THE HAWKMOTHS (LEPIDOPTERA: SPHINGIDAE) OF MUSSOORIE, UTTARAKHAND, INDIA: CONFIRMATION OF FAUNAL DRIFT IN RESPONSE TO CLIMATE CHANGE

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Introduction

The Hawkmoths of parts of the present day administrative division of Garhwal, Uttarakhand, India, were surveyed by F.B. Scott during the 1920s. Since modern attractants like mercury vapour lamps had not been developed at that time, he located most of his species in the caterpillar stage and probably attracted moths to paraffin lamps and electric lamps available at the time.

The results were published (Bell & Scott, 1937) and added considerably to the available information about the family at the time, remaining the standard work on the subject for India.

Smetacek (1994) noted a possible extension westward to the known distribution of over 30 species of typically eastern Himalayan hawkmoths and suggested this was in response to ongoing climate change in the region. However, the main study site of Smetacek (1994) at Bhimtal was around 200 km east of Mussoorie, where Scott (in Bell & Scott, 1937) had undertaken his work, giving rise to the possibility that the species newly recorded from Bhimtal had, in fact, always been present there. Therefore, a survey of the hawkmoths of Mussoorie was seen as the only way of conclusively proving that the moths had extended their distribution westward along the Himalaya in the period after Scott had concluded his studies, or around 1937 at the latest, since this was the date of publication of the work.

Material and Methods

Mercury vapour lamps were set up at two locations in Mussoorie, one at Oakville (2150 m), Landour, Mussoorie, the private residence of the Alter family and the second at the Hanifl Centre for Outdoor Education and Environmental Study at Woodstock School, Mussoorie (2130 m). The lamps reflected their light off a white cloth screen. Surveys were conducted at different seasons over the course of a year, from March, 2014 to March, 2015. No Sphingidae were recorded during March and April, 2014 and 2015. Some were recorded in May, June and July.

Specimens were curated at the Hanifl Centre. They are now stored partly at the Hanifl Centre and partly at the Butterfly Research Centre, Bhimtal, Uttarakhand. The results of the study have been presented in Table 1.

Discussion

There are relatively few hawkmoth species found over 2000 m elevation in the western Himalaya. Of these, we recorded a fair percentage, but widespread species like *Theretra nessus* (Drury, 1773), *Theretra clotho* (Drury, 1773), *Theretra alecto* (Linnaeus, 1758), *Theretra lycetus* (Cramer, 1775) and *Agrius convolvuli* (Linnaeus, 1758) were conspicuous by their absence. Species

normally found at that elevation which did not appear include *Cechenena mirabilis* (Butler, 1875), *Dahira rubiginosa* Moore, 1888 and *Langia zenzeroides* Moore, 1872.

Of interest is that out of 22 species recorded, 7 are westward extensions and were not recorded from Mussoorie by Bell & Scott (1937). Only two *Rhagastis* Rothschild & Jordan, 1903 species were recorded from the Western Himalaya by Bell & Scott (1937), yet there are now at least four, with *R. velata* (Walker, 1866), which was not recorded in the present study, probably found at lower elevation, since it is by far the commonest member of the genus in Kumaon.

The present survey confirms the presence of *Marumba cristata*, which is well established at Mussoorie, but was not recorded by Bell & Scott (1937). Smetacek (2004) also reported *M. cristata* from Shimla, Himachal Pradesh, which is west of Mussoorie, on the basis of a single forewing found on a hotel verandah. The present records confirm that *M. cristata* is indeed now established in Mussoorie, where it was not found less than a century ago. The Indian population of this species has not been bred, but in China, it has been bred on *Persea* Mill. (=*Machilus* Rumphius), *Litsea* Juss. and *Phoebe* Nees.of the Lauraceae (Bell & Scott, 1937), all of which genera are represented in Mussoorie (Brandis, 1874). Interestingly, freshly emerged *M. cristata* larvae refused to feed on *Persea odoratissima* Nees. in Bhimtal, Kumaon (P.S.).

Similarly, *Dolbina inexacta* was not recorded from Mussoorie prior to 1937 and is likely a new entrant. It feeds on *Olea glandulifera* Wall. (Smetacek, 2000) which is found from low elevation to 1820 m in the area (Brandis, 1874). In this case again, the larval host plant existed but the moth had failed to colonise the area when surveys were carried out prior to 1937.

Rhagastis Rothschild & Jordan, 1903 feed on Vitaceae and Araceae (Bell & Scott, 1937), which occur plentifully in Mussoorie.

The main result of this year long study is the vindication of the proposition that there was a westward faunal drift along the western Himalaya during the second half of the 20th century. One third of the species recorded in the study are new records for the area, which is a very large proportion by any standards. This is taking into consideration that the area around Mussoorie was very thoroughly studied by F.B. Scott and that he studied the area from the foot of the hills to over 2000 m elevation, while the present study was confined to the area above 2000 m elevation. Almost certainly, surveys at lower elevation, below 1500 m, will yield further new records for the area. It seems likely that this colonisation of the western Himalaya by eastern Himalayan elements was the result of changes in the soil humidity regime in the area, since the larval host plants of these species are native to the western Himalaya. This was predicted as a consequence of global climate change in the region in Myers (1986). Stephen Alter, a resident of Mussoorie, noted that in his memory, the hills are more heavily forested now than during the 1960s and 1970s, when Himalayan Oak (*Quercus* sp.) was cut on a large scale to produce charcoal. The 1980 Indian Supreme Court ban on felling of trees above 1000 m elevation has resulted in a re-greening of the countryside that had been degraded over centuries to supply fuel and fodder to villages and the town of Mussoorie.

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Table 1.

S. N.	Species	Bell & Scott, 1937	Present records 2014 Mussoorie	Smetacek 1994 Kumaon	New record	Notes
1.	*Acherontia lachesis* (Fabricius, 1798)	Y	Y	Y		24.vi.2014
2.	*Pseudodolbina fo* (Walker, 1856)	Y	Y	Y		23.vii.2014
3.	*Dolbina inexacta* (Walker, 1856)		Y	Y	Yes	18.vi.2014; 31.vii.2014
4.	*Ambulyx sericeipennis* Butler, 1874	Y	Y	Y		24.vi.2014
5.	*Ambulyx placida* Moore, 1888	Y	Y	Y		24.vi.2014
6.	*Clanis deucalion* (Walker, 1856)		Y	Y	Yes	21.vi.2014; 27.vi.2014
7.	*Marumba cristata* (Butler, 1874)		Y	Y	Yes	22.vi.2014; 25.vi.2014
8.	*Marumba sperchius* (Menetries, 1857)	Y	Y	Y		21.vi.2014
9.	*Clanidopsis exusta* (Butler, 1874)	Y	Y	Y		21.vii.2014
10.	*Cypa pallens* Jordan, 1926	Y	Y	Y		24.vi.2014; 23.vii.2014 ;

						31.vii.2014 .
11.	*Ampelophaga rubiginosa* Bremer & Grey, 1852	Y	Y	Y		21.vii.2014 ; 22.vii.2014 ; 23.vii.2014 ; 27.vii.2014
12.	*Acosmeryx naga* (Moore, 1857)	Y	Y	Y		21.iv.2014; 21.vi.2014; 31.vii.2014
13.	*Eupanacra metallica* (Butler, 1874)	Y	Y	Y		20.vi.2014
14.	*Macroglossum saga* Butler, 1878		Y	Y	Yes	22-31.vii.2014
15.	*Macroglossum nycteris* Kollar, [1844]	Y	Y	Y		13.v.2014
16.	*Hippotion celerio* (Linnaeus, 1758)	Y	Y	Y		15.v.2014; 31.vii.2014
17.	*Theretra clotho* (Drury, 1773)		Y	Y		22.vi.2014.
18.	*Rhagastis confusa* Rothschild and Jordan, 1903	Y	Y	Y	Yes	25.vi.2014; 21.vii.2014
19.	*Rhagastis olivacea* (Moore,1872)	Y	Y	Y		21.vi.2014; 24.vi.2014; 22.vii.2014
20.	*Rhagastis acuta* (Walker, 1856)		Y	Y	Yes	21.v.2014
21.	*Rhagastis castor* (Walker, 1856)		Y	Y	Yes	21.vi.2014
22.	*Cechetra scotti* Rothschild, 1920	Y	Y	Y		24.vi.2014; 23.vii.2014 ; 31.vii.2014