted-vetch, clovers, broom, meadow-sweet, raspberry, bramble, strawberry, black-currant, rowan, knotgrass, dead-nettle, groundsel, honeysuckle, sallow, rush and wood club-rush. However, bird-cherry *Prunus padus* was eaten avidly and the larvae completed their growth on this food with negligible loss. Sprigs and, eventually, small branches were provided. These had to be replenished twice a day during the final instar, which at least ensured freshness. Also eaten were large crisp leaves of dock and sorrel when newly picked.

Supplies of bird cherry being limited, dozens of surplus larvae were periodically released at the original site; none was ever seen again. The twenty-five penultimate instar larvae eventually retained became fully-grown in mid to late June. In appearance and behaviour they agreed closely with the detailed description given by GMH. In the penultimate instar the length attained was 40-45 mm, and in the final instar they reached 65-70mm. They were remarkably invariable in colour and pattern.

Pupation took place at or near the bottom of a loose mixture of unsterilised, slightly damp, peat and *Sphagnum*, 20cm deep in large containers. Unlike other genera of autumn moths such as *Agrochola* and *Xanthia*, there seemed to be no prepupal diapause. One of the twenty-five larvae produced a deformed pupa. The twenty-four healthy pupae were disinterred and laid upon the surface of slightly damp *Sphagnum* but not sprayed. Development was slow and gradual, producing moths without loss; these emerged in the middle part of the day between 19 August and 13 September. Unless there is a diapause after emergence in the wild, this would be earlier than for wild moths. All were in the upper half of the normal size range. They were released at the original site.

4. By M.R. Young in Aberdeenshire

In the first instar, larvae were fed entirely on grasses, eating both coarse and fine. From the second instar, half were reared solely on hawthorn *Crataegus monogyna* leaves, and half on blackthorn *Prunus spinosa* leaves with equal success. They were kept entirely in the dark in a warm kitchen, and they fed up very rapidly. Larval losses were about 10%, and occurred in the third or fourth instar.

Most larvae were passed on to others or released. The two dozen larvae finally retained produced moths without loss. They pupated in a mixture of potting compost and sand, 10-15 cm deep. The pupae were not watered. Moths were of normal size.

5. By R.M. Palmer in Aberdeenshire

Of twenty third instar larvae received, three lagged behind and died. The seventeen pupae then obtained gave rise to fourteen moths. Hawthorn was the sole foodplant. No special treatments or techniques were used.

6. By David Brown in Warwickshire.

Larvae hatching from 120 ova were started on a mixture of dock and sallow, but they much preferred the former. They were reared in plastic boxes, and forced throughout at high temperatures, sometimes in direct sunlight. Sallow was offered at intervals but always refused. Overcrowding was tolerated, with no cannibalism. Five at most were lost before the final instar.

In the final instar the larvae were transported to North Wales. They now consumed huge amounts of carefully selected dock, which had to be replenished two to three times a day. About twenty full-grown larvae became less healthy, and mostly died. The remaining 100 larvae burrowed into 10cm of bulb fibre, from 6 June onwards, and they were left undisturbed until early August.

Only thirty of the 100 larvae that went into compost were found to have pupated successfully, the others being dead and shrivelled. The thirty healthy pupae were sprayed with water daily, and in due course twenty-six gave rise to moths.

7. By Andrew Gardner in Warwickshire.

Larvae from 90 ova were reared in plastic boxes at a constant room temperature of about 21°C. They were fed on dock, refusing sallow that was offered at various times. Few were lost during the early instars, but twenty-five died in the penultimate or final instar. Full growth was reached by mid-June, but the 60 larvae which went down into bulb fibre produced only twenty live pupae and from these, sixteen moths emerged.

8. By Michelle Stephenson in Warwickshire.

Began with twenty-four second instar larvae, reared on dock at room temperature. Again, sallow was refused. Two larvae died before the final

instar. None of the twenty-two larvae that reached full growth pupated successfully. The 20cm of bulb fibre provided may have been kept too dry.

9. By John Ward in Northamptonshire

Newly-hatched larvae were put on to osier *Salix viminalis* foliage in plastic boxes and they fed up well enough until the second instar when they were sleeved on osier in the hope of simulating a more natural environment. Development became very uneven with increasing losses so twenty-four of the largest individuals were sleeved on growing dock on which they fed until they were fully grown, when most of them died.

Fifteen of the surviving larger larvae of those still on osier were then tried individually in plastic boxes and offered a range of food that included flowers of sorrel and buttercup, also dock and osier, but these larvae shared the fate of their fellows, and there were no viable pupae from any treatment.

We understand that a similar attempt to rear this species was made a while prior to this study with larvae from three batches of eggs reared separately by different persons in different parts of England; the history of these larvae is said to be similar to our experience except that no moths at all were reared.

Summary descriptions of the early stages.

The only illustrations of early instars known to us are those by Buckler (1896) and Wilson (1880); the latter is crudely unrealistic while Buckler's figure, plate 96, fig. 2, does not convey the impact of a dark-green larva with fine stripes, and his larger figure 2a is improbable according to our experience.

First instar: length to 4mm just prior to moult; body uniformly yellow-green, the skin glassy and shining, totally lacking stripes or ornamentation and relieved only by the finely dotted black warts each finely ringed in blanced green and bearing a stiff short bristle. Head pale light brownish-green, prothoracic plate pale brown heavily studded with black warts and bristles, anal plate similar but paler, true legs, prolegs and anal claspers all translucent with black flecks.

Second instar: length at full growth to 8mm, glassy olive-green with fine dorsal and rather thicker subdorsal lines both pale-yellow, a fainter creamy spiracular band merging into the pale ventral region, warts black, conspicuous. All body lines continuous from prothoracic plate to anal plate.

Third instar: length to 15mm, deeper matt green with similar body lines and of same relative proportions but brighter and better defined, the whitish subspiracular in particular now contrasted against the dappled green and white ventral region; warts black but smaller in relation to body size and dorsally not outstanding.

Fourth instar: length to 26mm, handsome, fulvous darker green, the dorsal line so narrow and faint as to be noticeable only under magnification, and then well interrupted at ring divisions; subdorsal bold deep-yellow, subspiracular narrower than in the previous instar but crisply yellowish-white; tiny black warts quite indistinguishable from the wriggling dark-green pattern over the pale ground colour. In this instar and in the next the larva bears a striking resemblance to that of *Heliothis maritima* Grasl. (but of course lacking the posteriorly-directed body spines of that species).

Fifth instar: length to 35mm. similar in every aspect to the previous instar, the anal claspers with better developed extension of subspiracular stripe, which on the body is itself much broader (twice as broad) as the subdorsal, the dorsal scarcely discernible even under magnification.

Final instar: six instars were counted of the larvae reared by GH and RL, but Dr H. Beck who also reared larvae from this same stock has reported seven instars. The larva at full growth recorded by Buckler (1886) to be two and a half inches (60mm) long is quite correct, the largest even to 70mm, but considerable shortening takes place as the larva ceases to feed and as it grows firm to the touch, but before it begins its marathon perambulation prior to entering the pupating medium. It is only at this instar that the larva displays its highly individual and ornamental pattern that has led Barrett (1900) to write, page 54, "very few larva of equal beauty to this are known here" – an apt expression that has been copied by later writers.

Contrary to the account given by Lorimer (in Heath & Emmet, 1983) there was very little variation amongst the many larvae reared to last instar by GMH and RL; the separate orange lateral dashes that margin above the subspiracular band were quite uniform in size and colour, never dark-red as figured by Buckler (1886), Wilson (1880), Barrett (1900), Stokoe (1948) or Hoffmann (1893). The colour of the subdorsal and subspiracular stripes varied from whitish to cream and pale-yellow. No larva developed orange (and certainly none red) markings dorsally or along the subdorsal stripe, and the figure 2a of Buckler (*loc. cit.*, pl. 96) appears a combination of fifth instar with artist's licence that depicts rich orange subdorsals. Only the intensity of black markings that bordered the subdorsal could be described as significantly variable, in the weakest development reduced to a narrow line that merely edged the subdorsal and simply linked the trapezoidal warts which, in this genus and its allies, are so far displaced towards the subdorsal as to be almost in straight alignment; the opposite was the maximum development of this black figure to broadly rectangular proportions that engulfed both warts so masking their usual black edges. There was but one example only of each of these extreme varieties, but the weakly etched form is the sole (and very stylised) figure of Wilson (*loc. cit.*, pl. 38, larger fig. 13), and Buckler's fig. 2d is even more extreme. The illustrations of

Hoffmann (pl. 32, figs. 21a, 21b) are also of the stylised presentation of that time, fig. 21b being remarkable for the total absence of orange from the subspiracular band, while fig. 21a has its upper edge bright-red and continuous.

Pupa

Barrett (1900) gives a good description that is evidently copied by Lorimer in Heath and Emmet (1983): the most significant features are its light, glossy, thin cuticle of chestnut-brown colour, contorted abdominal rings and rather *Cucullia*-like appearance but so much more substantial and with no projection of mouth-parts beyond the wing covers. Cremaster conical and heavily sculptured, bearing two almost straight, pointed spines 1mm long, which diverge at an angle usually of 30-40 degrees, whereas those of *X. vetusta* are parallel.

Cocoon

A large rounded, oval structure, greatly larger than the pupa, which is comparatively short and dumpy although bulky; the cocoon is of fragile construction that does not appear to be strengthened by silk, instead its wall of some 2-3mm thickness is simply firmly pressed to present a smooth interior. Those in sand are reminiscent of the *Agrochola* texture and like them it crumbles as soon as touched.

Larval comparison with other species

The last instar is so individual that it could not be confused with any other larva in Britain or indeed in Europe. The well-developed but fine dark or blackish dorsal edge of the subspiracular band present in *X. vetusta* in both last instar and in earlier instars is an immediate and constant character that easily separates *exsoleta* from it, while *vetusta* has never a pea-green body colour and lacks the black subdorsal suffusion around the trapezoidal warts; *vetusta* alone has the continuous pale medio-dorsal line.

Confusion is more likely between the earlier instars of *exsoleta* with larger larvae of common green noctuids that feed up at the same time of year; but the common green *Orthosia* larvae have yellow dots through the green body colour and display a conspicuous pale dorsal stripe against weak subdorsals, and have a large, rounded, pale-brown head, which features are shared also by *Dryobotodes eremita*. The *Lithophane* species have well-marked and well-developed, conspicuous dorsal stripe and large, rounded pale-brown head. The head of the young *exsoleta* larva is consistently pale green with fainter flecks.

The third to fifth instars of *exsoleta* could be likened to the larger and yellow-striped larva of *Ceramica pisi* L. because this larva lacks a dorsal stripe and because both species have their spiracles placed at the dorsal edge of the subspiracular band; in *C. pisi* the dorsum is much darker and its mottling denser than those of its lateral zones, whereas in *exsoleta* these zones are all of equal intensity; the head of *C. pisi* is warm honey-coloured

to light-brown, that of *exsoleta* pale-green; however the larva of *C. pisi* is scarcely to be found before September whereas young *exsoleta* will be feeding in May.

The larva closest in superficial appearance to the third to fifth instar *exsoleta* is the last instar *Heliothis maritima* because of the matt dark-green body colour and pale-yellow lateral stripes present in both species; *maritima* has its head and prothoracic plate with black etching, and particularly its skin coated with tiny black, backwardly-directed spines; and *maritima* is of course another September feeder.

Occurrence of the wild larva

The finding of so striking a larva as the last instar of *X. exsoleta* would be a matter for record, even at a time when the species might be more plentiful than it is today, yet the absence of mention of the larva by Tutt (1901) suggests that wild-found examples were not recorded if not unknown up to the time when Tutt compiled his book. The range of figures made by Buckler would seem to indicate that his larvae were reared from the egg, and this at a time when he was receiving wild-found material from many colleagues of very diverse and hitherto undescribed larvae. In fact there is no book known to us that actually states the fact of a larva ever being found wild.

Examination of British journals has brought to light but one instance of the wild larva of *exsoleta*, this of a moth bred 28.ix.1929 by J.J. Walker from a larva found on thistle at Tubney, Berkshire (Baker, 1990). A second record (Haggett, 1992) of a third-grown larva found in a water-trap during the Welsh peatland invertebrate survey is now recognised to have been a mis-identification due to the lack of knowledge of the early instars. Just recently we have learned from John Fenn of his discovery of a fully grown last instar larva amongst commercially grown lettuces at Wissington, Norfolk, in 1950, and that he knew additionally of larval records from Vic Day in the Stoke Ferry area also of that time; these records are notable also because they confirm the species to be still resident in Norfolk at that date.

There are however two recent records of the wild larva, both unpublished, and for which we are pleased to acknowledge the experience of Dr M.R. Young. The first was a larva at Udney in 1974 and the second at Oldmeldrum in 1986, both in Aberdeenshire, Scotland; both were full-grown and engaged in their pre-pupatory wanderings, thus giving no clue as to foodplant.

There may surely be records of wild larvae from the period of the last century into this when the insect was regarded as common over Britain including the southern counties of England, and these would be worthy of collation. In the absence of such data we can only conclude that the life history of *exsoleta* has been based wholly on examples reared from the egg.

There are two accounts of larvae found in the Middle East, one of fully fed larvae found in April in Iran, the other of a larva found by Mountfort

(Wiltshire, 1948) in Cyprus on 10 April. Another unpublished account from John Fenn concerns his finding two larvae both in the penultimate instar feeding on low herbs in the Italian Alps at Col de Tende on 17-18 July 1974, and which reminded him of *Heliothis viriplaca* Hufn.; they constitute the latest larval dates known but still produced moths in the following September.

Discussion

The main feature of the rearing programme was the contrast between the success rather casually achieved by the Scottish rearers, and the high levels of mortality at about the time of pupation amongst the stock reared in England.

Because all the ova were from the same source, differences in viability can be ruled out. Nor can husbandry have been a factor when so many experienced breeders had similar problems at the same stage. The simplest explanation is that the Scottish reared stock were fed mostly on a rosaceous shrub whereas dock was widely used in England. It might be that dock alone is not quite a sufficient food for last instar larvae. Many noctuid larvae that begin life feeding on low plants later climb to complete their growth on the foliage of woody shrubs or trees.

However, there is a more intriguing, if less likely possibility – that it was no coincidence the larvae reared in an area where the moth is still resident did much better than those reared in areas from which the species has died out in recent history. Perhaps *exsoleta* is particularly vulnerable to minute levels of toxins in its foodplant, arising from agricultural contaminants or industrial pollutants. The very large volume of food consumed by the larva in its final instar, remarked upon by many of the breeders, might cause toxin build-up to a fatal level at the time of pupation.

Until this question is resolved, the consensus of those taking part in this study is that *exsoleta* larvae should be reared in warm, and possibly humid conditions. At least in the early instars dock seems to be a suitable food, but it is important to select only large, fast-grown, crisp leaves from robust, vigorous plants, more readily obtainable from *Rumex obtusifolia*. Especially in the final instar, plum, cherry or blackthorn should be supplied. The pupation medium should be deep (20cm) and not too dry. Because of the extreme fragility of the cocoon, the danger of disturbance by other tunnelling larvae should be avoided by provision of plenty of space and by limiting numbers.

The foodplant(s) of wild larvae remains unknown; at the Banffshire site it is clearly not sallow, as RL had always assumed, and which is used by *X. vetusta* there; nor can it be bird cherry, blackthorn or hawthorn as these do not occur there naturally. The failure to find such a large, brightly coloured and (at least in captivity) diurnally feeding larva is puzzling, but fits in with the dearth of published records.

Acknowledgements

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Bird-cherry Ermine *Yponomeuta evonymella* L. (Lep.: Yponomeutidae) infestations in the Scottish Highlands

Dr Murdo Macdonald of Strathpeffer reported to me that he had seen serious defoliation of Bird-cherry *Prunus padus* along the Bridge of Gairn and main Royal Deeside roads, between Ballater and Braemar, in the 10km squares NO19, 29 and 39, in June 1996. Whole trees had been stripped of their leaves and branches were covered in webs.

On returning home he found several Bird-cherry trees were also infested on the Moy Island in the River Conon (10km square NH45), though not as devastatingly as in Aberdeenshire. I visited this Ross-shire locality with my wife on 23 July and found the infected trees. A few imagines of *Yponomeuta evonymella* L. were emerging from the webs. Bird-cherry trees were examined on the short drive to Muir of Ord but the only infestation noted was at Orrin Falls in the same 10km square. This species is not shown as occurring in VC 106 on Map 2 of Volume 3 of *The Moths and Butterflies of Great Britain and Ireland*.—DEREK C. HULME, Ord House Drive, Muir of Ord, Ross-shire IV6 7UQ.



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