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Identification of the females of the smaller British species of *Machimus* sensu lato (Diptera, Asilidae) with a note on the morphology of the ventral abdominal and thoracic plates

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Summary
Characters that can be used to separate the three smaller species of *Machimus* sensu lato found in Britain are discussed and illustrated with photographs. Attention is drawn to an anomaly in the terminology currently in use for the ventral plates in the postmetacoxal region of Asilidae.

Introduction

The identification of British Asilinae, especially in the field, can prove rather daunting for those not familiar with the group. Judging from the number of requests for confirmation of identity that I receive, the separation of females of the smaller species of *Machimus* sensu lato, i.e. *M. atricapillus* (Fallén, 1814), *M. cingulatus* (Fabricius, 1781) and *M. cowini* (Hobby, 1946), appears to be particularly problematic. The features used in couplet 5 of the key by Stubbs and Drake (2001) have proved to be difficult to use and not completely reliable. Here I review and evaluate the characters used historically to separate the species in published keys including that of Stubbs and Drake, using photographs to illustrate and explain the differences described. An alternative version of couplets 4 and 5 (p. 121) of Stubbs and Drake is offered in the hope that it may prove easier to identify the species with confidence.

Characters historically used to separate the females of the species

Machimus cingulatus has historically been placed in the genus *Epitriptus* Loew, of which it is the type species, while *M. atricapillus* has been placed in either *Machimus* sensu stricto or *Tolmerus* Loew. Similarly, *Machimus cowini*, described in 1946 in the genus *Epitriptus*, has more recently been placed in *Tolmerus*. Consequently, despite their close physical similarities, they were generally separated at the generic level in early keys to the North European fauna. Since the generic key characters were primarily male sex-specific, this caused some confusion. Even Rikhter (English translation 1989) only separated *Machimus atricapillus* and *cingulatus* on the basis of male genitalia.

Prior to the recognition and description of *Machimus cowini*, keys separating *M. cingulatus* from *M. atricapillus* were published by Lundbeck (1907), Verrall (1909), Séguy (1927), Engel (1928) and Hobby (1932). Of these, it appears that only Engel had specimens of *Machimus cowini* before him but confused them with *M. cingulatus* (Speight 1987).

While describing *Machimus cowini*, Hobby (1946) amended his previous key to include it, and all subsequent keys covering the North European *Machimus* fauna except Trojan (1970) and Rikhter (1989) also considered it. These included the work of Oldroyd

(1969) as well as that of van der Goot (1985), who treated *cowini* as a colour form of *cingulatus*. Speight (1987) quickly responded to van der Goot with a re-affirmation of the specific status of *cowini*.

The work of Hull (1962) in his key to genera of the world is worthy of particular mention. His key, if properly applied, would place females of our subject species in two separate 'genera' (text) or 'subgenera' (key) as follows: *atricapillus* and *cowini* in *Tolmerus* and *cingulatus* in *Epitriptus*. Unfortunately, his list of species inexplicably placed *atricapillus* in *Machimus* sensu stricto and *cingulatus* plus *cowini* in *Epitriptus*. It is likely that he had never seen specimens of *cowini* and was simply following Hobby.

Drake (1995) specifically addressed the separation of females of *cingulatus* and *atricapillus,* proposing use of the bristle arrangement beneath the ovipositor to separate them. He also drew attention to a difference in relative length of the last segment of the ovipositor in the two species. Among later keys, those of Weinberg and Bächli (1995) and van Veen (1996) were almost identical to that of van der Goot. Stubbs and Drake (2001) used the characters proposed by Drake (1995) and earlier authors in their key to separate *cingulatus* from *atricapillus* but relegated the most definitive character to the text. The most recent key, built into a pictorial atlas of the German species by Geller-Grimm and Dikow (2003), unfortunately failed to recognise the significant differences between females of *cingulatus* and *cowini* and does not separate them, although both species were illustrated with several photographs.

The following list of characters historically used to separate the species can be extracted from the references cited above.

Character	First use	Date	Choice 1	Choice 2
Pile/bristles beneath abdomen	Lundbeck	1907	Bristly	Not bristly
General colour (abdomen)	Verrall	1909	Darker	Lighter
Size	Verrall	1909	Larger	Smaller
Colour of hairs on frons	Verrall	1909	All (except 1 or 2) black	Roughly half white
Acrostichal bristles	Séguy	1927	Shorter	Longer
Colour of femur	Hobby	1946	With orange apical ring	With posterodorsal stripe
Colour of tibia	Hobby	1946	With median black ring	Without median ring
Profile of facial tubercle	Oldroyd	1969	More angular (figure)	Less angular (figure)
Bristles under ovipositor	Drake	1995	Longer	Shorter
Ovipositor length	Drake	1995	Longer	Shorter
Ovipositor last segment	Drake	1995	Longer	Shorter
Relative length of antennal style	Stubbs	2001	Longer	Shorter
Hairs on axis of tergites	Stubbs	2001	Pale colour	Dark colour

The nomenclature of the ventral abdominal plates of *Machimus*

Because I refer below in detail to the underside of the abdomen, it is necessary to first discuss a problem relating to the nomenclature of the sclerotised plates to be found there.

If one examines the underside of the base of the abdomen of a *Machimus*, or indeed of most Asilidae, it is clear that there are more plates present than there are tergites on the top of the abdomen (see Fig. 7). Dissection shows that the extra plate is the hairy anterior one, which lies immediately in front of (bare) sternite 1, and is actually part of the thorax. It is directly associated with the post-metacoxal membrane and appears to be part of the metathorax (i.e. part of the metasternum). A search of the literature on Diptera morphology and terminology has failed to find any discussion of this particular plate. In particular, it is not mentioned in either of the classic works on this subject (Crampton 1946 or McAlpine 1981). Geller-Grimm and Dikow (2003), in a key to German Asilidae and also (undated) on a web-site, showed it on a diagram (Fig. 6: Thorax, ventral: item 17) with the label "metasternum, = postcoxal bridge ?". A detailed anatomical study is necessary to determine the true nature and correct nomenclature of this plate. In the meantime, in the absence of a formal name and since it is necessary to refer to this plate in the following discussion, I have chosen for simplicity to call it "Anterior Sternite" and to label it "SA" in the photographs.

In the text of Stubbs and Drake (pp. 223-224) this hairy plate (which I am now calling the anterior sternite, SA) was referred to as sternite 1 and the true (bare) sternite 1 (my S1) was treated as the anterior part of sternite 2.

Evaluation of the usefulness of the differentiating characters identified

In this section I discuss the value of each of the characters for differentiating the three subject species (particularly the females) and the use as key characters.

Nature of the pile/bristles on the ventral abdominal plates (sternites)

This is by far the most important of all the available key characters because it is the only one so far recognised which definitively distinguishes *cowini* from *cingulatus* in both sexes by a factor other than coloration. It also very clearly separates both sexes of *atricapillus* from *cingulatus*. The situation in *cowini* is not quite identical to *atricapillus* but the difference is not really sufficient to quantitatively differentiate them.

Species	Figure	Sternite	State
atricapillus	10	S2	All hair similar to SA
		S3	~50% like SA, mixed with 50% short stiff bristles
		S4	~25% like SA, mixed with 75% short stiff bristles
cowini	11	S2	Hair similar to SA, with a few slightly stiffer log hairs
		S3	~50% like SA, mixed with 50% stiff bristles mostly of similar length
		S4	~50% like SA or shorter, mixed with 50% stiff bristles mostly of similar length
cingulatus	12	S2-5	No mixture, hair/bristle texture progressively stiffer and shorter towards the rear.

The differences are subtle but, once understood, this character is easy to use at a magnification of about 20X. It is illustrated in Figs 10-12. The character is described in detail in the text of Stubbs and Drake (p. 223) but is unfortunately not used in their keys. I repeat the description here with slight enhancements to add clarity.

The anterior sternite in all three species bears long soft white wispy hairs, which are so fine that the ends are slightly wavy and bend in random directions. The difference between the species lies in the presence or absence of similar fine (sometimes slightly longer) hairs on tergites 2, 3 and 4 in addition to any stronger (usually shorter) bristles which are also present on sternites 3 and 4. The above table describes in detail the nature of the bristles typically present on each sternite.

General size and colour

When I look at a drawer full of specimens, I can see some difference in average colour but not in size between *atricapillus* and *cingulatus*. I have not seen enough specimens of *cowini* to make a serious judgement other than to say that all three species look rather similar to me. There is a subtle difference in the abdominal colour pattern when viewed from certain angles but (as Drake 1995 noted) this cannot be easily described or illustrated. I do not believe that these characters are of any value in keys for determination of species.

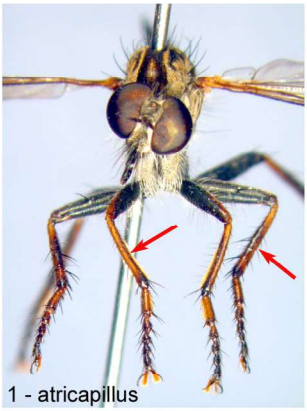
Colour of hairs on frons

Although only a colour difference, this character seems to separate *atricapillus* reliably from *cingulatus*. Most *atricapillus* have all the bristles black and I have never seen one with more than 2 white out of a total of between 20 and 35 bristles. The least white bristles that I have seen in *cingulatus* is 4 out of 22 total, but the average seems to be around 13 white. *Machimus cowini* seems to be much more variable, the number of white bristles ranging from 1 to 6 out of a total of 18 to 21 in a batch of 5 specimens that I examined.

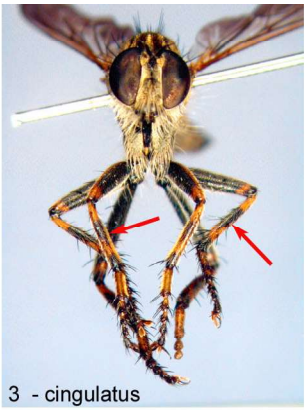
Nature of the acrostichal bristles

A character used by Séguy to separate *atricapillus* from *cingulatus*. His description is lengthy and I cannot recognise the difference he described when I compare specimens of these species. I do not believe it to be a useful key character.

Plate 1: Figs. 1, 3 and 5. *Machimus atricapillus*, *M. cingulatus* and *M. cowini* in front view. Red arrows indicate the absence (Fig. 1) or presence (Figs. 3 and 5) of apparent black rings near the middle the four front tibiae. Figs 2, 4 and 6. Posterodorsal aspect of front and mid femora of the same species. Arrows point to orange longitudinal stripes in *M. atricapillus* and *M. cingulatus* Figs 2 and 4), and to the orange apical rings in *M. cowini* (Fig. 6). Fig. 7. Ventral view of the area at the base of the abdomen in *M. cingulatus*. Blue lines indicate the position of boundaries between the plates and membranes present. PMM = Postmetacoxal membrane (part of thorax), SA = Anterior sternite (part of thorax), S1 = Sternite 1, S2 = Sternite 2, S3 = Sternite 3. Figs. 8 and 9. Lateral views of the ovipositors of *M. atricapillus* and *M. cingulatus*. Red arrows point to long ventrally-placed bristles on sternite 8. Blue lines indicate the positions of boundaries between the tergites incorporated into the ovipositor. T8 = Tergite 8, T9 = Tergite 9, T10 = Tergite 10.

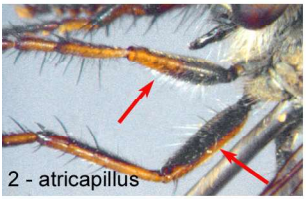


1 - atricapillus

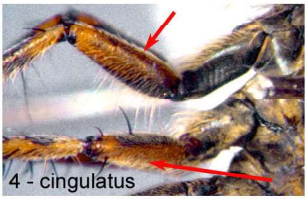


3 - cingulatus

5 - cowini

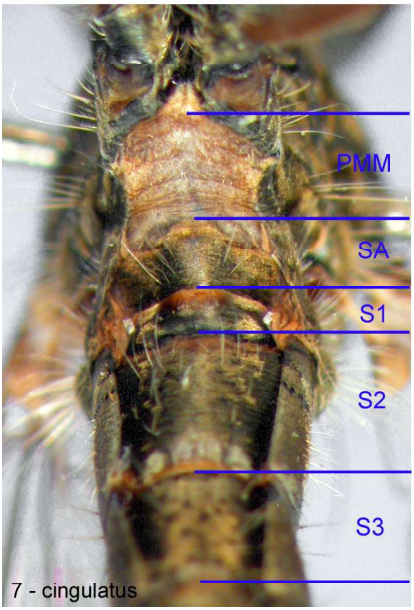


2 - atricapillus

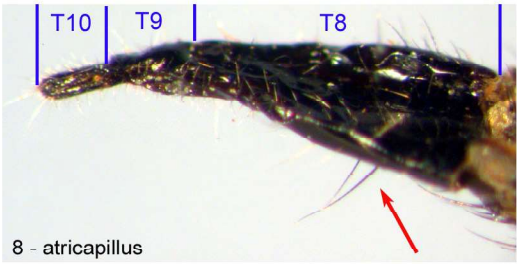


4 - cingulatus

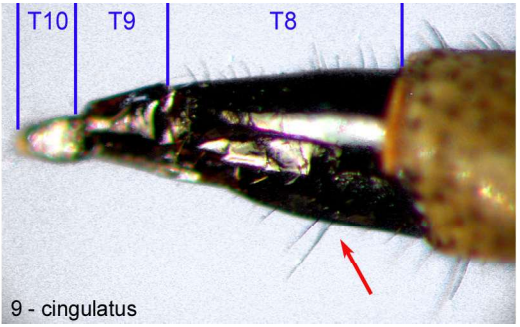
6 - cowini



7 - cingulatus



8 - atricapillus



9 - cingulatus

Colour pattern on femur

In *cowini* the front and middle femora are completely black except for an orange ring at the apex (Fig. 6). The hind pair are similarly coloured but also have a small posterodorsal orange patch near their base (sometimes very inconspicuous). *Machimus cingulatus* and *atricapillus* also have orange-ringed tips but additionally have extensive orange longitudinal posterodorsal stripes on all femora. In *cingulatus* these stripes all reach from the apical ring to the base (Fig. 4), in *atricapillus* the stripes on the front femora may not reach to the base (Fig. 2).

Although based on colour, this appears to be a very good character for recognition of *cowini*. However, I must caution that I have seen one undoubted specimen of *atricapillus* that had almost totally black femora.

Colour pattern on anterior / anterodorsal face of front and middle tibiae

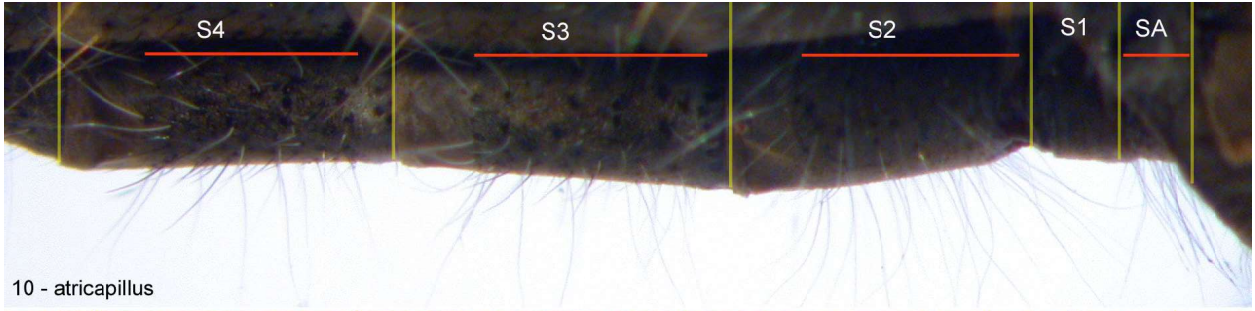
In *cingulatus* the front and middle tibiae, when viewed from the front (Fig. 3) have a very obvious dark patch creating an apparent black central ring. This is not obvious in *atricapillus* (Fig. 1). Although the specimen of *cowini* shown in my picture (Fig. 5) has the same ringed appearance as *cingulatus*, Hobby (1946) pointed out that some *cowini* have "...tibiae with more extended dark markings, so that the annulate appearance so characteristic of *E. cingulatus* is obscured...". John Ismay (*pers. comm.*) has confirmed that the holotype male of *cowini* in the collection of the Oxford University Museum does indeed have more extensively darkened tibiae than usual for this species.

Although based on colour, I have found this to be a very reliable character for separating *atricapillus* from *cingulatus* and have never come across a case in which it did not work. It is particularly useful in the field where it can be recognised instantly with a hand lens. It has been used as the main key character by recent continental authors (van der Goot 1985, Weinberg and Bächli 1995 and van Veen 1996). Because it may be unclear in darker specimens of *cowini* it is best avoided as a key character for distinguishing *cowini* from *atricapillus*.

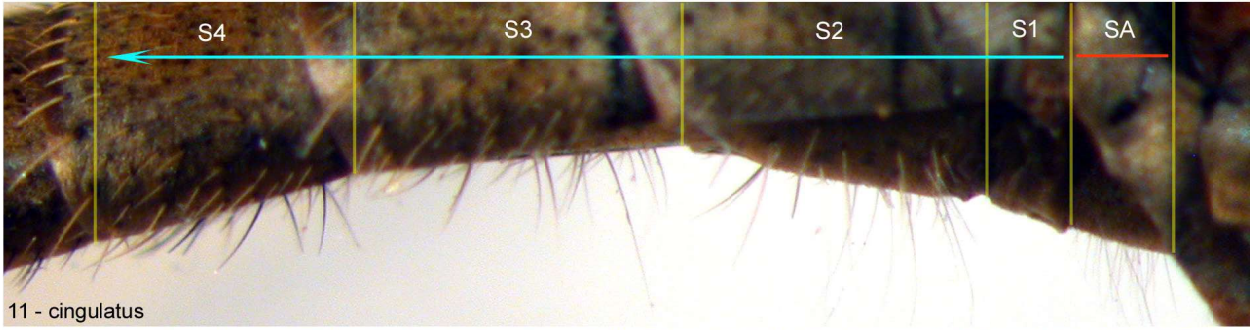
Shape of facial tubercle

Oldroyd (1969) gave diagrams showing a quite strong difference between the profile of the face in *cingulatus* and *atricapillus*. In practice, the facial bristles make it very difficult to see any difference that may exist. I do not believe that this character is of value in separating the species.

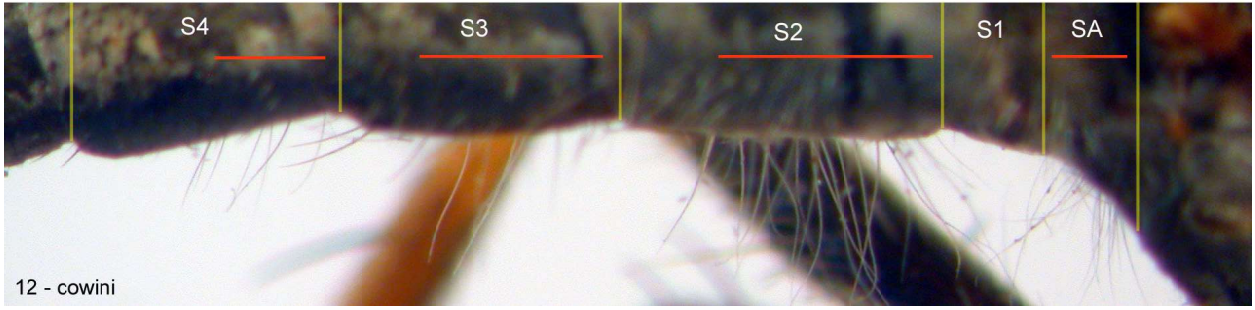
Plate 2. Figs. 10-12. Sternites of *Machimus atricapillus*, *M. cingulatus* and *M. cowini* in side view. SA = Anterior sternite (part of thorax), S1 = Sternite 1, S2 = Sternite 2, S3 = Sternite 3. Yellow lines indicate position of boundaries between sternites. Red lines indicate zones where some long fine "wispy" hairs, similar in texture to those on SA, are present in the specimens illustrated (dense on S2, sparser towards posterior). Blue arrow indicates zone where hairs (if present) become progressively more bristly and shorter towards the posterior in *M. cingulatus*.



10 - atricapillus



11 - cingulatus



12 - cowini

Structure of the ovipositor

Drake (1995) drew attention to three structural differences that might be used to separate *atricapillus* from *cingulatus*: its relative total length, the length of the last segment (abdominal segment 10 = cerci) and the length of the bristles beneath the first segment (abdominal sternite 8).

In dried specimens, the ovipositor always becomes to some extent twisted or otherwise distorted, making it difficult to make accurate comparative measurements. In particular, the joints between abdominal segments (especially segments 6-9) are telescopic so that measurements of relative visible segment lengths are unreliable.

There is no doubt that the ovipositor of *cingulatus*, especially (abdominal) segments 8 and 10, is shorter and more robust than that of *atricapillus* (compare Figs 8 and 9), but this is difficult to quantify for use a key character.

Drake proposed that the two species can be distinguished on the basis of the presence or absence of a pair of differentiated long bristles beneath sternite 8 and use of this character was followed by Stubbs and Drake (2001). In my experience, the long bristles present in both species appear similar (Figs 8 and 9). I have never been able to understand Drake's distinction and believe that it is not valid. I conclude that the ovipositor does not provide any characters useful for distinguishing the species in a key.

Length of the antennal style (= "arista" of Stubbs & Drake)

I have measured the relative length of the style to the third antennal segment in a number of specimens and found them to be reasonably consistent within each species. The ratios I measured lie in the following ranges:

Machimus atricapillus: 0.8 - 1.0; *M. cingulatus*: 0.4 - 0.5; *M. cowini*: 0.7 - 0.8.

Those for *atricapillus* and *cingulatus* are in good agreement with the values used in the Stubbs and Drake key. It would appear that the character can be used with reasonable confidence to distinguish *cingulatus* from *atricapillus*, but *cowini* seems to be intermediate between the other two.

Colour of hair on axis of the tergites 3, 4 and 5

It is true that the hair on these tergites is almost completely black in typical *atricapillus* and *cowini* and can be almost totally white in some specimens of *cingulatus*. However, there is much variation and I have seen *cingulatus* specimens in which it was almost totally black. I do not believe that this character could reliably be used to differentiate the species in a key.

A revised key for separation of the smaller British species of *Machimus*

I offer the following two couplets as an alternative for couplets 4 and 5 on p. 121 in the Stubbs and Drake (2001) key to *Machimus*. I have based these on the premise that the most easily recognisable character should appear first, the most definitive character (where different) second.

If followed carefully, these should enable correct distinction of both male and female specimens of the three species involved. They would work on all specimens that I have seen

with the exception of a single specimen of *Machimus atricapillus* with almost totally black femora.

4 Front and middle femora completely black with a narrow orange ring around the apex (Fig. 6). Sternites 2 - 4 bear a quantity of very fine long hair similar to that on the anterior sternite in addition to any more robust bristles or hairs that are also present (Fig. 12). Male without a tab on the hind margin of sternite 8 .... *M. cowini* (Hobby)

\- Front & middle femora with extensive longitudinal posterodorsal orange markings in addition to an apical ring (Figs 2 and 4). Sternite hair/bristles (Figs 10 and 11) and male sternite 8 variable, with or without a tab 5

5 Front tibiae without any obvious apparent central black ring when viewed from the front, a very weak one may be present on the middle tibiae (Fig 1). Sternites 2 - 4 bear a quantity of very fine long hair similar to that on the anterior sternite in addition to any more robust bristles that are also present (Fig. 10). Male with tab on sternite 8. Bristles on frons all black (occasionally 1 or 2 white) ..... *M. atricapillus* (Fallén)

\- Anterior and anterodorsal surfaces of front and middle tibiae with a central darkened patch so that there is an obvious apparent central black ring when viewed from the front (Fig. 3). Sternites 2-4 with progressively stiffer and shorter hairs/bristles in contrast to the very fine hairs on the anterior sternite (Fig. 11). Male without a tab on the hind margins of sternite 8. A substantial proportion (~ 50%) of bristles on the frons white ..... *M. cingulatus* (Fabricius)

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