THE STATUS OF *Melanostoma dubium* (ZETTERSTEDT) (DIPT. SYRPHIDAE)

Iain MacGowan, Scottish Natural Heritage, Battleby, Redgorton, Perth. PH1 3EW
Francis Gilbert, Department of Life Science, University of Nottingham, University Park, Nottingham. NG72RD

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Introduction

The identification of *Melanostoma dubium* (Zetterstedt) has been a difficult problem for some time. Verrall (1901) first introduced this species to the British list. He states that in his opinion "*M. dubium* is still a very dubious British species". Verrall described two *M. dubium* females, one from approximately 915 m on top of Grey Fell in Perthshire and the other from Rannoch. Both specimens were taken by Colonel J. W. Yerbury in 1898. Verrall described the male from an Austrian specimen but as Speight (1978) points out, this most probably refers to a male *Platycheirus* sp. Verrall found it disconcerting that a male specimen also taken "high up on Grey Fell" on the same day as the described *M. dubium* female was in his opinion only an obscurely marked, very dark legged *M. mellinum*.

In his major work on the British Syrphidae, Coe (1953) regarded *M. dubium* as a variety of *Melanostoma mellinum* (Linnaeus). In his view, specimens apparently referable to *M. dubium* being no more than a darker, more dusted form found in northern England and Scotland.

Speight (1978) reviewed the status of *M. dubium* in the British Isles and with reference to the work of Andersson (1970) and Kanervo (1938) re-established the validity of *M. dubium* as a full species. Comparing Verrall's descriptions to that of these authors and to material which he had collected himself, Speight reintroduced *M. dubium* to the British list. He also provided a revised key to the British *Melanostoma* Schiner species. Speight apparently bases these descriptions on 9 specimens which he records in the text.

Stubbs and Falk (1983) followed Speight (1978) in recognising *M. mellinum* and *M. dubium* as distinct species. They did, however, state that "there remain considerable problems since some specimens were neither ideal *M. dubium* or *M. mellinum*". In response to this predicament they defined a taxon referred to as *Melanostoma* Form A which covered the range of variation present between *M. dubium* and *M. mellinum*. This form is close to *M. dubium* but its inclusion in that species would extend its definition to a point where key characters break down. They hoped that the definition of *Melanostoma* Form A would be a step towards solving some of the taxonomic problems but recognised that the scarcity of material for study was a major drawback. As part of a survey of the montane Diptera of Scotland (Horsfield and MacGowan in press) a further evaluation of the status and distribution of montane *Melanostoma* was possible. During this survey extensive trapping and collecting resulted in approximately 130 *Melanostoma* specimens from various

altitudes being available for study. A sample of these specimens plus others from lower levels throughout Scotland (28 males and 30 females) were used for a detailed morphological study (locations of capture in Table 2). In addition data was obtained about the ecology of montane species in general, information which can prove useful in interpreting the status of *Melanostoma* sp.

Morphological basis for recognising *Melanostoma dubium*

One major weakness in the recognition of *M. dubium* has been that no difference has been found in the structure of the genitalia of that species and *M. mellinum* (Speight 1978). In most cases the species have been separated only by the basis of facial dusting, body colouration, colour of pubescence and length of antennal segments (Table 1).

Andersson (1970) examined Zetterstedt's (1838) type material. The nominate form, var.a, was described from 3 females collected in northern Sweden. A second form, var.b, was also described from northern Sweden and Norway. Andersson designated a female of var a as the lectotype. This specimen has all the femora darkened, narrow dark bands on all the tibiae and abdomen is black with hardly any dusting. The other two var.a females turned out to be *Platycheirus* sp. Andersson states that the male genitalia of *M. dubium* are of the *Melanostoma* type but gives no details on possible differences from other *Melanostoma* species. With regard to the separation of female *M. dubium* from the not infrequent melanic form of *M. mellinum*, Andersson gives the character of a divided tergite 8 in the former whilst in *M. mellinum* this tergite is in one piece. This represents the first definite taxanomic character in the distinction of the two species

On examination of the *Melanostoma* specimens captured during the montane Diptera survey it was obvious that there were indeed some from higher altitudes which under the existing key characters fitted the description of *M. dubium* and likewise some from lower altitudes which fitted the *M. mellinum* description. There were however a considerable number of intermediate individuals at intermediate altitudes which by using Stubbs and Falk (1983) would key out as Form A. It was also noted at this stage that there was an apparent altitudinal range difference between the two sexes of *M. dubium* with females being found at altitudes above 460m and 700m in males. In an attempt to clear up this confusion we embarked upon a more detailed examination of the key characters of *M. dubium* and *M. mellinum* which included the use of statistical analysis of morphological features.

TABLE 1

The differences between *M. mellinum*, *M. dubium* and Form A as described by Andersson (1970), Speight (1978) and Stubbs and Falk (1983).

Character	M. mellinum	M. dubium	Form A
Males			
Arista	long and narrow	short and thickened	short and thickened
Face	narrow	wide	wide
Frons angle	< 90	> 100	intermediate?
Thoracic dorsum	black	black	greenish black
Abdomen	widening posteriorly	parallel sided	parallel sided
Tergite pubescence	extensively black haired	pale haired	intermediate
Tergite colour	usually with paired yellow spots on t2 - t4	usually completely dark	reduced markings
Sternites	usually pale	usually dark	usually dark
Females			
Face	narrow	very wide	wide
Frontal dust spots	very small	extensive	extensive
Antennal segment 3	long and usually yellow below	short and black	short and black
Thorax	black	black	brassy greenish black
Abdomen	long and narrower	shorter and wider	intermediate?
Tergite pubescence	dark haired	pale haired	intermediate
Tergite colour	paired yellow spots on t2 -t5	entirely dark	strongly reduced spots
Tergite 8	complete	divided	?

TABLE 2 Capture site details of morphologically examined specimens

Site name	No. and sex	Grid ref.	Altitude	Date
Aonach Beag	1m	NN1870	850	.6.89
Am Faochagach	1m	NH3177	780	.6.88
Am Faochagach	2m	NH3177	730	.6.88
Am Faochagach	1f	NH3177	655	.6.88
Beinn Bhan	1f 1m	NG7841	700	31.5.90
Beinn Eighe	3f 1m	NG9862	625	12.6.90
	4f 2m	NG9863	525	12.6.90
	2m	NG9962	350	12.6.90
	1f 3m	NH0062	250	12.6.90
	2m	NH0162	150	12.6.90
	4m	NH0162	50	12.6.90
	3m	NH0162	20	12.6.90
Beinn Heasgarnich	1f	NN4438	730	16.6.85
Coll Sands	2f	NB4337	10	29.6.86
Creag Mhor	2f	NC7021	450	14.6.91
Fionchra	1f 1m	NG3300	425	3.6.90
Glen Orchy	1f	NN2841	260	
Kinlochmoidart	1f	NM7172	20	
Laggan	1m	NN2895	50	
Laggan Fen	1m	NN5515	150	
Loch Skipport	1f	NF8238	15	
Loch Sligachan	1f	NG4930	10	
Loch Tuamister	1f	NB2645	10	
Meall a Bhuiridh	1m	NN2550	1000	
	1f	NN2550	960	
Sgurr na Ruaidhe	1f 2m	NH3042	715	
	1f	NH3042	710	
	1f	NH3042	790	
	1m	NH3042	800	
Tillicoultry	2f	NS9296	20	
Uig	1f	NG3963	5	18.5.
Ullapool	1f	NH1294	20	

Distribution in relation to altitude

Figure 1 shows the distribution of *M. dubium, M. mellinum* and intermediate forms in relation to altitude. The determinations were based on Speight (1978) and Stubbs and Falk (1983). The main range is indicated by solid shading; individual records outwith this area are indicated by partial hatching. As might be expected, *M. dubium* specimens are found at the highest altitudes, only at over about 700 m in males and 500 m in females. Intermediate forms occur at lower altitudes followed by *M. mellinum* specimens which were only found below 150 m.

The most outstanding feature of this distribution is that *M. dubium* males and females do not fully share the same altitudinal ranges. There is on average an altitudinal zone of some 200m, between heights of 500m and 700m where only females of *M. dubium* occur with no corresponding males. Both sexes of *M. mellinum* were only found below 150 m.

The *M. dubium* records given by Speight (1978) would seem to agree with the altitudinal separation of the *M. dubium* sexes. He records two males and two females at 760 m on Beinn a'Chuallaich, but only females at lower altitudes, two at 460 m on Schiehallion and one near Camghouran, Rannoch (estimated altitude 250 m).

It is always difficult to accurately assign specimens to a known altitude in the mountains. High winds which are common even in summer can quickly transport an individual from one location to another several hundred metres higher or lower. In general, however, broad altitudinal zoning of forms is evident, especially in early summer soon after the emergence of the adults.

Critical examination of key features.

(a) Colour of abdominal hairs

Speight (1978) uses the presence of white hairs over all the abdominal tergites apart from a few on the tip of t4 as one of his key points in distinguishing male *M. dubium*. Stubbs and Falk (1983) also use this criteria for male dubium but also state that this condition can occur in Form A where the abdominal hairs can be all white or transitional to the black haired nature of *M. mellinum*. In specimens which I have examined the white haired tergites are not restricted to the *"dubium"* form but also occurs occasionally in other specimens from intermediate altitudes.

(b) Antennal length

Speight states that in both sexes of *M. dubium* antennal segment 3 (A3) is less than one and a half times as long as deep. Stubbs and Falk also state that in males of *M. dubium* and Form A this segment is short. Measurements from specimens collected in the Highlands do indeed show that there is a strong correlation between increasing

altitude and decrease in length of A3. This occurs from specimens taken at sea level right through to specimens taken at high altitude. *"dubium"* specimens do tend to have A3 lengths which are 1.5 times or less than the depth of the segment. Even although this measurement shows the best correlation with altitude, there is still a certain amount of variation present.

(c) Aristal length

Stubbs and Falk state that in males of dubium and Form A the arista is short and thickened at the base. Measurements of the arista on a range of specimens from different altitudes has shown that there is considerable variation in this character in both sexes. This criteria seems to show little correlation with altitude.

(d) Face width

Speight (1978) states that for *M. dubium* males "the face is wider than the maximum width of the eye". Stubbs and Falk use as their key character the angle of the eyes where they meet at the top of the frons. Where this angle is less than 90^{o} the specimen is *M. mellinum*, when more than 90^{o} the specimen is either Form A or dubium. Measurements made on males show that there is a strong correlation between face width and altitude. This ranges from specimens at 780 and 730 m where the face width was 50% of the head width, to an average of between 43% and 44% of head width at lower altitudes. Although there is a strong underlying trend relating face width to altitude, considerable variation is still present.

In females the face width varied between 40% and 48% with apparently little relation to altitude. The height of the face as measured between the upper mouth edge and a line between the lower edge of the antennal pits, when compared to face width varied between 68% and 85%, again showing little correlation with altitude.

(e) Antennal colour

Speight (1978) states that in male *M. dubium* "antennal segment three is nearly always black" and for female *M. dubium* this segment is "nearly always black". Stubbs and Falk state "both sexes have entirely black antennae (or at most some yellow on the base of the female third segment)". They also state that Form A has the antennae black in both sexes. Here again the variability of the descriptions for *M. dubium* is evident. Examination of a range of specimens from differing altitudes shows that antennal darkening is a process which is strongly correlated with increasing altitude.

(f) Colouration of the thorax

Stubbs and Falk use as the feature to separate Form A the fact that the colouration of the thoracic dorsum differs from that of the tergites.

In Form A the thorax has brassy reflections which contrast with the black reflections from the tergites. We would certainly agree that in specimens from intermediate altitudes there are often strong brassy or iridescent reflections on the thoracic dorsum and more especially on the pleurae. This feature does, however, vary in intensity between individuals and may only represent another aspect of changing morphology with altitude. As the intensity of reflections does seem to vary throughout the Highlands this character may possibly be effected by some other geographical factor. It is not a constant enough feature on which to base the description of a form.

(g) Female tergite 8

Andersson (1970) first introduces this character as a means of separating melanic *M. mellinum* females from those of *M. dubium*. This feature has been presented as one of the few clear cut morphological differences between female *M. mellinum* and *M. dubium*. As with other characters which have been used in the past, it would appear that Andersson only examined specimens which were at the edge of the range of variation of *M. mellinum*. Detailed study of this feature through the range of various *M. mellinum* groups present in Scotland shows that increased excision and separation of tergite 8 occurs as altitude and latitude increase (Fig 2).

Ecological comparison with other species

Data does exist on the altitudinal distribution of the sexes in the closely related montane syrphid *Platycheirus melanopsis* Loew (D. Horsfield pers. comm.). Specimens of this species were taken in traps at a range of different altitudes on Creag Meagaidh, a mountain in the central Grampians. The analysed results show that both sexes are evenly distributed throughout the altitudinal range of the species (Fig 1). Studies on the distribution of montane Empid *Platypalpus alter* have shown that whilst the females tend to be restricted to intermediate altitudes it is the males which are caught out with this main range, on montane ridges and below the tree line (Horsfield and MacGowan 1992). This is a pattern which might be expected as males which once mating has occurred are not tied to the larval habitat areas and may roam more widely in search of mates. Both these cases contrast with the situation which is found in *M. dubium*.

Multi variate analysis

In order to further test the theory that gradual change was taking place with altitude key morphological features were measured on males and females taken at three different altitudinal ranges. These measurements were then subjected to multi variate analysis.

The characters measured for this analysis were, in males, face width, angle of eyes where they meet above the antennae, width, depth and colour of antennal segment 3, presence or absence of abdominal spots, colour of abdominal hairs and colour of legs. Similar measurements were made on females but instead of eye angle face width was measured.

Ten males and ten females were measured from low, medium and high altitudes. Unfortunately only 8 male specimens were available from the mid altitudes. Low altitude specimens were captured at between 0m and 250m, mid altitude specimens between 250m and 525m and high altitude specimens at over 525m.

Discriminant Function Analysis was performed on the males and females separately. For the male data, the first axis showed highly significant discrimination ($x \sim= 55$, $df=18$, $p << 0.001$), and is negatively correlated with the colour of abdominal hairs and the depth of the 3rd antennal segment. It is positively correlated with the colour and length of the 3rd antennal segment. For females, the first axis is likewise highly significant ($x \sim=48, df=14$, $p << 0.001$), reflecting a positive correlation with antennal colour and a negative correlation with the presence of abdominal spots and leg colour. In both cases, the low altitude samples have the most negative scores and high altitudes the most positive scores. This looks like a cline, rather than distinct species at different altitudes. The next step was to run a Principal Components Analysis, which tries to find the direction of maximum variation between individuals ignoring any *a priori* groupings. If there are really two species this should show up as two distinct clusters of points. In females the first two Principal Axes accounted for 77% of the variation with no sign of any clustering of individuals into groups. Similarly in males the first two axes contained 93% of the variation, again with no obvious clustering. The conclusion is therefore that only one species is involved which changes gradually with altitude.

CONCLUSIONS

In evolutionary terms the genus *Melanostoma* lies close to the stem group of the Syrphidae. It is a rather adaptable and plastic genus which occurs in a wide range of habitats in the Nearctic and Palearctic. It is not surprising therefore that a great deal of morphological variation exists throughout its range. Vockeroth (1990) states that *Melanostoma* is almost entirely an Old World genus with one very variable New World species having many synonyms (or perhaps a complex of species) extending south to Mexico.

In earlier keys which attempted to separate *M. dubium* from *M. mellinum* there were always many provisos included to take into account the variation encountered in these species. This led Stubbs and Falk to describe a Form "A" in which were included all the transitional specimens which did not fit easily into either species. A further problem in the past determination of *M. dubium* was that in most cases the descriptions were based upon a few individuals taken at relatively high altitudes. No attempt was made to study the changes which happened to *M. mellinum* as the

altitude gradually increased. To an entomologist most familiar with the forms of *M. mellinum* which are found in lowland Britain the "dubium" specimens appear strikingly different and raise the obvious question of whether indeed there is a different species present.

Field observations show that it is the females of *M. mellinum* which show signs of melanism at lower altitudes rather than the males. This would seem to be more symptomatic of a species which was gradually changing its colouration in response to a decline in temperature with altitude. The females which spend a far greater time feeding and convert the food to eggs would gain the greatest advantage of a dark colouration which would allow them to maximise on the available solar energy in order to maintain body temperature. The males which are not faced with the same demands of energy conversion and which perhaps benefit in attracting a mate or holding territory by having obvious yellow markings, do not exhibit melanism until a much higher altitude.

In conclusion, from a study of the changes in morphology with altitude, the differences in the altitudinal distribution of sexes and from a comparison of the distribution of closely related species, it becomes clear that a gradual morphological change in *Melanostoma mellinum* populations is taking place in response to increasing altitude. In my opinion both Form A and *M. dubium* are part of the variation within *M. mellinum* populations. This is most probably part of a cline whereby as the altitude or latitude increases morphological change takes place which includes greater darkening of the abdomen and increase in face width take place.

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Appendix 1 Multi variate analysis data

(A) Females

No	Altitude M	1	2	3	4	5	6	7
01	20	43	79.5	63	1	3	7	37
02	20	39	84	62.5	2	3	7	33
03	10	43	79	60	2	2	18	30
04	15	42	94	58	1	3	8	36
05	10	44	97	63	1	2	16	42
06	5	42	83	59	2	3	9	34
07	20	44	87	76	1	1	11	33
08	20	43	87	59	1	3	8	36
09	10	45	88	64	2	2	10	30
10	10	43	88	67	1	3	8	34
11	250	46	78	77	2	2	18	31
12	525	45	84	69	3	2	20	33
13	525	49	81	62.5	3	1	24	37
14	525	47	71	66	3	1	22	33
15	525	46	79	77	3	1	22	33
16	425	47	71	78	2	2	20	28
17	450	46	82	75	3	1	24	34
18	450	43	86	70	3	1	22	31
19	450	46	80	62.5	3	1	22	33
20	260	45	83	51.5	2	2	18	35
21	625	48	72	67	3	1	24	36
22	625	48	80	71	2	1	20	30
23	700	45	83	67	3	1	18	33
24	710	43	85	68	3	1	24	33
25	960	43	72.5	68	3	2	22	34
26	655	50.5	84	79	3	1	20	33
27	730	45	81	72	3	1	22	34
28	625	46	73	69	3	1	24	32
29	790	45	76	69	3	1	24	35
30	715	54	84	62.5	3	1	24	30

Key

1 = Face width as % head width

2 = Face height as % width

3 = Antennal Segment 3 Depth as % length

4 Abdominal spots:
1 = normal 2 = reduced 3 = melanic

5 Antennal colour:
1 = black 2 = <15%Yellow 3 = >15%Yellow

6 Leg score: (all x 6)
1 = Yellow 2 = ringed 3 = Yellow/Black

4 = Black

7 Antennal Segment 3, length as % head width

(B) Males

No	Altitude M	1	2	3	4	5	6	7	8	9
1	20	44	61	148	1	2	20	3	1	29
2	50	45	63	147	1	2	20	3	1	37
3	50	43	58	135	1	3	20	3	1	36
4	50	42	65	135	1	1	20	2	1	30
5	150	41	67	123	1	3	18	3	1	32
6	150	41	60	127	1	2	20	2	1	34
7	100	40	68	135	1	3	18	3	1	34
8	20	48	64	150	1	1	15	3	1	32
9	50	38	64	187	1	3	13	1	1	34
10	20	41	64	132	1	1	17	1	1	40
11	350	39.5	72	140	1	1	20	3	2	29
12	350	42.5	73	142	1	1	20	2	2	30
13	250	43	68	128	1	1	20	1	2	34
14	250	39.5	60	136	1	3	20	2	1	31
15	525	39	68	136	1	2	16	1	1	35
16	525	43	71	148	1	1	20	3	3	29
17	425	45	64.5	145	1	1	18	3	3	30
18	250	43	64.5	129	1	2	20	2	3	33
only 8 specimens in this group										
21	730	47.5	74	130	3	1	24	3	3	34
22	730	44	68	113	2	1	20	3	3	32
23	1000	46	64	153	2	2	20	3	3	29
24	850	46	70	130	1	1	20	2	3	34
25	715	47	75	146	2	1	24	3	3	29
26	780	47	65	154	3	1	20	3	3	28
27	715	44	78	152	1	1	18	2	3	28
28	700	46	76	164	2	1	22	3	3	31
29	800	45	75	128	3	1	24	3	3	30
30	625	46	74	152	1	1	20	3	2	27

Key

1 Face width as % head width

2 Antennal Segment 3, depth as % length

3 Arista length as % Antennal Segment 3 length

4 Abdominal spots:
1 = normal 2 = reduced 3 = melanic/silver

5 Antennal Segment 3 colour:
1 = black 2 = <15%yellow 3 = >15%yellow

6 Leg score: (all x 6)
1 = yellow 2 = ringed 3 = yellow/black
4 = black

7 Eye angle on frons:
1 = $<90^{o}$ 2 = 90^{o} 3 = $>90^{o}$

8 Abdominal hairs:
1 = normal 2 = black hairs reduced
3 = black hairs absent

9 Antennal Segment 3 length as % head width