

THE IDENTITY OF *STENOPSOCUS* SPECIES (PSOCOPTERA: STENOPSOCIDAE) IN BRITAIN

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ABSTRACT

The study of the standard identification characters of 100 *Stenopsocus immaculatus/lachlani* specimens provided evidence that only one of the two species, *S. immaculatus* (Stephens), occurs in Britain. The measurements of the characters showed that British specimens of this species are considerably more variable than those on mainland Europe. Specimens previously considered as *S. lachlani* Kolbe have been reinvestigated and are now considered to be *S. immaculatus*.

INTRODUCTION

Two of the three European *Stenopsocus* species of barkfly, *S. immaculatus* (Stephens) and *S. stigmaticus* (Imhoff & Labram) have long been recorded in Britain (New, 2005). Separation of these two species is straightforward since *S. stigmaticus* usually has a dark mark along the posterior margin of the pterostigma as well as having vein Cu2 of the fore wing glabrous. The third European species, *S. lachlani* Kolbe, resembles *S. immaculatus* (unmarked pterostigma and Cu2 vein setose) and was not recorded from Britain until 1999 when the author recorded specimens in Scotland (Saville, 2001). The identification proved to be problematic and the specimens needed to be sent to the European Psocoptera authority, Charles Lienhard (Geneva Natural History Museum), for confirmation as *S. lachlani*.

Since then the author has continued to experience considerable difficulty separating *S. immaculatus* (Fig.1) and *S. lachlani* and undertook a study to determine which of the identification characters are most effective for use with British specimens.

METHODS

New (2005) follows Lienhard (1998) and uses four characters for separating the two *Stenopsocus* species: i) vertex colour and pattern (see Fig.2), ii) ratio of interocular distance to eye diameter (IO/D) in dorsal view (see Fig.2), iii) colour of the abdominal apex and iv) tree type association. These characters are summarised in Table 1.



Fig. 1. A female adult *Stenopsocus immaculatus*.

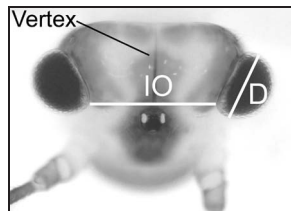


Fig. 2. Vertex of *Stenopsocus* showing interocular distance (IO) and compound eye diameter (D) measurements.

Table 1. Characters used for identification of *Stenopsocus* species according to Lienhard (1998)

ID character	<i>S. immaculatus</i>	<i>S. lachlani</i>
Vertex	Yellowish or pale brown with at least two very pale longitudinal bands	Almost uniformly dark brown
IO/D ratio – male	0.8–1.0	1.3–1.5
IO/D ratio – female	1.6–1.9	2.0–2.4
Abdominal apex colour	Yellowish	Brown
Tree type	Broadleaved	Coniferous

In the study, the identification characters of 100 specimens (35 males, 65 females) of *S. immaculatus/lachlani* that had been collected mainly from Scotland (84 specimens) but also some English (13) and Welsh (3) locations were recorded. All of these were collected by the author with the exception of three collected from England by Keith Alexander. All of the specimens were preserved in 70% alcohol. Since the colouration of psocid specimens often fades following prolonged storage in alcohol only specimens that had been preserved for less than two years were used in the study. The original specimens that were confirmed as *S. lachlani* by Lienhard (Saville, 2001) had faded and were consequently not included in the main study. However, the IO/D ratios of these specimens were measured separately and are included in the results section.

The tree species on which specimens were collected was recorded. Forty-three specimens were from broadleaves while 57 were from conifers/evergreens. Broadleaved species were: oak spp. (23 specimens), alder (5), hawthorn (3), elder (2), willow spp. (2), hazel (2), unspecified (2), beech (1), birch spp. (1), honeysuckle (1) and rowan (1). Coniferous/evergreen species were: yew (25), unspecified conifer (12), pine (9), cypress (7), Sitka spruce (2), larch (1) and holly (1). Almost half of the specimens were found on either oaks or yew.

Ten additional specimens (five males, five females) of genuine *S. lachlani* from Finland (kindly provided by Jussi Kanervo) were also measured and photographed to provide a comparison with the British material.

The IO/D ratios were measured using a Leica MZ16 microscope fitted with an eyepiece graticule. In order to standardise the results an identical magnification was used for all specimens. The graticule could be read to 0.5 divisions and the approximate error in the measurements was 2%. The size of the eyes on the same specimen was occasionally different and so the IO/D ratios were measured for each eye separately and then averaged.

RESULTS

The vertex colour of the two species would appear from their identification descriptions to be distinctly different. However, the colour and pattern of the specimens in the study formed a continuum between the two extremes and there was a need to decide which the 'nearest fit' was for many specimens. Confusingly, despite the identification description given in the literature the vertex of specimens ranged from pale to dark brown irrespective of the presence of light bands (e.g. see Figs. 3a and 3b). When assigning specimens the presence of light bands was given precedence over the vertex colour. The following photographs (Figs. 3a–f) show which forms of facial pattern have been assigned to each character. Female specimens 3a–b and male specimens 3d–e were considered as having light bands on the vertex. Female

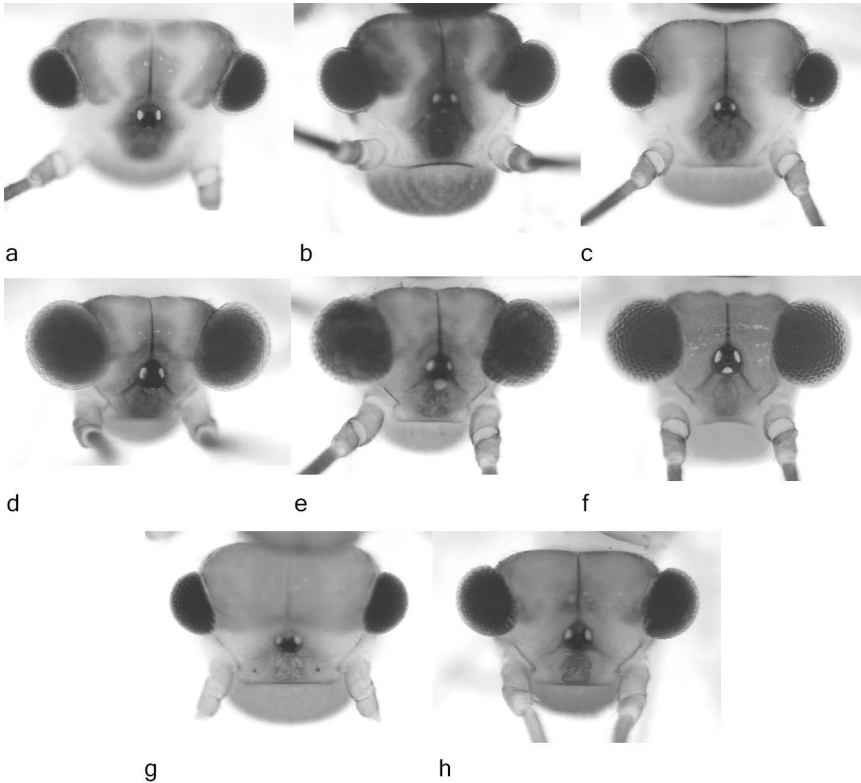


Fig. 3a–h. Variations in vertex pattern and eye dimensions of *Stenopsocus immaculatus*. a–c, British females. d–f, British males. g–h, Finnish *Stenopsocus lachlani* (female and male).

specimen 3c and male specimen 3f were considered as having a ‘dark’ vertex. The colour and pattern of males and females were somewhat different (e.g. the light bands on males were never as marked as in some females). Photographs of female and male specimens of *Stenopsocus lachlani* from Finland are included (3g–h) as a comparison with the British material.

The colour of the abdominal apex of all the specimens was brown/grey-brown ranging from moderately dark to virtually colourless. No specimens exhibited the yellowish colour described by Lienhard as a characteristic feature of *S. immaculatus*. This could be explained by assuming that *S. immaculatus* does not occur in Britain but since many specimens had other characters of *S. immaculatus* this explanation was considered unlikely. It seems that in Britain at least this character is not suitable for separating the two species and has not been included in the analysis.

The numbers of specimens having the different combinations of the three other characters are summarised in Fig. 4 and Table 2. In Fig. 4 each symbol (triangle or circle) indicates the characteristics of a single *Stenopsocus* specimen. The triangle and circle symbols represent specimens from coniferous and broadleaved trees, respectively. On the chart, specimens found on conifers are shown to the left of

Table 2. Numbers of *Stenopsocus* specimens with different combinations of characters

Vertex colour	Tree type	IO/D ratio – male			IO/D ratio – female		
		0.8–1.0	1.01–1.29	1.3–1.5	1.6–1.9	1.91–1.99	2.0–2.4
Light bands	Broadleaved	10	3	0	7	10	4
	Coniferous	4	1	0	12	9	6
‘Dark’	Broadleaved	6	1	0	1	1	0
	Coniferous	9	1	0	9	4	2

the vertex lines, broadleaves to the right. Data from all the study specimens are included in the chart but because some specimens have identical characters the number of symbols shown is less than 100. The long shaded rectangles indicate the expected ranges for male and female *S. immaculatus* and *S. lachlani* specimens based on the three identification characters mentioned in the literature (see Table 1).

The results in Fig. 4 show that:

- 1) The range of ratios of inter-ocular distance to eye diameter (IO/D) of all specimens was closely similar for both males (0.8–1.1) and females (1.6–2.1) irrespective of the vertex type or tree type.
- 2) The IO/D ratios fitted more closely to the expected range of *S. immaculatus* with only two specimens falling into the range of *S. lachlani*.
- 3) The ranges in IO/D ratio were greater than expected for both sexes i.e. the range for females was 1.6–2.1 compared to an expected range of 1.6–1.9; for males, the range was 0.8–1.1 compared to an expected 0.8–1.0.
- 4) The tree preference of females with a dark vertex was predominantly coniferous.

The total numbers of specimens having the different combinations of the three identification characters are summarised in Table 2.

The numbers in bold in the table represent the number of specimens that exhibited all three expected characters of a particular species. These figures indicated that there were 10 male and 7 female ‘typical’ *S. immaculatus* and 0 male and 2 female ‘typical’ *S. lachlani*. In total, these comprised 19% of the 100 specimens in the study (29% of the 35 males, 14% of the 65 females).

Only two specimens displayed all the characteristics of *S. lachlani*. One of these with an IO/D ratio of 2.02 was collected with four others from the same tree on the same day and this additional data helps put the significance of the ‘*S. lachlani*’ specimen into perspective. The five specimens were collected from a yew tree at Vogrie Country Park, Midlothian, Scotland on 7.ix.2006. Three of the specimens also had a ‘dark’ vertex but the two females had an IO/D ratio of less than 2.0 while the male had an IO/D ratio of less than 1.0. The other specimen had light bands on the vertex. These results indicate that there was significant variability between specimens in the local population with the one ‘*S. lachlani*’ specimen representing one end of a continuum.

Specimens collected by the author in the Lothians, Scotland and determined by Charles Lienhard as *S. lachlani* were not included in the main study because the vertex colour of the specimens had faded. Two of the four specimens fell within the range of *S. lachlani* but, as in the case of the two specimens in the main study only by a small amount (IO/D ratios of 2.00 and 2.03).

Because so few of the British specimens appeared to have the characteristics of *S. lachlani* it was considered valuable to take measurements of genuine *S. lachlani*

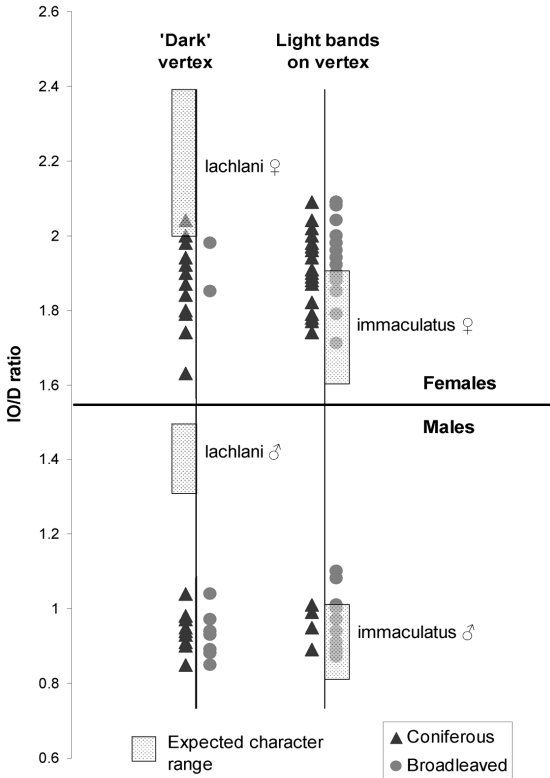


Fig. 4. Identification characters of British *Stenopsocus* specimens

specimens from Europe to provide comparative data. Of the ten specimens (5 male, 5 female) from Finland none had light bands on the vertex expected of *S. lachlani* although the colour of the vertex was pale brown (see Figs. 3g–h). The IO/D ratio of the males ranged from 1.44 to 1.62 and of the females 2.12 to 2.20, respectively. The small eye size of the males in particular was strikingly different from the British male specimens.

DISCUSSION

In order to be able to distinguish specimens of *S. immaculatus* from *S. lachlani* in Britain it is necessary to determine which of the four identification characters (see Table 1) are effective and reliable. As mentioned in the methods section, the abdominal apex colour was not considered an effective character and was not included in the detailed analysis.

If the three remaining characters are all effective then all of the specimens shown in Fig. 3 should fall within the four shaded areas. This is not the case, with only 19% of the specimens having all three expected characters. This observation goes a good way to explaining why so much difficulty has been experienced identifying the species; one or more of the characters are not effective for British material.

Table 3. Percentage of specimens with both expected characters

Character pair	'Correct' characters (%)			
	<i>S. immaculatus</i>		<i>S. lachlani</i>	
	Male	Female	Male	Female
IO/D ratio – vertex type	40	29	0	3
IO/D ratio – tree type	46	12	0	12
Vertex type – tree type	37	32	29	23

The next step was to check whether two characters alone were effective for identification purposes. The percentage of specimens showing the correct combination of two characters for the two species, based on the total sample of 35 males and 65 females is summarised in Table 3.

In theory a pair of characters is likely to be effective for identification purposes if the percentage value is close to 100. If a species is not present, then the percentage should be 0. None of the pairs achieved 100% indicating that at least one of the characters of the pair was not effective. The zero percentages of specimens with the expected characters of males of *S. lachlani* for two of the pairs both included the IO/D ratio character. This suggests that the IO/D ratio may be an effective character and that males of *S. lachlani* are not present in the study specimens.

A striking feature of the results (see Fig. 4) is that the IO/D ratio ranges for both males and females form tight clusters that are to a great extent independent of the vertex and tree types. The only exception is that females with a 'dark' vertex are much more likely to be found on conifers. Is this observation due to *S. lachlani* being present or is it due to environmental factors (e.g. available food) modifying the form of the species? If *S. lachlani* were present it would be expected that all of the specimens in a local area would have a dark vertex but the data from Vogrie Country Park show that the population on a single tree can have both light and dark vertexes. This suggests that the presence of a dark vertex does not have to indicate the presence of *S. lachlani* and shows that although the vertex and tree type characters are apparently successful at separating *S. immaculatus* and *S. lachlani* on the Continent they do not work with British material.

The question then is whether the IO/D ratio, on its own, is an effective identification character? The IO/D ratio ranges form tight groups for each sex. These ranges are close to the expected ranges of *S. immaculatus* and only slightly overlap (in the case of females) with the ranges of *S. lachlani*. This suggests that: i) IO/D ratio is an effective identification character for British material and that ii) only one species is present in the study sample. Although the IO/D ratio ranges of the specimens extends beyond the expected ranges the closest fit for the species present is *S. immaculatus*.

Although no specimens of *S. lachlani* were found in the study there is still the possibility that the species occurs in Britain or may be introduced with imported conifers in the future. The IO/D ratio range is the only character that can be used to determine its presence in Britain. Based on the results shown in Fig. 3 suitable ranges for *S. immaculatus* are: females – 1.6–2.1 and males – 0.8–1.1; ranges for *S. lachlani* are: females – 2.2–2.4 and males – 1.3–1.5.

CONCLUSIONS

Of the four identification characters used by Lienhard to separate *S. immaculatus* and *S. lachlani*, the abdominal apex colour was found to be ineffective for British

material and was excluded from the main analysis. The results for the other three identification characters indicate that neither the combined three characters nor any of the three pairs of characters were effective in separating *S. immaculatus* and *S. lachlani* in the study specimens. The range of variability between specimens in local populations (as illustrated by the '*S. lachlani*' specimen from Vogrie Country Park) further reduces the value of the characters for separating the two species. Although the specimens are mainly from Scotland it is likely that this reflects a general problem using the three identification characters on British specimens.

The evidence suggests that the IO/D ratio range, although apparently more variable than has been found on the Continent, is suitable for separating the two species and the results show that only *S. immaculatus* was present in the study sample. Although Lienhard confirmed specimens collected in Scotland as *S. lachlani* this was based on vertex type and the Continental IO/D ratio range. This study has shown these to be inappropriate for British material. So, current evidence suggests that *S. lachlani* has not yet been recorded in Britain. The present study also raises the question of how *S. lachlani* can be recognised and it is recommended that specific IO/D ratio ranges are used. There is still the possibility that *S. lachlani* occurs in Britain but has not yet been found due to under-recording. However searches of Caledonian pine forest, one of the potentially most suitable habitats, by the author at Rothiemurchus and the Black Wood of Rannoch in 2008 failed to turn up any *Stenopsocus* specimens of any species.

There is also the question of why *S. immaculatus* is so much more variable in Britain than on the Continent. It would be helpful, in the first instance, to find out whether this variability is specific to Britain or whether similar studies in other European countries show comparable trends. This additional information is likely to be required before a satisfactory explanation can be formulated.

Lienhard has pointed out that *S. immaculatus* and *S. lachlani* are not always easy to distinguish and there is a need to study the reproductive isolation of the two species (Lienhard, 1998). It would be particularly informative to extend this and carry out breeding studies between British material and each of the two species using Continental material.

This study was started because of the difficulty in assigning a name to *Stenopsocus* specimens in Britain. The results suggest that only *S. immaculatus* is likely to be present and as it stands it is advisable to regard all British records of *S. lachlani* as *S. immaculatus*.

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