FURTHER ILLUSTRATED STUDIES OF LEPIDOPTERA LARVAE: *APAMEA EXULIS* (LEFEBVRE), SSP. *ASSIMILIS* (DOUBLEDAY), THE NORTHERN ARCHES (NOCTUIDAE)

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NOMENCLATURE

Two British moths have suffered more than most from changes to their scientific names; they are the Northern Arches, found in mainland Scotland, and its other form, the Exile, restricted to the Shetland Isles. The Northern Arches was first found at Rannoch in Perthshire in 1846 and given the name *Hadena assimilis* by Doubleday in 1847. A similar moth, discovered in the Shetlands in 1883, was recognised as belonging to the species *H. exulis* Lefebvre, 1836, named from specimens from Labrador but also found in Greenland and Iceland. It had already been suggested that *H. assimilis* and *H. exulis* were conspecific, but that did not prevent the two forms being given separate English names. By the publication of Barrett (1897) and South (1907), it was generally accepted that *assimilis* was a subspecies of *exulis*. The species was then in the genus *Crymodes* but in the 1939 revision of South it was placed in *Apamea*, a genus of about seventeen resident British moths. This arrangement has been followed by most subsequent authors, with a few species removed from the genus. In the late twentieth century *exulis* itself was reduced to a subspecies of two different continental species, first *A. maillardi* (Geyer) by authors such as Wolff (1971), Goater (1983) and Skinner (1984), and then *A. zeta* (Treitschke) by Mikkola & Goater (1988), Bradley (1998, 2000) and Waring & Townsend (2003). All the latter authors referred the Shetland moths not to ssp. *exulis* of *A. zeta*, but to ssp. *marmorata* (Zetterstedt), a form from Scandinavia. Finally, *A. exulis* has been restored as a full species (Agassiz, Beavan & Heckford, 2013). They give no subspecies, but here Goater (1983) is followed using ssp. *assimilis* for moths from mainland Scotland.

INTRODUCTION

In 1856 Dr Otto Staudinger of Berlin mounted an entomological expedition to Iceland (Staudinger, 1857). As companion he took C. Kalisch, a gardener by profession but also with the reputation of being the best field entomologist in Berlin. They left Copenhagen on 2 May in a "really fast schooner" and on the evening of 18 May arrived at Reykjavik where they spent the next four days. Here they found an unfamiliar larva which was later proved, by rearing, to be *exulis*. The surroundings of Reykjavik were uninviting for entomologists, being mainly rocks and moss, so they moved their base 40 km inland to the richer habitats around Thingvellir, the ancient site of Iceland's parliament and now a National Park. During June they continued to find larvae of *exulis*, mostly by raking tall moss and especially where grasses grew sparingly among the moss; by the end of the month they had thirty, some fully grown, others hardly half as large, and others still smaller. Although adult *exulis* emerged from pupae found during the second half of June, no captive larva had pupated by the time they left Iceland on 15 August. Most died at sea through only being supplied with moss, but a few survived to reach the adult stage. While still in Iceland, captive females laid eggs into the lower parts of stems of *Poa alpina*. The resulting larvae fed on the lower stems and down into the root. In mid September

they were all small, 5–8mm long, but by the end of November some were almost fully grown, others about half as large, while still others had hardly grown at all.

Staudinger's very detailed account of this visit to Iceland remains the standard reference for Icelandic forms of *exulis* (pp. 238–246); he also discussed the adult moth and its named forms and gave very good descriptions of larva and pupa. He then visited London, probably in 1858, and told J. W. Douglas that *assimilis* was an exact match for one of the dark varieties of the highly variable *exulis*. This opinion was published along with an English translation of Staudinger's account of *exulis* (Douglas, 1859). Parts of this translation were quoted at length by Barrett (1897). An error in translation led Barrett to state that larvae of *exulis* were found 'early in May near Reykjavik', and this has been repeated by subsequent authors. The German words 'schon in Mai' mean 'already in May' and not 'early in May' (R. D. Hawkins, pers.comm.). Barrett's compression of the text also did not mention that almost all the larvae were found around Thingvellir during June, with only the very first being from near Reykjavik in late May.

Mikkola & Goater (1988, p. 256) pointed out the long isolation of *exulis* in Shetland from *assimilis* in mainland Scotland. The larval habitat occupied by *exulis* in Greenland and Iceland also appears to be very different from that inhabited in Scotland. Whereas the former is described as calcareous rock with larvae found beneath surface fragments and amongst grass roots in loose, crumbling soil, the Scottish highland and Shetland locations include peat moor, as different an environment as could be expected. It therefore appeared that a separate study of Scottish larvae would be of interest.

In 1988 I, and several others, searched for larvae of *assimilis at* Dalwhinnie, a noted locality for the adult moth, and at other sites in East Inverness-shire. We looked under stones, a method used successfully in Iceland by Wolff (1971), but found no larvae. I tried digging for larvae at Dalwhinnie but the peat was so choked with roots of *Calluna, Erica* and *Molinia* that I was unable to make any progress. In fact, had I known, there was no need to dig because captive larvae follow the lifestyle as described by Staudinger for *exulis* reared from the egg, in that they dwell in the grass litter just at and slightly above soil level.

A breakthrough came when an *assimilis* female taken by Graham Collins at Dalwhinnie in early August 1988 laid eggs in captivity; some of the resulting larvae were given to Jim Porter and at least one was reared to maturity, to form the subject of the photograph on plate 42 of his book (Porter, 1997). A few were sent to me as newly hatched larvae and developed into the larvae figured and described in this paper.

Life-style in captivity

The young larvae were received on 16.viii.88 and were given sods of grasses growing around my home in Norfolk. They bored into stems of *Poa annua* and ejected piles of dry blanched frass; they also ate little holes from leaf blades, eating through both cuticles. Only three larvae prospered, two feeding within cut stems of *Schedonorus giganteus* (formerly *Festuca gigantea*), eating out the stem linings and packing fine blanched frass tightly behind them to fill the stem cavity. By 15.ix.88 the other larva on *Poa annua* was in its second instar and measured 15 mm long; by 29.ix.88 it reached 20 mm long and was described and figured. While the two smaller larvae grew slowly and lived in stems of *S. giganteus*, the largest continued to grow quickly to reach 33 mm by 15.x.88, when it was in its third instar and was figured again.

This largest larva occupied a pressed-out chamber at the grass stem bases and not actually in the soil. The larva did not eat roots, only blanched lower grass stems which it cropped close to the soil. On 21.x.88 this same larva was put into a clump of couch grass (*Elytrigia repens*) while its smaller brethren, having eaten through their 10 cm stems of *S. giganteus*, had themselves moved into *Poa annua* and made little cells at the stem bases. On 27.x.88 the larger larva was lying up for its last moult in its pressed-out chamber between moss and couch roots. The smaller two had entered their plant root-balls to excavate small hollows with fine dry green frass piled at the entrances. On 4.xi.88 the largest larva passed its last moult and was drawn for the third time a few days later. In this final instar it maintained the same curled resting posture, with head tucked against its body, within a roomy chamber with walls simply pressed out and not at all stuck or spun together; dry brown frass was deposited outside the chamber.

All larvae were reared at the same temperature of around 10° C. None were retained to become adult moths, but all were preserved as larvae in spirit or as blown skins.

The accelerated growth of some larvae was also noted by Staudinger; this is especially remarkable in a species believed to pass more than one year as a larva in the wild, but it is recorded also for other northern or high altitude species.

In 2005 I had opportunity to rear this insect again, thanks to the kindness of Roy Leverton who was given a female moth taken at Lumsden, Moray, on 15 September, a late date but with eggs laid within weeks after capture. Larvae hatched in ten days and were put on to uprooted tufts of *Poa annua* where larvae tunnelled out the lower stems before spinning small pockets of roots and soil in their second instar. As the larvae grew so they vacated silken balloons which were seen to have dry frass lining the walls, and also scattered through soil. The largest larvae reached 20 mm by mid October and were found lying upside down, each on the ceiling of its balloon, exactly as do larvae of others of this *Abromias* section of *Apamea*. Larvae require the minimum of attention as long as their grass sod remains free from mould; I used the top sod of soil with trimmed grass stems and leaves, but with plenty of fine roots as well as ramifying larger roots. Loose soil was shaken off and the whole packed into a large plastic box and left until I judged it time to renew the sods. I found it convenient to dig sods from raised tumps of *Arrhenatherum* and associated fine grasses which were always dry and friable.

Descriptions of larval instars

First instar

Body colour grey, faintly tinged with greenish and pinkish dorsally on abdominal rings; narrow body rings twice as long as broad; head black; prothoracic plate crescent-shaped, dark brown; anal plate narrow, dark brown; true legs dark brown; prolegs pale grey touched with a dark spot on the outer surface at the crochets; warts minute with weak bristles.

Second instar (Plate 6, Fig. 1)

Length 20 mm. Now milk-white with weak grey-brown warts and distinctive reddish head, its body deeply suffused grey on the thorax; prothoracic plate large, greenish-grey with a dusky margin all round.

Third instar (Plate 6, Fig. 2)

Length 33 mm. Colour now putty-grey with dorsal vessel prominent on abdominal rings; abdominal warts pale grey, oval and inconspicuous; head ginger-brown, lobes well differentiated, labrum paler, mandibles deep black; prothoracic plate rounded, grey-ochreous with smoky edge all round; anal plate hemispherical, grey-ochreous with a dark grey rim all round; warts on preceding ring heavier than on rest of body; prolegs and anal claspers pale grey, crochets darker; spiracles broadly oval, darker centred wih darker edge.

Fourth (last) instar (Plate 6, Figs. 3 & 4)

At full growth the larva is rather over 40 mm long, but its habit is to keep the head and thorax retracted. Body shape cylindrical, flattened dorso-ventrally, thickset with the thoracic rings a little swollen beneath so that the only obvious taper is at rings 11 and 12. Body colour ochreous-grey with silver lights and pinkish-purple hues along the abdomen which is much puckered and quilted by the shining skin and which on the distended early abdominal rings can appear to be quite glassy. Thorax much wrinkled transversely with three main ring divisions, the centre bearing a row of four dorsal warts each placed on its individual circular patch of grey chitin, the subsegments to each side bearing dorsally a wedge of grey chitin streaked outwards from the medio-dorsum. This pattern is similar to that found in *A. monoglypha* (Hufnagel) and its allies in which the streaks are more heavily chitinised black, and in *A. oblonga* (Haworth) which is more similar to *assimilis*, and it is typical of the larva of this section of *Apamea* that is better called *Abromias*. Trapezoidal warts pale grey, inconspicuous except on rings 11 and 12 where they are black and bold, the lateral warts tiny. Spiracles oval, brown-centred, thickly rimmed in black. The dorsal vessel conspicuous and pulsating on all abdominal rings except 11 and 12. Head globular, dark chestnut brown, polished and shining, the lobes well separated above; labrum and mouthparts black, the head bearing soft, fine hairs. Prothoracic plate large and solid, broadly shield-shaped, rounded laterally, highly polished but with dimples, ochreous-grey with darker posterior margin that is interrupted where the fine medio-dorsal line meets it. Anal plate broadly semi-circular, ochreous, highly polished and shining, edged anteriorly by a very dark thin margin. True legs short, pale brown; prolegs and anal claspers short, pale grey with blackish crochets.

An illustration of the larva of *exulis* is given by Millière (1858–70) but the figure 9 on his plate 65 is sadly stylised and not at all as successful as that of the moth (fig. 11); the larva looks more like a hepialid, being drab uniform bone-white, with short, stiff bristles, yellow head and small grey prothoracic plate; none of these characters are typical of *assimilis*, and were it not for the accompanying text we might be misled into thinking there was a difference in appearance between Icelandic and British larvae. Millière describes the head as reddish and the prothoracic plate reddish-yellow and covering the whole of the dorsum – all of which agrees with *assimilis*. But he does describe the body colour to be glossy livid whitish tinted with yellowish above on the second and third rings which, while this can be said to match his figure, is quite unlike the pinky-putty hue of *assimilis*.

Discussion

The genus *Apamea* Ochsenheimer, 1816, as recognised by Kloet and Hincks (1972) and subsequent checklists (Bradley 1998, 2000; Agassiz, Beavan and Heckford, 2013), remains very unsatisfactory with its larvae falling into two very clearly

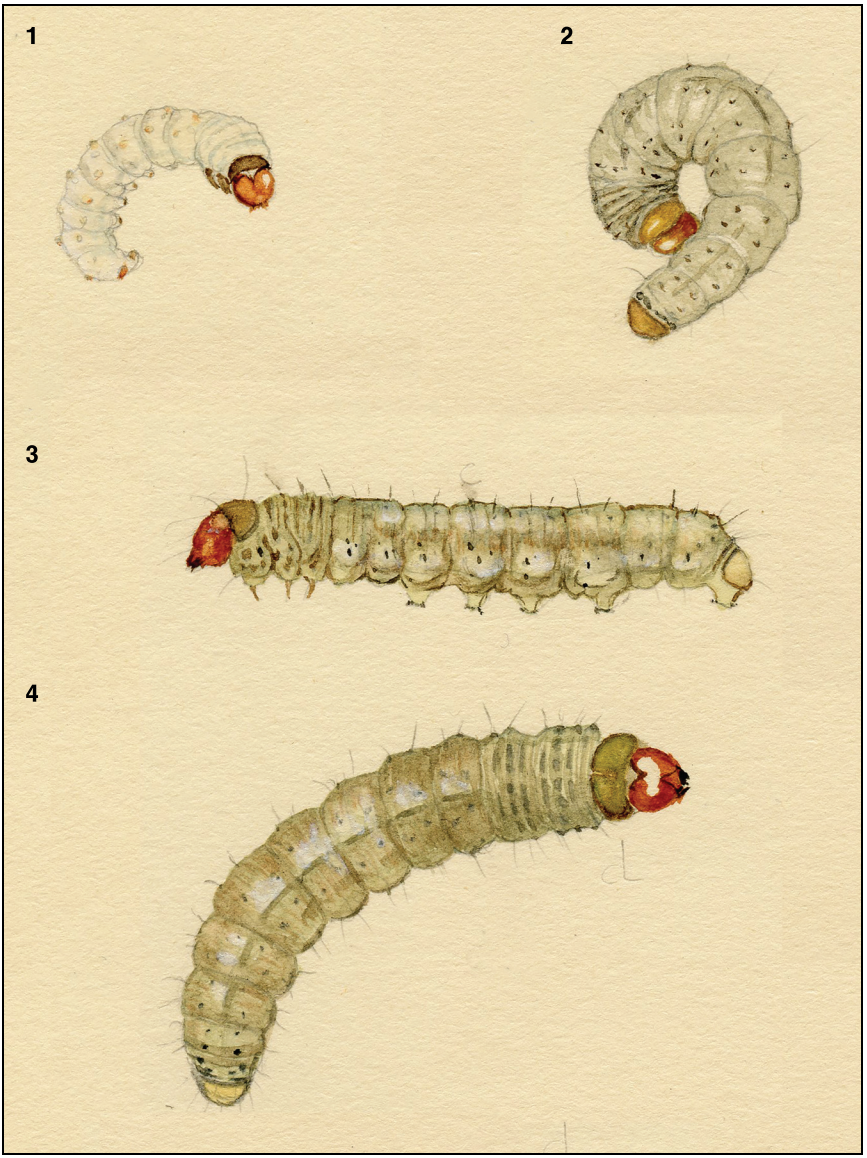

PLATE 6. *Apamea exulis* ssp *assimilis*, larvae ex female, Dalwhinnie, G. A. Collins, viii.1988. Fig. 1. Second instar, 29.ix.1988. Fig. 2. Third instar, 15.x.88. Figs. 3 & 4. Last instar, 8.xi.1988. Illustrations ($\times 2$): G. M. Haggett.

separated groups. One group comprises larvae that are but weakly pigmented, with a waxy cream body tinted pinkish-grey and bearing conspicuous black warts, a heavily armoured head capsule, and chitinised streaks on meso- and metathorax; larvae of the other group are dorsally well pigmented and display well-defined dorsal and subdorsal lines and a bold spiracular band with weaker warts and plates. The first group has earlier been recognised in some form as *Xylophasia* Stephens, 1829, *Crymodes* Guenée, 1841, or *Abromias* Billberg, 1820, and comprises the British members *monoglypha, lithoxylaea*, *sublustris, exulis, oblonga* and *furva* plus the migrant *lateritia*. The resident British species of the second group are *crenata, epomidion, remissa, anceps, sordens, unanimis* and *scolopacina*. The whole genus has more recently been closely examined by Beck (1999-2000) who proposes a fundamental reclassification of this and other genera in which larval characters both morphological and ornamental contribute a significant part; Beck uses the generic name of *Abromias* for the *monoglypha* group with most of the other British species retained in the genus *Apamea*; the only exception is *scolopacina*, given its own genus *Loscopia*.

It appears that no wild larva of ssp. *assimilis* has yet been found in Britain, and so its natural foodplant has not yet been determined. This is suspected to be *Molinia caerulea*, the purple moor-grass, since this is the dominant grass where adult *assimilis* occur. As we now know, other members of this *(Abromias*) part of the *Apamea* genus feed in a similar manner to a*ssimilis*, so this larva may pass its existence in the *Molinia* crowns critically above the wet substrate.

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