INTRODUCTION

Mountain Ringlet *Erebia epiphron* is found locally at high altitude in Europe with colonies in Scotland and Cumbria in the north and in the mountains of southern and central Europe much further south. The altitude range in southern Europe is very wide, occurring from 500 to 3000m (Chinery, 1998), while it is narrower in the UK, being 500–700m in Cumbria and 350–900m in Scotland (Asher et al., 2001).

A paper which provides an explanation for the limited distribution of Mountain Ringlet in Scotland was published in *Atropos* 41 (Masterman, 2010a). That paper demonstrated that 1km squares within the range of Mountain Ringlet had significantly more Mat-grass *Nardus stricta*, the larval foodplant, and more nectar plants than 1km squares outside the range of Mountain Ringlet in the Cairngorms. The nectar plants were Tormentil *Potentilla erecta*, Heath Bedstraw *Galium saxatile*, Meadow Buttercup...
Ranunculus acris and Wild Thyme Thymus praecox. A positive relationship was found between the number of Mountain Ringlet recorded in a 1km square and the abundance of Mat-grass and the nectar plants. These results support the hypothesis that it is herb-rich Nardus grassland which is the preferred habitat of Mountain Ringlet and that it is the distribution of herb-rich Nardus grassland which accounts for the limited distribution of the butterfly in Scotland.

Masterman (2010a) found 2,274 Mountain Ringlet during survey work in Scotland during 2008 and 2009. The mean altitude of the Mountain Ringlet observations was 684m in 2008 and 675m in 2009 with 95% occurring between 460 and 902m, which is similar to the 350–900m altitude range given by Asher et al., (2001). Further survey work in 2011 resulted in 861 Mountain Ringlet being recorded with a mean altitude of 704m and 95% occurring between 516 and 891m (Masterman, 2012).

This paper provides a plausible explanation for the observation that Mountain Ringlet is only found at altitudes of 350–900m in Scotland. It also relates Mountain Ringlet habitat to some topographical features and discusses whether or not climate warming is having an effect on the altitude range of Mountain Ringlet, or will do so in the future.

**Survey Methodology**

The main objective of the survey work in 2008 was to obtain an understanding of why the species only occurs at altitudes of 350–900m in Scotland and to measure how its habitat changes with altitude.
During the flight period from late June to July, a number of 200m long transects were surveyed for the presence of Mountain Ringlet, Mat-grass and a number of nectar plants on the south-facing aspects of different mountains where the butterfly is known to be present. The distribution of the 15 mountains which were surveyed is shown in Figure 1 and this is representative of the range of Mountain Ringlet in Scotland (Figure 2).

The 5m wide transects were along gullies, with or without streams, where grassy flushes containing Mountain Ringlet habitat occur (Baines, 1993). Owing to the differing south-facing area and height of each mountain, the number of transects per mountain varied but the key aim of sampling a range of different altitudes on each was accomplished.

Along each 200m long transect the following data were recorded:
• altitude and eight-figure grid reference at bottom of transect.
• number of Mountain Ringlet seen.
the abundance of Mat-grass was measured with the following scoring system: absent: 0; present: 1; abundant: 2.

in addition to the four nectar plant species already mentioned, the abundance of a further three species was assessed (Alpine Lady’s Mantle *Alchemilla alpina*, Yellow Mountain Saxifrage *Saxifraga aizoides* and Heath Spotted Orchid *Dactylorhiza maculata*) as they have been suggested as good indicators of Mountain Ringlet habitat (Paul Kirkland, pers. comm.). Their abundance was recorded with the same scoring system.

Carnation Sedge *Carex panicea* was chosen as an indicator of wetter vegetation with sedges which some recorders have found to be favourable Mountain Ringlet habitat. Its abundance was recorded with the same scoring system.

**Number of Mountain Ringlet**

Mountain Ringlet was found in only ten of the 172 transects (6%) despite the surveyed mountains having historical records. However, the weather was poor in July 2008 with only two of the 15 survey days having predominantly sunny weather. No conclusions can be drawn from this limited data.

**Abundance of Mat-grass and Nectar Plants**

Table 1 shows the percentages of transects with the surveyed plant species on each mountain (abundance scores 1 or 2). Mat-grass, Tormentil and Heath Bedstraw were widespread (95%, 92% and 80% of transects respectively) whereas both Heath-spotted Orchid and Yellow Mountain Saxifrage were recorded in less than 10% of transects and on only a few mountains. These percentages for each plant species are significantly different which shows that not all of these species are characteristic of Mountain Ringlet habitat (Kruskal-Wallis: H (adjusted for ties) = 95.2, df 8, P < 0.001).

There were some differences in plant abundance between mountains. Cam Chreag (Table 1) had the highest abundance of nectar plants with five species being present in 100% of transects. In contrast, Schiehallion had fewer nectar plants with a maximum incidence of 64% of transects for Tormentil.
To assess the change in incidence and abundance of Mat-grass, the nectar plants and Carnation Sedge with altitude in an analytical way, the data from the 172 transects were pooled and then grouped according to six altitude bands (Figure 3).

Trends with altitude are present for all nine plant species. Relationships between the abundance scores of Mat-grass and the nectar plants with altitude were tested using linear regression. Only data for the lower four altitude bands were used because plant abundance declined in the higher two altitude bands. These lower four bands were given the values 1 to 4 respectively: 1 being 190–399m and 4 being 600–699m. All tests were non-significant except for Alpine Lady’s Mantle (n = 4  r = 0.962, P < 0.05) which indicates the abundance score of this species was significantly and positively correlated with altitude up to 700m. The abundance of the other plant species with altitude was a weak non-significant trend. However, it is clear from Figure 3 that the abundance of plant species associated with Mountain Ringlet habitat, particularly Mat-grass, Heath Bedstraw and Alpine Lady’s Mantle, does increase somewhat up to altitudes of 700m, and above altitudes of 700m the abundance of these species slowly decreases. Above 400m Mat-grass was a dominant grass species, and at altitudes above 600m Wild Thyme, Heath Bedstraw and Alpine Lady’s Mantle were sometimes very abundant, forming carpets of flowering plants alongside widespread Mat-grass.

Table 1. Percentage of transects with Mat-grass *Nardus stricta*, nectar plants and Carnation Sedge *Carex panicea* on the 15 mountains (abundance scores 1 or 2).

<table>
<thead>
<tr>
<th>Mountain</th>
<th>n</th>
<th>Mat</th>
<th>Bed</th>
<th>Thy</th>
<th>But</th>
<th>Orc</th>
<th>Tor</th>
<th>Sax</th>
<th>Man</th>
<th>Sed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beinn Churalain</td>
<td>6</td>
<td>100</td>
<td>83</td>
<td>50</td>
<td>50</td>
<td>17</td>
<td>83</td>
<td>0</td>
<td>0</td>
<td>67</td>
</tr>
<tr>
<td>Beinn Sguilard</td>
<td>14</td>
<td>86</td>
<td>86</td>
<td>64</td>
<td>36</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>79</td>
<td>64</td>
</tr>
<tr>
<td>Stob Mhic Mhartain</td>
<td>8</td>
<td>100</td>
<td>88</td>
<td>63</td>
<td>38</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>50</td>
<td>38</td>
</tr>
<tr>
<td>Ben Nevis</td>
<td>7</td>
<td>100</td>
<td>71</td>
<td>86</td>
<td>29</td>
<td>14</td>
<td>100</td>
<td>0</td>
<td>86</td>
<td>14</td>
</tr>
<tr>
<td>Sguur a Mhaim</td>
<td>9</td>
<td>100</td>
<td>89</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>89</td>
<td>0</td>
<td>22</td>
<td>33</td>
</tr>
<tr>
<td>Creag Meagaidh</td>
<td>44</td>
<td>100</td>
<td>73</td>
<td>30</td>
<td>70</td>
<td>32</td>
<td>98</td>
<td>0</td>
<td>39</td>
<td>11</td>
</tr>
<tr>
<td>Beinn Chaorach</td>
<td>9</td>
<td>100</td>
<td>100</td>
<td>56</td>
<td>56</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>22</td>
<td>44</td>
</tr>
<tr>
<td>Cam Chreag</td>
<td>4</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>100</td>
<td>25</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>Beinn Odhar</td>
<td>8</td>
<td>100</td>
<td>88</td>
<td>38</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>63</td>
<td>0</td>
</tr>
<tr>
<td>Stob Ghabbar</td>
<td>4</td>
<td>75</td>
<td>50</td>
<td>25</td>
<td>25</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Ben Lawers</td>
<td>18</td>
<td>100</td>
<td>83</td>
<td>67</td>
<td>28</td>
<td>0</td>
<td>56</td>
<td>17</td>
<td>78</td>
<td>33</td>
</tr>
<tr>
<td>Drumochter</td>
<td>4</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td>25</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Ben Lomond</td>
<td>13</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>92</td>
<td>0</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Beinn Heasgarnich</td>
<td>10</td>
<td>100</td>
<td>50</td>
<td>60</td>
<td>80</td>
<td>0</td>
<td>100</td>
<td>50</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>Schiehallion</td>
<td>14</td>
<td>71</td>
<td>43</td>
<td>50</td>
<td>43</td>
<td>0</td>
<td>64</td>
<td>43</td>
<td>36</td>
<td>29</td>
</tr>
<tr>
<td><strong>Mean %</strong></td>
<td>95</td>
<td>80</td>
<td>51</td>
<td>40</td>
<td>4</td>
<td>92</td>
<td>9</td>
<td>47</td>
<td>31</td>
<td></td>
</tr>
</tbody>
</table>

Mat – Mat-grass  Bed – Heath Bedstraw  Thy – Wild Thyme
But – Meadow Buttercup  Orc – Heath-spotted Orchid  Tor – Tormentil
Sax – Yellow Mountain Saxifrage  Man – Alpine Lady’s Mantle  Sed – Carnation Sedge
**Upper Altitude Limit of Mountain Ringlet**

Figure 3 shows that both Mat-grass and nectar plants slowly decline in abundance above 700m. Mat-grass was found in transects above 900m on Sgurr a Mhaim, Ben Lawers, Ben Lomond and Beinn Heasgarnich, although less abundantly and in poorer condition. It was not found along the three highest transects on Schiehallion which were dominated by Heather *Calluna vulgaris* and Blaeberry *Vaccinium myrtillus*, although scattered Mat-grass was present on these high slopes. On some mountains above 900m such as Sgurr a Mhaim, the terrain is largely rock with only a few patches of Mat-grass and other vegetation. Nectar plants too were scarce above 900m.

There are just three historical Mountain Ringlet records above 1000m where the altitude has been determined from a six-figure grid-reference. Use of a GPS device in recent years by the author and some volunteers has produced the following Mountain Ringlet records between altitudes of 900 and 1000m (highest in brackets): three in 2008 (919m); 12 in 2009 (925m); 26 in 2011 (978m; all on Ben Lawers); and one in 2012 (900m). While it is clear that Mountain Ringlet can be found above 900m, it appears that they are relatively few in number, except on Ben Lawers which is unusually grassy above 900m.

The current upper limit for Mountain Ringlet is considered to be 900m according to Asher *et al.* (2001), although Futter *et al.* (2006) give the upper limit as 1000m. The 2008 fieldwork supports an upper limit of 900m for suitable habitat, individuals flying above this threshold being considered vagrants outside of breeding habitat. This threshold means there are small areas of high altitude land above this threshold in Scotland (Ben Nevis is 1344m) which are currently unsuitable for Mountain Ringlet.

![Figure 3. Mean abundance scores for Mat-grass *Nardus stricta*, the nectar plants and Carnation Sedge *Carex panicea* recorded along 172 transects from 15 different mountains grouped into six altitude bands.](image-url)
French (1995) using a Geographical Information System found that Mountain Ringlet observations were few on exposed ridges and more numerous in sheltered hollows at Ben Lawers. This suggests that Mountain Ringlet cannot utilise exposed ridges and summits, which is consistent with an upper altitude limit of 900m in Scotland.

**Topography**

During the course of fieldwork in 2008 and 2009 it was observed that herb-rich *Nardus* grassland on some mountains was confined to certain topographical features, although on other mountains it was widespread. Where herb-rich *Nardus* grassland was limited it was mostly confined to the edges of burns and within gullies with or without streams.

Photographs from two mountains with topography favouring Mountain Ringlet habitat are presented. Beinn Chaorach near Tyndrum (see p. 43) is a mountain with many damp gullies and hollows containing lush Mat-grass, where the species was abundant in both 2008 and 2009. The mountain An Cearcallach, which is part of Creag Meagaidh National Nature Reserve (NNR), has a series of damp grassy shelves with suitable habitat separated by steep rocky and heathy escarpments (see p. 44).

Corries are much larger topographical features which provide good Mountain Ringlet habitat. These are glacial features, consisting of large concave amphitheatre-shaped hollows which are open on the downhill side. Corries above 900m in Scotland tend to be mostly rock but at 600–900m may be dominated by Mat-grass: examples are Coire Odhar at Ben Lawers (which is famous for its Mountain Ringlet colonies, see photo in *Atropos* 41: 14) and the corrie at the top of the Allt nan Cearcall at Creag Meagaidh NNR. These altitudes correspond with the higher abundance of Mat-grass and nectar plants shown in Figure 3.

On other mountains where Mountain Ringlet habitat was not confined to topographical features, large areas of slopes with different aspects were comprised of herb-rich *Nardus* grassland. It is likely that these slopes are to some extent ‘anthropogenic’ Mountain Ringlet habitat created by prolonged sheep grazing, which leads to swards dominated by Mat-grass (Fenton, 1937).

These associations of Mountain Ringlet habitat with topography suggest that both high soil moisture and mineral enrichment are important factors which favour herb-rich *Nardus* grassland and populations of the butterfly. Masterman (2010a) cited two National Vegetation Communities (NVCs) which are associated with Mountain Ringlet habitat: U5 *Nardus stricta-Galium saxatile* grassland and CG11 *Festuca ovina-Agrostis capillaries-Alchemilla alpina* grass-heath (Averis *et al.*, 2004). These NVC relationships are consistent with the topographical observations above and suggest that suitable underlying geology and soils are essential components of Mountain Ringlet habitat as proposed by Masterman (2010a).

**Climate Warming Effects on Mountain Ringlet**

It is interesting to speculate about the potential adverse effects of climate warming if this forced the butterfly to higher altitudes and reduced its distribution. Two recent papers (Hill *et al.*, 2002; Franco *et al.*, 2006) have argued that this is already occurring in northern Britain. The latter paper surveyed 89 1km squares in Scotland and Cumbria during 2004 and 2005 where Mountain Ringlet had been recorded between 1970 and 1999. Seventy of these squares were in Scotland and Mountain Ringlet was not found in 25 (36%) of them. The mean altitude of the 1km squares without Mountain Ringlet was significantly lower...
than the mean altitude of the 1km squares with Mountain Ringlet, and temperature data for northern Britain show a 0.031°C per year warming trend over the 1970–99 period. As Mat-grass was present in all but one of these 89 1km squares, Franco et al. (2006) argued that climate warming and not habitat deterioration was the likely cause of colony extinctions.

Nineteen of the 25 1km squares where Franco et al. (2006) did not find Mountain Ringlet in Scotland were revisited during the surveys of 2008 and 2009 and the species was found in seven of them. In a further seven cases Mountain Ringlet was seen in a neighbouring square. Bayfield et al. (1994) used a mark and recapture study to measure the distances moved by 54 Mountain Ringlet at Ben Lawers. The rate of movement was low—2.96 m/h for males and 1.5 m/h for females—and the conclusion was that movement by the butterfly at Ben Lawers was random with little evidence of dispersal. Nevertheless, the occupancy of a neighbouring 1km square means it is quite possible that Mountain Ringlet is present in these further seven squares despite not being found on the day.

Recent surveys in Cumbria in 15 1km squares where Franco et al. (2006) did not find the butterfly in 2004/2005 have subsequently found Mountain Ringlet in eight squares (Steve Clarke, pers. comm.).

The data analysis of Franco et al. (2006) using data from the seven 1km squares in Scotland where the author found Mountain Ringlet in 2008/2009 have been re-tested and the overall results were not changed (Aldina Franco, pers. comm.)

Nevertheless, both the author in Scotland and recorders in Cumbria have found Mountain Ringlet in 1km squares in which Franco et al. argued the butterfly had become extinct as a result of climate warming. Using experience gained over four seasons of surveys, the author provides two possible explanations for the recorded absence of the species by Franco et al. in 2004/2005 in 25 previously occupied squares, and for the absence in a sub-sample of 12 of these squares surveyed by the author in 2008/2009:

1. Survey dates were too late in the flight period to record the species at low altitude sites. Masterman (2010a) reported a trend in the altitude of Mountain Ringlet observations to increase later in the flight period, which may be the result of individuals emerging later at higher altitudes. The Franco et al. survey dates in Scotland were between 5 and 28 July in 2004/2005, whereas the flight period in Scotland is late June to early August (Futter et al., 2006). The transect at Glasdrum operated by Scottish Natural Heritage at a low altitude of 500m shows the peak flight period to be in the second half of June.

2. There was little suitable habitat in the square, meaning that if present the species could be very scarce and difficult to detect. This was the case for five of the 12 1km squares where the author did not find Mountain Ringlet in 2008/2009.

The Mountain Ringlet colony with the lowest altitude in Britain is at Irton Fell, Cumbria, at just 200–250m and sensitivity to any adverse effects of climate warming might be expected here. This colony has been observed for over 60 years with little apparent change in strength, even in recent years (Peter Wilde, pers. comm.).

It is possible that climate warming may be beneficial to Mountain Ringlet rather than adverse. A major difficulty in recording the species in Scotland is that temperatures at altitudes of 400–900m in July are often below or near to 13°C, which is the minimum temperature threshold for butterfly flight used by the UK Butterfly Monitoring Scheme (Pollard & Yates, 1993). Therefore, many survey days result in few or no Mountain Ringlet being recorded. As temperatures are so marginal for the species to fly, it is more likely that in Scotland the effects of climate warming will be positive for the species.
Climate Warming Effects on Mountain Ringlet Habitat

Higher temperatures could influence the altitudinal range of herb-rich *Nardus* grassland which is the habitat of Mountain Ringlet. Studies of the effects of climate warming on upland vegetation in Scotland have been mainly concerned with the snow-bed communities. While there have been no specific studies on the effects of climate change on Mat-grass, there is no apparent evidence at Ben Lawers that Mat-grass is declining (David Mardon, pers. comm.). The likelihood of Mountain Ringlet habitat being forced uphill by climate warming can be considered by summarising the knowledge about *Nardus* grassland ecology.

Rainfall is important in determining Mat-grass abundance as the plant is not found in regions with less than 508mm per year. It is more abundant in the north and west of the UK with increased percentage cover where rainfall exceeds 1,270mm per year. It is a slow-growing species which does not compete successfully with other species in more fertile habitats. Therefore it is not common on low ground but thrives on the poorer soils of upland areas (Chadwick, 1960). Sheep grazing is well-known to favour the spread of Mat-grass swards in upland areas (Fenton, 1937) owing to the ability of sheep to graze between tussocks to obtain the more palatable plants and avoid intake of relatively unpalatable Mat-grass (Grant et al., 1996). Sheep also like to graze young Heather, which results in moorland changing to grassy areas under the influence of sheep grazing (Fenton, 1937).

So high rainfall and sheep grazing are probably the most important factors which account for the high abundance of Mat-grass between 400 and 800m shown in Figure 3. Higher temperatures in theory may permit more competitive plant species to move uphill and perhaps lead to some loss of Mat-grass at the low altitude margins of Mountain Ringlet habitat. Sheep grazing is currently in decline in Scotland (Renwick et al., 2008) and this might result in some loss of Mat-grass at low altitudes of 400‒500m as other plant species become more abundant.

Trivedi et al. (2008) have looked specifically at the potential effects of climate warming on montane grasslands in three nature reserves in the Breadalbane area of Scotland: Ben Lawers, Ben Heasgarnich and Meall na Samhna. Using observed plant community data as a baseline they used modelling to predict how different montane NVCs would be affected under a low and a high emissions climate change scenario. They concluded that areas which currently have U5 and U6 would change towards moorland communities such as M15, and this would extend to higher altitudes. Areas with CG11 and CG12 would reduce in size, although at higher altitudes some snowbed communities which are currently U10 and U7 would trend towards species-rich calcareous grasslands, CG11 and CG12. While areas with Mat-grass are predicted to decrease overall, some new habitat for Mountain Ringlet might be created at higher altitude as snow-bed communities change to CG11 and CG12.

Climate Warming and Montane Invertebrates

There is an expectation that montane invertebrates in general will be forced uphill by climate warming, resulting in a smaller distribution. However, this is more likely to be the case towards the southern part of a species range where temperatures are higher. There are a number of recent publications concerning the effects of climate warming on Lepidoptera which suggest that this expectation is perhaps simplistic and untrue in some cases.
In the mountains of central Spain 16 species of montane butterfly moved uphill by an average of 212m between 1967–1973 and 2004–2005, climate warming being considered the likely explanation (Wilson et al., 2005; Wilson et al., 2007).

Chen et al. (2011) examined over 100 species of Geometrid moths on Mount Kinabalu in Malaysia and compared data obtained in 2007 with data recorded 42 years earlier in 1965. Changes in species upper and lower boundaries, elevational extents and range areas were assessed. High altitude margins shifted uphill faster than low altitude margins retreated, which meant that many species increased their elevational extents.

Dieker et al. (2011) studied two species of montane burnet moths in the Pyrenees to determine whether there was an uphill shift in the range of these two species and whether this was driven by climate and/or land-use changes. Twenty-eight sites were re-visited in 2008/09 at the lower altitudinal range limit at which the species had been recorded between 1958 and 1986. The upper range limits were also determined. The arctic-alpine Mountain Burnet Zygaena exulans showed an uphill shift of 148m/decade which was attributed to climate change. For the endemic species Zygaena anthyllidis an uphill shift was only found for 33% of the sites investigated (60m/decade) but this was attributed to changes in grazing intensities.

Franzen & Ockinger (2012) studied changes in the insect species richness and community composition of wild bees, butterflies and moths over 60 years in an area situated above the tree limit in northern Sweden. The observed number of species increased from 52 in 1944 to 64 in 2008. The mean number of butterflies and moths per site increased significantly. Among the species that were recorded in both periods, the average altitude of 17 species had shifted downhill, 12 shifted uphill, and the altitude of the remaining 17 did not change. Their results suggest that lower alpine habitats (600–800m) have become colonized by southern species, and that high alpine habitats (above 1000m) have recently been colonized by high alpine species previously absent from these sites, probably as a result of increasing habitat availability.

**Conclusion**

The observation that Mountain Ringlet only occurs between 350 and 900m in Scotland (Asher et al., 2001) may be explained by the higher abundance of Mat-grass and nectar plants between altitudes of 400 and 800m shown in Figure 3. Little suitable habitat, either Mat-grass or nectar plants, was found above 900m, so this is likely to be the upper limit of Mountain Ringlet habitat. This, together with a general lack of vegetation above 900m in Scotland and the very exposed terrain, suggests that it is unlikely that the species could move to altitudes higher than 900m in response to climate warming.

The issue of whether or not Mountain Ringlet in Scotland has been affected by climate warming is contentious. The historical data held by Butterfly Conservation is sparse owing to Mountain Ringlet being under-recorded (there are 246 and 173 six-figure and four-figure grid-reference records respectively up to 2007 for Scotland). Without good quality historical data it is not possible to make claims that the distribution and/or altitudinal range of Mountain Ringlet has changed in response to climate warming. Masterman (2010a) attributed the 30% increase in the distribution of the butterfly at the 1km resolution in 2008/2009 to previous under-recording. Fieldwork by the author in 2008, 2009, 2011 and 2012 has found Mountain Ringlet to be present at lower altitudes of 400–500m provided searches take place early in the flight period, which is the second half of June in Scotland (Asher et al., 2001). Some individuals have been found below 400m in
recent years (lowest altitude in brackets): three in 2008 (334m); five in 2009 (357m); seven in 2012 (343m).

As a result of recording Mountain Ringlet with a GPS device in recent years, there is now a database of 2,694 records with an accurate altitude measurement which provides good baseline data on the current altitudinal distribution. Regular recording with a GPS device is required to see if there are any changes due to climate warming. The species is certainly still under-recorded and may be present north of the Great Glen despite the absence of any records.

Asher et al. (2001) state that Mountain Ringlet is associated with south-facing aspects in Scotland. One possible effect of climate warming might be expansion of colonies onto slopes without south-facing aspects. In 2009, Mountain Ringlet was recorded on the north-facing aspects of four mountains: Beinn Chaorach, Stuchd an Lochain, Creag Dhubh ridge on Meall a Bhuird, and Schiehallion. Masterman (2010b) found that 50% of historical 1km squares with Mountain Ringlet had a southerly aspect and 10% had a northerly aspect. The statistics for the new 1km squares in 2008 and 2009 were similar, which does not suggest recent range expansion onto non south-facing aspects. However, it may be the case that Mountain Ringlet is very under-recorded on aspects other than south-facing.

The effects of climate warming on Mountain Ringlet could be positive or negative and may affect not only distribution and altitudinal range but also flight phenology, predation of larvae and pupae by invertebrates, predation of adults by Meadow Pipit *Anthus pratensis*, parasitism, fecundity and adult lifespan. To assess the effects of climate warming on Mountain Ringlet habitat, monitoring of vegetation in the 400‒500m altitude range is required to see if Mat-grass is displaced by more competitive plants moving uphill. Studies on NNRs where the NVCs are known may provide additional knowledge about the habitat of Mountain Ringlet.

**ACKNOWLEDGEMENTS**

This research is one aspect of a wider project funded by Scottish Natural Heritage, involving the National Museums of Scotland, National Trust for Scotland, the John Muir Trust and Butterfly Conservation, which aims to increase the knowledge and understanding of Scotland’s montane invertebrate fauna.

**REFERENCES**


www.atropos.info


Andrew Masterman, Flat 1/3, 214 Calder Street, Glasgow, G42 7PE