Description of Morphological Characters

The characters with their respective states as included in the morphological matrix are given below. Character descriptions and notes about their coding are based mainly on Vilhelmsen (2001) and Schulmeister (2003a, 2003b), but with some recent changes to character interpretation as noted. Characters that were excluded from the analysis are shown in brackets. References cited in this appendix are listed at the end of this document. Figure references correspond to the respective papers where the characters were described for the first time, as given below.

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Characters from Vilhelmsen (2001): 1-236

Head
Head capsule, dorsally and anteriorly
1. Ocellar corona (Vilhelmsen, 1997a: 1; Ronquist et al. 1999: 2): no conspicuous structures around median ocellus = 0; median ocellus surrounded by ring of cuticular teeth = 1.
2. Subantennal grooves (Vilhelmsen, 1997a: 2,1997b): no conspicuous grooves ventrally of the eyes= 0; grooves extending posteriorly from the anterior tentorial pits ventrally of the eyes present = 1.

Labrum and epipharynx
4. Position of labrum (Vilhelmsen, 1996: 1): labrum situated anteriorly of the tips of the mandibles, partly covering them (Fig. 1A)= 0; labrum situated posteriorly of the tips of the mandibles, at least partly covered by them (Fig. 1B) = 1.
5. Shape of labrum (Vilhelmsen, 1996: 2): labrum broader or just as broad as high= 0; labrum several times higher than broad = 1.
8. Lateral epipharyngeal brush (Vilhelmsen, 1996: 5): absent = 0; microtrichian brush connected to one of the tormae present = 1.
9. Tormae (Vilhelmsen, 1996: 6): distinct apodemes continuous with the labrum and receiving the posterior labral retractors present, not continuous medially = 0; present, continuous medially = 1; absent = 2 (unordered).
11. Labral apodemes (Vilhelmsen, 1996: 9): absent = 0; distinct apodemes connected to the tormae present = 1.
12. Labral compressor muscles (Vilhelmsen, 1996: 12): present = 0; absent = 1.

Head capsule, ventrally and posteriorly
14. Mandibular foramina (Vilhelmsen, 1997a: 17; Ronquist et al., 1999: 4): confluent with the oral foramen= 0; separated from the oral foramen by sclerotized subgenal bridges = 1.
15. Occipital sulci and ridges (Vilhelmsen, 1999): present = 0; absent = 1.
16. Sclerotization between the occipital and oral foramina (Ronquist et al., 1999: 5; Vilhelmsen, 1999): absent, occipital and oral foramina confluent = 0; sclerotization in the integument present, separating occipital and oral foramina = 1. The interpretation of this feature has been subject to much disagreement (see Vilhelmsen, 1999 for a review). With the exception of the postgenal bridge (character 18), we have abstained from coding information concerning which elements might be included in the sclerotization.
17. Postoccipital bridge (Vilhelmsen, 1999): insertion points of the ventral profurco-postoccipital muscles separate = 0; insertion points connected by internal sclerotized bridge ventrally of the tentorial bridge = 1.

18. Postgenal bridge (Ronquist et al., 1999: 6; Vilhelmsen, 1999): postgenae not in contact between the occipital and oral foramina = 0; postgenae closely abutting or fused between the occipital and oral foramina = 1. Scored as inapplicable when sclerotizations between the occipital and oral foramina are absent.

**Tentorium**

19. Dorsal tentorial arms (Vilhelmsen, unpublished): present, well developed, in contact with head capsule = 0; absent or reduced = 1.

20. Shape of tentorial bridge (Ronquist et al., 1999: 7, 8): broad, not arched = 0; narrow, not arched = 1; narrow, arched = 2 (ordered). Combined and scored slightly differently from Ronquist et al. (1999), as we failed to appreciate the subtle difference between "narrow, stripe-like" and 'thin, rodlike" (their character 7).

21. Corpotendon (Ronquist et al., 1999: 9): point of origin of the ventral cibarial and pharyngeal dilatators on tentorial bridge not conspicuous = 0; distinct apodeme present anteriorly on tentorial bridge = 1. We observed a corpotendon in *Megalodontes*, in contrast with the scoring of Ronquist et al. (1999).

**Antennae**

22. Male antennae: flagellomeres without lateral projections = 0; flagellomeres with distinct, slender lateral projections many times longer than the base of the flagellomeres, projections not flattened and appressed = 1; flagellomeres with flattened and appressed lateral projections = 2 (unordered).

23. First flagellomeres (Vilhelmsen, 1997a: 3; Ronquist et al., 1999: 14): not broader, and not much longer than the length of any of the following flagellomeres = 0; distinctly broader and much longer than any of the following flagellomeres = 1; distinctly enlarged, distal flagellomeres absent = 2 (ordered).

24. Apical flagellomeres: not conspicuously modified = 0; clubshaped = 1; reduced and with flattened apex = 2 (unordered). The last character state was newly added. Scored as inapplicable when only one flagellomere was present.

25. Multiporous plate sensilla (Basibuyuk & Quicke, 1999): absent = 0; present = 1.

**Mouthparts**

26. Mandibles (Vilhelmsen, 1997a: 16; Ronquist et al., 1999: 24): neither highly asymmetric nor extremely long and curved = 0; highly asymmetric, with distinct molar process on the right mandible corresponding to a concavity on the left = 1; elongate and curved, lying in distinct clypeal furrow at rest (Fig. 1B) = 2 (unordered).

27. Sitophore (Vilhelmsen, 1996: 14): absent = 0; present, does not extend distally of the functional mouth := 1; present, extends distally of the functional mouth = 2 (ordered).


29. Infraorbucal pouch (Vilhelmsen, 1996: 16): small and/or with inconspicuous armature = 0; large, with distinct cuticular teeth developed for grinding pollen = 1. Redefined and rescored relative to Vilhelmsen (1996); state 1 is here only assigned to taxa having a true ‘triturating basket’.

30. Hypopharyngeal pectens (Vilhelmsen, 1996: 17): absent = 0; minute microtrichian hairs present on hypopharyngeal rods = 1; distinct brushes formed by large, closely appressed microtrichian hairs = 2 (ordered).
31. Ventral salivarial dilatators (Vilhelmsen, 1996): present = 0; absent = 1. These muscles are absent from Micropterix according to Kristensen (pers. comm.), contrary to Hannemann (1956).

32. Glossa (Vilhelmsen, 1996: 18): present, distinct = 0; reduced or absent = 1.

33. Shape of glossa (Vilhelmsen, 1996: 19): flat = 0; longitudinally folded into an inverted U-shape, or hoodlike = 1. Orthogonalyx was observed to have a flattened glossa, in contrast to the Trigonidae examined by Vilhelmsen (1996).

34. Paraglossae (Vilhelmsen, 1996: 20): club-shaped, without microtrichia = 0; flattened, with scale-like microtrichia in transverse rows = 1; distal scale-bearing part reduced = 2; totally reduced, fused with glossa = 3 (unordered).

35. Number of labial palp segments (Vilhelmsen, 1996: 21): four = 0; three = 1; two = 2; one = 3. (ordered). Vilhelmsen (1996) erroneously reported Blasticotoma to have only three labial palp segments.

36. Rod-like sensilla (Vilhelmsen, 1996: 22): absent = 0; specialized sensilla on distal labial palp segment present, not situated in invagination = 1; present, situated in invagination = 2 (ordered).

37. Ventral premental adductors (Vilhelmsen, 1996: 24): inserting separately on the prementum = 0; inserting through a common tendon on the posterior end of the prementum = 1. Vilhelmsen (1996) erroneously reported Syntexis to have state 1 for this character; the insertions are situated closely together on the posterior margin of the prementum, but are still separate.

38. Postmentum (Vilhelmsen, 1996: 25): present = 0; absent = 1. We followed the coding of Schulmeister (2003a), treating the very small postmentum as found in some Pamphiliidae as present.

Mesosoma

Pronotum

39. Posterodorsal margin of pronotum (Ronquist et al., 1999: 28; Vilhelmsen, 2000b: 1): at most slightly curved = 0; deeply curved = 1.

40. Anterolateral corners of pronotum (Vilhelmsen, 2000b: 2): not conspicuous, anterior surface of pronotum without any differences in surface sculpture = 0; with prominent projections, separating smooth anterior surface of pronotum from distinctly sculptured dorsolateral parts = 1.

41. Posterolateral margins of pronotum (Vilhelmsen, 2000b: 3): straight, not covering anterior thoracic spiracles = 0; with concavities for the accommodation of the anterior thoracic spiracles = 1; straight, covering anterior thoracic spiracles = 2; straight, anterior thoracic spiracles visible in lateral view, but surrounded by pronotaprepectal cuticle = 3 (ordered). Gibson (1985) proposed that the presence of a pronotal lobe covering the anterior thoracic spiracles is a synapomorphy for the Orussidae and Apocrita, though subject to secondary modification within the latter taxon. The occurrence of the pronotal lobe has been incorporated in this character, its presence corresponding to state 2.

42. Subspiracular articulations (Vilhelmsen, 2000b: 4): pronotum separated from the anterior margins of the mesopleura = 0; posterolateral margins of pronotum closely abut or articulate with the anterior margins of the mesopleura ventrally of the anterior thoracic spiracles = 1; posteroventral corners of pronotum fused with the anterior margins of the mesopleura ventrally of the anterior thoracic spiracles = 2; posterolateral margins of pronotum fused with the mesopleura all the way to the anterior thoracic spiracles = 3 (ordered). Ronquist et al. (1999: 29) included the nature of the pronoto-mesepisternal attachment in their analysis, recognizing only two states, ‘loose’ and ‘rigid’ attachment. In
contrast, Vilhelmsen (2000b) subdivided this character to code the variation observed within the Tenthredinoidea.

**Propleuron**

43. Dorsal cervical sclerites (Vilhelmsen, 2000b: 5): absent = 0; present as separate sclerites = 1.

44. Cervical prominences (Vilhelmsen, 2000b: 6): not retracted = 0; partly retracted, cervical swellings face medially = 1; fully retracted, cervical swellings face laterally = 2 (ordered). This character is treated here as ordered again, after Schulmeister (2003a) treated it as unordered because the ordering was not the most parsimonious solution on her topology resulting from a completely unordered analysis.

45. Position of cervical prominences (Vilhelmsen, 2000b: 7): at the anterodorsal corners of the propleura = 0; ventrally of the anterodorsal corners of the propleura = 1. Schulmeister (2003a) interpreted the occurrence of 45:1 in some taxa (e.g., Pamphiliidae and Cephidae) as being caused by the fusion of the dorsal cervical sclerites with the propleura, as indicated by the presence of setae anterodorsally on the propleura; she subdivided 43:0. This homologisation is only corroborated by the position of the setae, which are not always restricted to the dorsal cervical sclerite (Vilhelmsen 2000). However, the interpretation in Schulmeister (2003a) is very dependent on these inferences, rather than the primary observations. Furthermore, Schulmeister (2003a) decided to delete these two characters entirely because of problems with delimiting the states. This seems to us too drastic an exclusion of putatively phylogenetically informative characters, and we revert to the coding of Vilhelmsen (2001).

46. Cervical apodemes (Vilhelmsen, 2000b: 8): absent = 0; short, barely delimited from cervical prominences = 1; elongate, distinct, projecting posteriorly from cervical prominences = 2 (ordered).

47. Insertions of the profurco-laterocervical muscles (Vilhelmsen, 2000b: 9): double, both on the posterior ends of the cervical apodemes and on the ventral internal margins of the cervical swellings = 0; single, only on the posterior ends of the cervical apodemes = 1. This character was scored as inapplicable when the cervical apodemes are absent.

48. Cervical lines (Vilhelmsen, 2000b: 10): laterocervicalia and propleura proper completely separated = 0; laterocervicalia and propleura proper partly fused, cervical lines present = 1; laterocervicalia and propleura proper completely fused, cervical lines absent = 2 (ordered).

49. Pronoto-postoccipital muscles (Vilhelmsen, 2000b): present = 0; absent = 1.


51. Prophragmo-laterocervical muscles (Vilhelmsen, 2000b: 12): present = 0; absent = 1.

52. Dorsal propleural apodemes (Vilhelmsen 2000b: 13): absent or weakly developed = 0; present, distinct = 1.

53. Dorsal parts of propleura (Vilhelmsen, 2000b: 14): not inflected and not differing in sculpture from the rest of the propleura = 0; inflected and delimited from the rest of the propleura, smooth, articulating with the lateral margins of the pronoturn= 1.

54. Propleural sulci andridges (Vilhelmsen, 2000b: 15): present, well developed = 0; reduced or absent = 1.


56. Medioventral propleural margins (Ronquist et al., 1999: 32; Vilhelmsen, 2000b: 17): widely separate, not inflected = 0; parallel, inflected and closely abutting = 1.

58. Prothoracic katepisterna (Vilhelmsen, 2000b: 19): present = 0; absent = 1.

59. Configuration of the katepisterna (Vilhelmsen, 2000b: 20): undivided, in contact with or continuous with trochantins = 0; undivided, proximal ends abut lateral propleuro-procoxal articulations, trochantins absent = 1; subdivided, proximal parts abut lateral propleuro-procoxal articulations, distal parts entirely separate from the procoxae = 2; proximal parts absent, distal parts entirely separate from the procoxae = 3 (ordered).

**Prosternum and profura**

60. Laterosternal sclerites (Vilhelmsen, 2000b: 21): present = 0; absent = 1.

61. Anterolateral corners of prosternum (Vilhelmsen, 2000b: 22): separate from the propleura = 0; fused with the propleura at the propleuro-procoxal articulations = 1.

62. Profurcal arms (Vilhelmsen, 2000b): not closely associated with the median surfaces of the propleura = 0; fused with the propleura ventrally, near the propleuro-procoxal articulations = 1; articulated, but not fused with the propleura at the dorsal margins of the latter = 2 (unordered).

63. Posterodorsal profurcal apodemes (Vilhelmsen, 2000b: 23): absent = 0; present = 1.

64. Profurcal bridge (Vilhelmsen, 2000b: 24): absent = 0; present = 1.

65. Prospinasternum (Ronquist et al., 1999: 47; Vilhelmsen, 2000b: 25): entirely separate from the anterior margin of the mesothorax = 0; closely associated with the anterior margin of the mesothorax, connected to the latter by short distance of weakly sclerotized cuticle = 1; entirely fused with the anterior margin of the mesothorax = 2 (ordered). This character is treated here as ordered again, after Schulmeister (2003a) treated it as unordered because the ordering was not the most parsimonious solution on her topology resulting from a completely unordered analysis.

66. Prospinasternal apodeme (Vilhelmsen, 2000b: 26): present, short = 0; present, large, projecting far into thorax = 1; rudimentary or absent, at most external part of prospinasternum developed = 2 (unordered).


69. Prophragmo-profurcal muscles (Vilhelmsen, 2000b: 29): present = 0; absent = 1.

70. Dorsal mesofurco-profurcal muscles (Vilhelmsen, 2000b: 30): present = 0; absent = 1.

**Fore leg**

71. Posterior apical protibial spurs (Basibuyuk & Quicke, 1995: A): present, well developed = 0; reduced or absent = 1.

72. Anterior apical protibial spurs (Basibuyuk & Quicke, 1995: B, E, F): unmodified = 0; modified into curved calcars with velum for use in antennae cleaning = 1; absent = 2 (unordered). Basibuyuk & Quicke (1995) coded additional characters for the variation in the configuration of the calcars (shape, occurrence of velum). These characters were omitted here, since they are evidently closely correlated. Including them would result in assigning this character system undue weight, especially in case of reversal, which seems to have occurred within the Tenthredinoidea.

73. Tips of apical protibial spurs (Basibuyuk & Quicke, 1995: C): pointed and sclerotized = 0; blunt and membranous = 1.

75. Probasitarsal combs (Basibuyuk & Quicke, 1995: J): probasitarsi without any specialized setae proximally = 0; with few, well separated setae in a row = 1; with many, closely set setae or row of platelike structures = 2 (ordered). Cephoidea, Syntaxis, Xiphidiida, Orussus, Aulacus, and Orthogonalys were scored after Basibuyuk & Quicke (1995). The probasitarsal combs in Orthogonalys differ from those of other Apocrita (Basibuyuk & Quicke, 1995), but were not assigned a separate state here since that would be autapomorphic for this taxon. This character was treated as ordered again, after Schulmeister (2003a) treated it as unordered because the ordering was not the most parsimonious solution on her topology resulting from a completely unordered analysis.

76. Paddle-shaped setae on anterior part of probasitarsi (Basibuyuk & Quicke, 1995: character K): absent = 0; one row of paddleshaped setae present = 1; several rows of paddleshaped setae present = 2 (unordered).

Mesonotum

77. Median mesoscutal sulcus (Gibson, 1985): well developed = 0; reduced or absent, internal ridge at most developed on 1st phragma= 1.

78. Parapsidal signa on mesoscutum (Gibson, 1985): absent = 0; weakly developed = 1; conspicuous = 2 (ordered).

79. Transscutal fissure (Gibson, 1985): no conspicuous transverse line on mesoscutum anteriorly of the mesoscuto-scutellar sulcus = 0; curved line not less sclerotized than the rest of the mesoscutum present = 1; straight line which is distinctly less sclerotized than the rest of the mesoscutum present = 2 (ordered). Gibson (1985) did not consider the structures in Siricidae (state 1) to be homologous with the ones in Xiphydriidae, Orussidae, and Apocrita (state 2), in contrast to Rasnitsyn (1988). In both Siricidae and Xiphydriidae the mesonoto-laterophragmal muscles arise posteriorly of the line, corroborating the homology of these areas, the axillae (A. P. Rasnitsyn, pers. observ.). The axillae lie just posteriorly of the transcutal lines, laterally of the mesoscutellum (Gibson, 1985). However, the configuration of the line is clearly different in Xiphydriidae + Orussidae + Apocrita, and Siricidae, respectively. Treating this character as unordered reflects the view of Gibson (1985), treating it as ordered is in accordance with Rasnitsyn (1988).

80. Mesonoto-mesotrochanteral muscles (Gibson, 1985): present = 0; absent = 1. These muscles are present in several apocritan taxa besides those included here (Gibson, 1985).

Mesopostnotum and second phragma

The character complex dealing with the mesolaterophragma and its associated structures has been divided into more characters than recognized by Heraty et al. (1994). Nematus was scored differently from Heraty et al. (1994) for these characters; Ibalia was scored after Heraty et al. (1994).

81. Mesolaterophragmal lobes (Heraty et al., 1994: 2 in part): present, well developed= 0; reduced or absent= 1.

82. Anterior apodemes of mesolaterophragmal lobes (Heraty et al., 1994: 2 in part): absent = 0; present = 1.

83. Excision between apodemes and lobes (Heraty et al., 1994: 2 in part): absent = 0; present = 1.

84. Shape of anterior apodemes (Heraty et al., 1994: 2 in part): short, rounded= 0; elongate = 1.
85. Mesonoto-mesolaterophragmal muscles (Heraty et al., 1994: 4): present = 0; absent = 1.

86. Mesolaterophragmal-mesofurcal muscles (Heraty et al., 1994: 3): one composite pair present = 0; two pairs present = 1; anterior pair absent (150a) = 2; posterior pair absent (150b) = 3 (unordered). Panorpa, Syntexis, Umcerus, and Tremex were scored after Heraty et al. (1994). Only one pair of muscles was observed in Perga and Orussus, but their identity is difficult to decide due to the reduction of the laterophragmal lobes and the absence of mesonoto-mesolaterophragmal muscles in these taxa (Heraty et al, 1994).

87. Mesopostnotum (Heraty et al., 1994: 5): exposed, without opening ventrally = 0; exposed, with opening ventrally for the tendon of the mesoscutello-metanotal muscle = 1; covered dorsally by anterior parts of metanotum, without opening = 2 (unordered). Contrary to Heraty et al. (1994), the insertion point of the mesoscutello-metanotal muscle has been treated as a separate character (112) here (see Vilhelmsen, 2000b).

88. Pseudophragma of mesopostnotum (Heraty et al., 1994: 6): 2nd phragma without any anteriorly projecting lobes = 0; 2nd phragma with a pair of lobes (pseudophragma) projecting anteriorly of the connection between the mesoscutellum and the mesopostnotum = 1. Schulmeister (2003a) followed Heraty et al. (1994) in considering the pseudophragma to be present in Orthogonalys. Heraty et al. (1994) scored this feature to be present in all Apocrita except some Ichneumonidae. The development of the pseudophragma is in fact highly variable within Apocrita (Vilhelmsen unpublished), even if it is probably present in the apocritan ground plan, so we uphold the scoring (absent) of Vilhelmsen (2001).

89. Lateral attachment points of the mesopostnotum with the mesepimera (Heraty et al., 1994: 10): broad and exposed = 0; invaginated = 1; reduced, mesopostnotum internal = 2 (ordered). Schulmeister (2003a) considered 89:2 to be correlated with 87:2 (mesopostnotum covered dorsally by anterior part of metanotum) and hence scored all taxa having 87:2 as inapplicable for 89. However, even if the mesopostnotum is entirely internalized, it still might have retained the connection with the mesepimeron. Since this is not the case, we revert to scoring the taxa that have lost this connection as a separate state (2).

‘Intersegmental’ sclerites and thoracic spiracles

90. Repecti (Gibson, 1985, 1999: 10, 11; Vilhelmsen unpubl.): present, freelying, not overlapped by the pronotum = 0; present, small and wedged in between the pronotum and the mesopleura = 1; present, overlapped by the posteroventral corners of the pronotum = 3; absent as independent sclerites (fused with either the pronotum or the mesopleura) = 3 (unordered). In contrast to the scoring of Ronquist et al. (1999: 40, 41), none of the Pergidae included here have the prepecti present. Cephus and Calameuta have the prepecti fused with the anterior margins of the mesopleura, though clearly delimited by sutures, and were assigned state 3. According to Gibson (1985), the Siricidae have the prepecti concealed by the posterolateral margins of the pronotum, resembling the condition in Xiphydriidae (Fig. 2B) and Orussidae. The Siricidae, however, have the posterolateral margins of the pronotum separate from the anterior margins of the mesopleura as indicated by the absence of subspiracular articulations (character 42). The prepecti are hardly visible externally, but they are lying in a pair of folds posteroventrally of the anterior thoracic spiracles rather than beneath the pronotum (Fig. 2A). Consequently, the Siricidae included have been assigned state 0 in the present analysis. Gibson (1985, 1999: 12) and Ronquist et al. (1999: 42-46) further subdivided this character to encode the variation observed within the Apocrita. This has not been attempted here, since the small number of apocritans included would result in them being assigned autapomorphic states.
91. Occlusor muscles of the anterior thoracic spiracles (Vilhelmsen unpubl.): arise from the prepecti = 0; arise from anterior margins of the mesopleura = 1; arise from posterior parts of the pronotum = 2 (unordered).

92. Mesothoracic anepisterna (Gibson 1985,1993): not separated from the rest of the mesopleura = 0; separated from the rest of the mesopleura as postspiracular sclerites = 1; absent = 2 (unordered). Gibson (1985) reported that the postspiracular sclerites are absent from Megalodontesidae; this was based on observations of a dried specimen (G.A.P. Gibson pers. comm.). We examined wet-preserved specimens of Megalodontes, which have small, but distinct sclerites partly covered by the posterior lips of the anterior thoracic spiracles, in addition to the small prepecti.


94. Posterior thoracic spiracles (Vilhelmsen, 2000a: 17): concavities in posterior margins of mesepimera opposite spiracles undeveloped or quite shallow = 0; spiracles accommodated in distinct concavities of the mesepimera = 1; spiracles covered laterally by mesepimera = 2 (ordered).

95. Occlusor muscles of the posterior thoracic spiracles (Vilhelmsen, 2000a: 18): arise from separate sclerites posteriorly of the spiracles = 0; arise from the posterior margin of the mesepimera ventrally of the spiracles = 1.

Mesopleura

96. (Mesopseudosternal sulci (Ronquist et al., 1999: 48): mesepisterna subdivided by oblique longitudinal grooves corresponding to internal ridges = 0; at most shallow grooves without corresponding internal ridges present = 1. This character was deleted: it is represented by character 251 again, with a slight recoding.)

97. Configuration of mesopseudosternal sulci (Ronquist et al., 1999: 49): not reaching the anterior margins of the mesepisterna, terminating in the discrimen of the mesothorax = 0; terminating in the anterior margins of the mesepisterna = 1. Sulci are absent or weakly developed. Scored as inapplicable when the mesopseudosternal

Mesofurca

98. Anterior mesofurcal arms (Heraty et al., 1994: 1 in part): short, inconspicuous = 0; elongate = 1. Heraty et al. (1994) combined this and the following character (99). Scoring differs from Heraty et al. (1994) and Ronquist et al. (1999) in Paremphytus.

99. Mesofurcal bridge (Heraty et al., 1994: 1 in part): anterior mesofurcal arms entirely separate = 0; fused only at their apices = 1; fused for most of their length = 2 (ordered). Heraty et al. (1994) further subdivided state 2. The additional states recognized by Heraty et al. (1994:) are rather subtle and weakly defined, so we decided to combine them.

100. Lateral mesofurcal arms (Vilhelmsen unpubl.): short, not extending towards the mesopleura = 0; elongate, extending towards the mesopleura = 1.

101. Mesofurco-metabasalar muscles (Heraty et al., 1994: 9; Vilhelmsen, 2000a: 23): present, not inserted on anterior margin of metapleura = 0; present, inserted on anterior margin of metapleura = 1; absent = 2 (unordered).

102. Mesospina (Vilhelmsen, 2000a: 42): small, does not project posteriorly between the anterior metafurcal arms = 0; elongate, projects posteriorly between the anterior metafurcal arms = 1; absent = 2 (unordered).

103. Metafurco-mesospinal muscles (Heraty et al., 1994: 8; Vilhelmsen, 2000a: 43): present = 0; absent = 1. Heraty et al. (1994) stated that these muscles are present in all Tenthredinoidea, but Vilhelmsen (2000a) observed them to be absent from many tenthredinoid taxa. Heraty et al. (1994) considered the absence of the metafurco-
mesospinal muscles to be an autapomorphy of the Apocrita; the presence of a mesospina in *Schlettererus* (Stephanidae; Vilhelmsen, 2000a) makes this doubtful, even though it was not possible to decide whether the muscles are present in *Schlettererus* or not.

**Basal part of mid leg**

104. Mesothoracic trochantins (Vilhelmsen unpubl.): present, connected to both mesopleura and anterior margins of mesocoxae = 0; present, free apodemes neither connected to mesopleura nor mesocoxae = 1; absent = 2 (unordered). State 1, which resembles the groundplan state of the Hymenoptera for the metathoracic trochantins (Vilhelmsen, 2000a; present paper, character 148), was observed only in *Cephus* (Fig. 3) and *Hartigia* among the Hymenoptera included here, all other taxa having the mesothoracic trochantins entirely absent.

105. Mera of the mesocoxae (Kristensen, 1991): mesocoxae with distinctly demarcated mera dorsally = 0; mera not delimited on mesocoxae = 1.

106. Mesocoxae (Johnson, 1988): not subdivided= 0; subdivided by distinct transverse grooves = 1.

107. Medial articulations of mesocoxae (Johnson, 1988): situated proximally = 0; displaced distally along the medial surfaces of the mesocoxae = 1. Ronquist et al. (1999) scored Stephanidae as having state 1. In *Schlettererus*, the medial articulations are indeed some distance from the proximal margins of the mesocoxae, but not as much as in *Megalyra, Aulacus*, and *Orthogonalys*. *Oriussus* has a condition resembling that of *Schlettererus*. Johnson (1988) considered the length of the articulating mesal lobes on the mesopleura to be the best indication of the state of this character. However, this feature varies considerably among all the taxa included in the present analysis, regardless of the position of the articulation points on the mesocoxae. We decided to score only *Megalyra, Aulacus*, and *Orthogonalys* as having state 1, though the distinction between the states is somewhat arbitrary. The displacement of the medial articulation points of the mesocoxae distally is correlated with the presence of transverse grooves on the mesocoxa (character 106), allowing the proximal parts of the coxae to be retracted into the mesothorax during the movement of the legs (Johnson, 1988). The reduction of the proximal parts of the mesocoxae observed in many Apocrita (Johnson, 1988), but only in *Iballia* among the taxa included here, might have resulted in the medial articulation points becoming secondarily situated close to the proximal margins of the mesocoxae. Gibson (1999) proposed a transformation series where the elongated mesal lobes observed in the Evaniomorpha (Megalyroidea, Trigonalyoidea, Ceraphronoidea, and Evanoidae) represent a plesiomorphic, transitory stage relative to the condition in the Apocrita with reduced proximal mesocoxae, which supposedly have the mesal lobes inflected, forming a plate between the mesocoxal foramina.

108. Mesonoto-mesocoxal muscles (Johnson, 1988): present = 0; absent = 1.

109. Mesobasalar-mesocoxal muscles (Johnson, 1988): present = 0; absent = 1.

110. Mesofurco-mesocoxal muscles (Johnson, 1988): arise posteriorly of the paracoxal ridges from the base of the mesofurca = 0; arise anteriorly of the paracoxal ridges from the discriminatal lamella of the mesothorax = 1.

111. Basal rings of femora (Konigsmann, 1976, fig. 4: 19): femora not subdivided = 0; femora subdivided, with small proximal parts, the basal rings, set off from the rest = 1.

**Metanotum**

112. Insertion point of mesoscutello-metanotal muscles (Vilhelmsen, 2000a: 1): not on any conspicuous structure on the anterior margin of the metanotum = 0; flanked by small projections from the anterior margin of the metanotum, projections not continuous ventrally = 1; on distinct projections from the anterior margin of the metanotum, forming
entire ring of sclerotized cuticle around the insertion point = 2 (ordered). A separate state for *Xiphydria* (3: dorsally on 2nd phragma) was recognized by Vilhelmsen (2000a). However, this is autapomorphic for *Xiphydria*, which has been scored inapplicable in the present analysis. Furthermore, the character is treated as ordered here.

113. Connection between 2nd phragma and anterior margin of metanotum (Vilhelmsen, 2000a: 2): totally fused or at most connected by narrow strip of unsclerotized cuticle = 0; separated by membranous area of considerable length = 1.

114. Lateral metanotal processes (Vilhelmsen, 2000a: 3): blunt or inconspicuous = 0; slender, projecting ventrally and/or medially = 1.


116. Cenchri (Vilhelmsen, 2000a: 5 in part): absent = 0; present = 1. Vilhelmsen (2000a) combined this and the following characters (117, 118) into one character, but it was decided to split it up for the present analysis to enhance the information content. Vilhelmsen (1997a: 69) considered the cenchri to be homologous with certain wing attachment features in Neuroptera and primitive Lepidoptera. However, the condition in the ‘symphytan’ superfamilies possessing cenchri is clearly different from that in any of the outgroup taxa, all of which have been assigned state 0.

117. Shape of cenchri (Vilhelmsen, 2000a: 5 in part): about as broad as long (more or less round) = 0; about twice as broad as long (oval) = 1; about three times as broad as long or more (very narrow) = 2. Ordered. We here follow the character state definition in Schulmeister (2003a).

118. Posterior part of cenchri (Vilhelmsen, 2000a: 5 in part) membranous and inflected, devoid of hooks = 0; not inflected, hooks present on the entire surface = 1.

119. 2nd phragmo-3rd phragmal muscles (Whitfield, Johnson & Hamerski, 1989; Vilhelmsen, 2000a: 6): present, undivided = 0; present, subdivided, lateral parts arise from the metalaterophragmal lobes = 1; absent = 2 (unordered).

120. Metanoto-metalaterophragmal muscles (Vilhelmsen, 2000a: 7): present = 0; absent = 1.

121. Lateral metanoto-metapleural muscles (Mickoleit, 1966, 1969): attached to the lateral margins of the metascutum= 0; at least part of the muscles attached to the 1st axillaries = 1.

122. Apodemes for the lateral metanoto-metapleural muscles (Vilhelmsen, 2000a: 8): absent or small = 0; large = 1.

123. Hindwing tegulae (Vilhelmsen, 2000a: 9): present = 0; absent = 1.

124. Metanoto-metabasalar muscles (Vilhelmsen, 2000a: 10): present = 0; absent = 1.

**Metasternum and 3rd phragma**

125. 3rd phragma (Vilhelmsen, 2000a: 11): present = 0; absent = 1.

126. Metalaterophragmal lobes (Vilhelmsen, 2000a: 12): well developed = 0; weakly developed or absent = 1.

127. Metalaterophragmo-metafurcal muscles (Vilhelmsen, 2000a: 13): present = 0; absent = 1.

1st abdominal tergum (T1)

129. T1 (Whitfield et al., 1989; Vilhelmsen, 2000a: 15): divided medially = 0; continuous medially = 1. In Megalyra, T1 is subdivided longitudinally by a sulcus corresponding to an internal ridge. However, since the two halves of T1 are not separated by a membranous area, this taxon was scored as state 1, as in other Apocrita. Whitfield et al. (1989) considered the fusion of the metapostnotum with T1 to be a synapomorphy for the Orussidae and the Apocrita. However, in many other ‘Symphyta’ apart from the Orussidae, the metapostnotum is very closely associated or partly fused with T1; according to Konigsmann (1976), this is a hymenopteran autapomorphy.

130. Relation between metacoxal foramina and petiolar foramen (Ronquist et al., 1999: character 57): 0 = continuous; 1 = separate. We coded this character following Schulmeister (2003a)

131. T1-S2/metapleural muscles (Vilhelmsen, 2000a: 16): present = 0; absent = 1.

Metapleura

132. Apodemal parts of the metabasalares (Vilhelmsen, 2000a): broadly contiguous with the dorsal parts of the metepisterna = 0; cup-shaped apodemes invaginated from the membranous areas anteriorly of the metepisterna = 1; reduced or absent = 2 (unordered).

133. Metapleural arms (Vilhelmsen, 2000a: 19): not covered laterally by metepimera = 0; covered laterally by posterodorsal parts of metepimera = 1.

134. Association between metapleural arms and T1 (Vilhelmsen, 2000a: 20): not abutting T1= 1; abutting T1= 1; fused with T1= 2 (ordered).


136. (Anapleural clefts in the metathorax (Vilhelmsen, 2000a: 22): present = 0; absent = 1. This character was deleted from the analysis.)

137. Metasubalares (Vilhelmsen, 2000a: 24): present, receiving metapleuro-metasubalar and metasubalar muscles = 0; absent, muscles insert on membrane = 1.

138. Metepimera (Vilhelmsen, 2000a: 25 in part): well developed throughout = 0; posterior parts of metepimera reduced = 1. This and the following character (139) have been rescoring relative to Vilhelmsen (2000a: 25), who mixed up the size of the metepimera and their association with T1 in the same character.

139. Association between T1 and metepimera (Vilhelmsen, 2000a: 25 in part, 26): entirely separate = 0; articulating posteriorly = 1; closely abutting along their entire length = 2; totally fused=-- 3; fused anteriorly = 4 (unordered).

140. Articular inflections on the metepimera (Vilhelmsen, 2000a: 27): present = 0; absent = 1. Coded as inapplicable for taxa with 139:3 or 139:4 (Schulmeister 2003a).

141. Metapleural-S2 muscles (Vilhelmsen, 2000a: 28): present = 0; absent = 1.

142. Metapleural apodemes (Vilhelmsen, 2000a: 29): at most shallow ridges present, the anterior metapleuro-metafurcal muscles arising above the metapleural ridges = 0; distinct apodemes present, from which muscles arise = 1.

143. Apodemes/tendons receiving the insertions of the posterior metapleuro-metafurcal muscles (Vilhelmsen, 2000a: 30): present = 0; absent = 1.

144. Metepisternal depressions (Vilhelmsen, 2000a: 31): at most shallow, weakly demarcated concavities present = 0; well-developed depressions accommodating the mesocoxae present, separated medially by the raised metathoracic discrimen, delimited laterally by distinct carinae = 1.

146. Metathoracic paracoxal sulci and ridges (Vilhelmsen, 2000a: 33): straight or curving slightly anteriorly, if curving posteriorly then only for a short distance at the extreme lateral ends = 0; curved posteriorly = 1; strongly curved posteriorly, extending subparallel to metathoracic discrimen = 2 (ordered).

147. Termination points of metathoracic paracoxal sulci (Vilhelmsen, 2000a: 34): in the posterior margins of the metepisterna = 0; in or close to the metapleural sulci at the anterior margins of the metepisterna = 1; in the metepisterna some distance from both the anterior and posterior margins = 2 (unordered).

Extrinsic hind leg musculature

148. Metathoracic trochantins (Vilhelmsen, 2000a: 35): present, connected to the metapleura and anterior margins of metacoxae = 0; present, invaginated apodemes not connected to the metapleura and metacoxae = 1; trochantins and attached muscles absent = 2.

149. Anterior metanoto-metacoxal muscles (Vilhelmsen, 2000a: 36): present = 0; absent = 1.

150. Posterior metanoto-metacoxal muscles (Vilhelmsen, 2000a: 37): present = 0; absent = 1.

151. Metanoto-trochanteral muscles (Vilhelmsen, 2000a: 38): present = 0; absent = 1.

152. Metabasalar-metacoxal muscles (Vilhelmsen, 2000a: 39): present = 0; absent = 1.

153. Metabasalar-metatrochanteral muscles (Vilhelmsen, 2000a): present = 0; absent = 1.

154. S2-metacoxal muscles (Vilhelmsen, 2000a): absent = 0; present = 1.

Metafurca

155. Metafurca (Vilhelmsen, 2000a): metafurcal arms arise posteriorly on the discriminatal lamella of the metathorax = 0; metafurcal arms arise anteriorly = 1.

156. Anterior metafurcal arms (Ronquist et al., 1999: 53 in part; Vilhelmsen, 2000a: 40): elongate, at most only slightly shorter than the lateral metafurcal arms = 0; considerably shorter than the lateral metafurcal arms = 1.

157. Lateral metafurcal arms (Vilhelmsen, 2000a: 41): short = 0; elongate, extend towards the metapleural apodemes = 1, fused with the metapleural apodemes = 2 (ordered).

Hind legs

158. Metatibial preapical spurs (Vilhelmsen, 1997a: 72; Ronquist et al., 1999: 67): present = 0; absent = 1. Ronquist et al. (1999) were followed when coding this character rather than Vilhelmsen (1997a), who recognized more states based on the number of preapical spurs. However, this made this character too variable to be of use in the present analysis.

Wings


The wing venation of Panorpa was interpreted according to and scored after Hasken (1939). Homologization of wing veins, both between Hymenoptera and outgroup taxa, and between Symphyta and Apocrita, is often difficult. Consequently, some taxa have been scored as unknown when the interpretation of the wing venation is problematic.
Forewing venation

159. Subcostae of forewings (Ronquist et al., 1999: 74): distinct, separate longitudinal veins = 0; running adjacent to R, but not entirely fused with it = 1; fused with R, at most short transverse anterior branches present = 2. The scoring of Xyela differs from that of Ronquist et al. (1999) for Xyelinae in that a separate longitudinal subcosta is considered to be absent. This character was treated as ordered again, after Schulmeister (2003a) treated it as unordered because the ordering was not the most parsimonious solution on her topology resulting from a completely unordered analysis.

160. Anterior branches of subcostae of forewings (Ronquist et al., 1999: 75): present, at least as cross veins in costal cells = 0; absent = 1.

161. Cell 1M of forewing (Schulmeister 2003a): angular anteriorly = 0; round anteriorly = 1. This character is a replacement for ―first abscissa of forewing Rs, absent or present‖, which Schulmeister (2003a) found impossible to score.

162. Shape of 1st abcissae of forewing Rs (Ronquist et al., 1999: 78): anterior ends more proximal than posterior = 0; posterior ends more proximal than anterior = 1. This character was scored as inapplicable when the 1st abcissae of Rs are absent.

163. Abcissae of forewing Rs (Ronquist et al., 1999: 80): present between cells 1R and Rs at least partly as tubular veins = 0; absent as tubular veins between cells 1R and Rs = 1. Short remains of the Rs abcissae are present in Monoctenus and Gilpinia (Diprionidae), but they do not reach M, so these taxa were assigned state 1. Contrary to Ronquist et al. (1999), these veins are considered to be absent from Orussus.

164. Rs of forewings apically (Ronquist et al., 1999: 81): furcate = 0; not furcate = 1.

165. Cross veins 1r of forewings (Ronquist et al., 1999: 82): shorter than or at most slightly longer than 2r = 0; significantly longer than 2r = 1; incomplete or absent = 2 (unordered). This character was scored as inapplicable when the veins 2r are absent. Ronquist et al. (1999) ordered this character, but this seems to me to be unjustified.

166. Cross veins 2r of forewings (Ronquist et al., 1999: 83): present = 0; absent = 1.

167. Position of cross veins 2r of forewings (Ronquist et al., 1999: 84): connected to Rs proximally or opposite to cross veins 2r-m = 0; connected to Rs distally of cross veins 2r-m = 1. This character is scored as inapplicable when the veins 2r and/or 2r-m are absent. Ronquist et al. (1999) included the position of the anterior ends of these veins relative to the pterostigmas in their description of the states for this character; however, since this does not enhance the information content of the character (all taxa having 2r arising from the middle of the pterostigma also have it connected to Rs proximally of 2rm, all taxa having 2r arising from the apex of the pterostigma also have it connected to Rs distally of 2r-m), this was not followed here. Furthermore, the anterior points of connection between 2r and the pterostigma was found to be too variable to allow taxa not having 2r-m to be coded on the basis of the anterior points of connection of 2r alone.

168. Cross veins 2r-m of forewings (Ronquist et al., 1999: 85): present = 0; absent = 1.

169. Cross veins 3r-m of forewings (Ronquist et al., 1999: 86): present = 0; absent = 1. Megalyra was scored as having these veins absent, contrary to Ronquist et al. (1999).

170. Cross veins 2m-cu of forewings (.Ronquist et al., 1999: 92): present= 0; reduced or absent= 1. Megalyra was scored as having these veins absent, contrary to Ronquist et al. (1999).

171. Posterior anal veins and cross veins la of forewings (Konigsmann, 1976; Ronquist et al., 1999: 94): present, reaching posterior wing margins = 0; present, not reaching posterior wing margins = 1; constricted in the middle (i.e. posterior anal vein fused to anterior anal vein in the middle), not reaching wing margin = 2; petiolate (i.e. posterior
anal vein absent proximally of 1a), not reaching wing margin; absent (i.e. posterior anal vein and 1a entirely absent). Ordered.

**Hamuli**

173. Distal hamuli (Basibuyuk & Quicke, 1997): present = 0; absent = 1.
174. Distal hamuli placement (Basibuyuk & Quicke, 1997: D): in zig-zag lines = 0; in straight lines = 1.
175. Number of distal hamuli (Basibuyuk & Quicke, 1997: F): more than four per wing = 0; four or less = 1.

**Hindwing venation**

177. Costae of hindwings (Ronquist et al., 1999: 99): present = 0; absent = 1. *Megalyra* was scored as having these veins absent, contrary to Ronquist et al. (1999).
178. Subcostae of hindwings (Ronquist et al., 1999: 101): present = 0; absent = 1.
179. Cross vein lr-m of hindwings (Ronquist et al., 1999: 102): present = 0; absent = 1. *Schlettereriatus* and *Megalyra* were scored as having these veins absent, contrary to Ronquist et al. (1999).
180. Cross vein 3r-m of hindwings (Ronquist et al., 1999: 104): present = 0; absent = 1.
181. Cross veins m-cu of hindwings (Ronquist et al., 1999: 108): present = 0; absent = 1. *Syntexis* was scored as having these veins absent. contrary to Ronquist et al. (1999).
183. 1st anal veins of hindwings (Ronquist et al., 1999: 110): present = 0; reduced or absent = 1. *Megalyra* was scored as having these veins absent. contrary to Ronquist et al. (1999).
184. Jugal lobes of hindwings (Ronquist et al., 1999: 97): distinct from vannal lobes = 0; not differentiated from vannal lobes = 1. In contrast to the apocritan taxa included here, many Aculeata have well developed jugal lobes (Ronquist et al., 1999).

**Metasoma**

**Pregenital abdomen**

185. Constriction between 1st and 2nd abdominal segments (Ronquist et al., 1999: 61): no distinct constriction = 0; constricted dorsoventrally = 1; constricted laterally as well as dorsoventrally = 2 (ordered). This character was treated as ordered again, after Schulmeister (2003a) treated it as unordered because the ordering was not the most parsimonious solution on her topology resulting from a completely unordered analysis.
186. 1st abdominal sternum (Vilhelmsen, 2000a): present = 0; absent = 1.
187. 2nd abdominal tergum (Konigsmann, 1977): undivided = 0; longitudinally subdivided by narrow membranous strip = 1. T2 is unsclerotized anteromedially in *Micropterix* (Kristensen, 1984b), but this condition is obviously not homologous with the condition observed in Pamphiliidae, where T2 is entirely subdivided by a narrow median unsclerotized strip. Therefore, *Micropterix* was assigned state 0.
188. Pleural region of abdominal segments (Vilhelmsen unpubl.): pleural regions of 2nd to 5th abdominal segments membranous = 0; pleural regions around the spiracles sclerotized, but at least partly separated from the tergum of the corresponding segment
by membranous lines (Fig. 5A) = 1; pleural regions sclerotized and entirely fused with the tergites, membranous lines absent (Fig. 5C) = 2 (Unordered). Kristensen (1991) suggested that it is autapomorphic for the Hymenoptera to have the abdominal spiracles surrounded by sclerotized cuticle. This was observed in all the hymenopteran taxa examined here. In *Xyela*, Blasticotomidae (Fig. 5B; but see character 189), Cimbicidae, Pamphiliidae (Fig. 5A), and *Xiphydria*, the pleural sclerites surrounding the spiracles are at least partly separated from the terga by unsclerotized lines (state 1). This state is probably the groundplan state of the Hymenoptera, since it seems reasonable to assume that it represents an intermediate step in a transformation series leading from having the spiracles lying in membranous cuticle (state 0) to having them surrounded by sclerotized cuticle which is continuous with the abdominal terga (state 2). The presence of a flattened and laterally keeled abdomen was suggested to be an autapomorphy of the Pamphiliidae by Konigsmann (1977) and Vilhelmsen (1997a). However, since the lateral keels are formed where the unsclerotized lines separating the lateral sclerites surrounding the spiracles from the abdominal terga are situated, it is obvious that the presence of lateral keels is strongly correlated with the presence of the unsclerotized lines. Therefore, the presence of a laterally keeled abdomen was not included as character in the present analysis. Vilhelmsen (2001) ordered this character 012. However, Schulmeister (2003a) demonstrated that the optimization 021 is more parsimonious in the results of her analysis; she then proceeded to order the character 021. While we accept that it is not justified, based on the morphology, to assume that the transitions series 012 is more likely to have occurred than 021, we would argue that this argues in favour of treating the character as unordered, which we did.

189. Position of abdominal spiracles 2-8 (Goulet 1993): in the pleural regions, whether these are sclerotized or unsclerotized (Fig. 5A) = 0; in the lateral parts of the terga, as indicated by unsclerotized lines between the terga and the pleural areas (Fig. 5B) = 1. This character has been scored as unknown when the pleural sclerites are fused with the terga (see previous character). The position of the abdominal spiracles in the lateral parts of the terga, dorsally of the unsclerotized lines separating them from the pleurites (Fig. 5B), is unique to the Blasticotomidae. According to Bitsch (1979), the positions of the abdominal spiracles in insects are morphologically in the pleural regions. In contrast, Snodgrass (1933) considered the spiracles to lie dorsally of the pleural regions, whether or not they are surrounded by sclerotizations. In the Blasticotomidae, the antecostae extend lateroventrally on the terga to the same level as the spiracles (Fig. 5B). This indicates that the spiracles have migrated dorsally of the unsclerotized lines separating the terga and pleurites. Alternatively, the unsclerotized lines in Blasticotomidae are not homologous with those that occur in other Hymenoptera, but represent independently evolved features ventrally of the spiracles. Either way, the condition in Blasticotomidae is autapomorphic for the family.

190. Female abdominal spiracles (Gibson, 1986: 18a in part): spiracles on abdominal segments 1-8 well developed = 0; spiracles on abdominal segments 2-7 reduced = 1. This and the next character are both included in again in this matrix after Schulmeister (2003a) excluded character 190 because of possible non-independence. However, this discards the information that in some taxa (Orussidae, Stephanidae) there is sex specific variation (females have 190:1, males have 191:2), which was exactly the reason for treating this feature in two separate characters, so we include character 190.

191. Abdominal spiracles, males (Gibson, 1986: 18a in part): spiracles on abdominal segments 1-8 well developed = 0; spiracles on abdominal segments 2-7 reduced = 1; spiracles on abdominal segments 2-8 reduced = 2 (ordered).

Ovipositor apparatus

192. Ovipositor apparatus (Kristensen, 1991): fully developed, 'lepismatoid ovipositor apparatus present = 0; partly reduced, 1st valvifer fused with T9, 1st valvulae fused, 2nd
valvulae not discrete structures = 1; highly reduced or absent, nonfunctional = 2 (ordered). The gradual reduction of the ovipositor apparatus within the Endopterygota has been incorporated into this character. The outgroup taxa being assigned state 1 and 2 for this character were scored inapplicable for many or all of the other ovipositor characters (193-215) in order not to place undue emphasis on loss in this character system.

193. Cordate apodemes (Vilhelmsen, 2000~: 1): apodemes situated on the anterior margin of T9 in the females absent = 0; present, fused at most for a short distance to the median walls of T9 = 1; present, fused to the median walls of T9 for a distance corresponding to at least half the length of the anterior flanges = 2 (ordered).

194. Lines of fusion of cordate apodemes (Vilhelmsen, 2000c: 2): not visible externally = 0; visible externally as distinct furrows = 1.

195. Basal articulations between the anteroventral margins of the 2nd valvifers and the proximal parts of the 2nd valvulae (Oeser, 1961): absent = 0; present = 1.

196. 1st valvifers (Vilhelmsen, 2000c: 3): posterior margin distinctly separate from T9 = 0; posterior margin closely appressed or partly fused with anterior margin of T9 = 1; 1st valvifers entirely fused with T1 = 2 (ordered). This character was treated as ordered again, after Schulmeister (2003a) treated it as unordered because the ordering was not the most parsimonious solution on her topology resulting from a completely unordered analysis.

197. Banding pattern (Vilhelmsen, 2000c: 4): neither 1st nor 2nd valvulae have alternating zones of differing degrees of sclerotization = 0; 1st and/or 2nd valvulae have alternating zones of differing degree of sclerotization = 1.

198. Lamnia of 1st valvulae (Ronquist et al., 1999 127 in part; Vilhelmsen, 2000c: 5): not reduced in size relative to radices, comprising the larger part of the 1st valvulae = 0; reduced in length and height distally, taper to narrow points = 1.

199. Sawteeth on 1st valvulae (Vilhelmsen 2000c: 6): absent = 0; present along the ventral margins = 1.

200. Distribution of sawteeth along 1st valvulae (Vilhelmsen, 2000c: 7): present along at least half of the length = 0; present for a short distance distally only = 1.

201. Serrulae (Vilhelmsen, 2000c: 8): absent = 0; present on the sawteeth of the 1st valvulae = 1.

202. Annuli of 1st valvulae (Vilhelmsen, 2000c: 9): without hairs = 0; with narrow fringes of hairs on their margins = 1.

203. Ctenidia on 1st valvulae (Vilhelmsen, 2000c: 10): absent = 0; present = 1.

204. 2nd valvifers and 3rd valvulae (Goulet, 1993; Vilhelmsen, 2000c: 11): at least partly separated by membranous areas = 0; totally fused = 1.

205. Dorsal flanges (Vilhelmsen, 2000c: 12): continuous with median bridge and sites of insertion of the posterior T9-2nd valvifer muscles = 0; separated from median bridge by weakly sclerotized strips, posterior T9-2nd valvifer muscles insert on apodemes continuous with 3rd valvulae = 1.

206. Distal ends of dorsal flanges (Vilhelmsen, 2000c: 13): do not project posteriorly of ventral margins of 2nd valvifers, membranous areas separating 2nd valvifers and 3rd valvulae more or less vertical = 0; distinctly produced posteriorly of ventral margins of 2nd valvifers, membranous areas separating 2nd valvifers and 3rd valvulae oblique = 1.

207. Median bridge (Vilhelmsen, 2000c: 14): distal ends of 2nd valvifers/proximal ends of 3rd valvulae fused medially or closely associated = 0; widely separated = 1.
209. Styli (Vilhelmsen, 2000c: 16): absent = 0; present distally on the 3rd valvulae = 1.
211. Ventral wall of 2nd valvulae (Quicke et al., 1994: E): evenly thickened = 0; more strongly thickened medially = 1.
212. Sawteeth on 2nd valvulae (Vilhelmsen, 2000c: 18): absent = 0; present on the dorsal margins = 1.

Male genitalia

The configuration of the male genitalia in Neuroptera is so different that it is difficult to homologize structures with anything outside the order (New, 1989), so Chrysopa has been scored as ‘unknown’ for male genitalia characters (216-220). Blasticotoma was scored after Shinohara (1983); Perga after Tait (1962); Ibia after Ronquist & Nordlander (1989); Vespula after Duncan (1939). Middlekauff (1964) illustrated and interpreted the peculiar male genitalia in Syntexis; his homologization of their constituent parts has been followed here.

216. Orientation of the male genitalia (Konigsmann, 1977: 22): not inverted at rest (orthandrous) = 0; rotated 180 degrees along the longitudinal axis when at rest (strophandrous) = 1. Ronquist et al. (1999: 133) discerned between orthandrous in the pupae and strophandrous both in the pupa and the adult (Tenthredinoidea s.s.); this has not been followed here because I did not have pupal material available for examination.

217. Basal ring in the male copulatory apparatus (Konigsmann, 1976, fig. 4: 20): absent = 0; present = 1.

218. Parameres (Konigsmann, 1977: 8): male parameres subdivided into gonostipes and harpes, with intrinsic musculature = 0; subdivided, without intrinsic musculature = 1; parameres undivided, musculature absent = 2; ordered.

219. Gonomaculæ (Konigsmann, 1977: 6): absent = 0; membranous discs with associated muscle situated on male parameres = 1. The gonomaculæ are considered to be absent from Syntexis, in accordance with Middlekauff (1964) rather than Ronquist et al. (1999). Vilhelmsen (1997a), mentioned the presence of possible homologues of the gonomaculæ in basal Mecoptera. They are absent from Panorpa and all other outgroup taxa included here, however.

220. Volsellæ (Konigsmann, 1976, 1977: 2): absent = 0; volsellæ with opposable digitus and cuspis present in the male copulatory apparatus = 1. The volsellæ in Syntexis are apparently not subdivided (Middlekauff, 1964), but clearly present nonetheless.

Larval morphology

Larval material was available only for few of the taxa included, so the scoring of larval characters relies heavily on information obtained from literature. Micropterix was scored after Hrenz (1961); Nematus, Monocotenus, Corynis, Sterictiphora, Neurotoma, Acantholyda, and Megalodontes after Lorenz & Kraus (1957); Perca after Tait (1962); Cephus, Hartigia, Xiphydria, and Orussus after Yuasa (1922); Syntexis after Middlekauff (1974); Schlettererius...
after Taylor (1967) and Evans (1987); *Ibalia* after Chrystal (1930; 4th instar). Several characters from the larval anatomy were included in the previous analyses of Vilhelmsen (1997a) and Ronquist et al. (1999), but were omitted here, because they were deemed to be insufficiently examined and/or poorly defined. These include the occurrence of an incisive molar flange on the mandible (Rasnitsyn, 1988), the degree of reduction of the metathoracic spiracle (Yuasa, 1922), the configuration of the subspiracular and the suprapedal lobes of the larvae (Rasnitsyn, 1988), the occurrence of longitudinal and oblique sulci on the sterna (Rasnitsyn, 1988), and a suite of characters concerning the salivary glands (Maxwell, 1955).

**Head**

221. Larval eyes (Yuasa, 1922): present = 0; absent = 1.

222. Cornea of larval eyes (Paulus, 1979): subdivided, one lens for each ommatidium = 0; only one common lens, covering all ommatidia, for each larval eye = 1.

223. Position of larval eyes (Ronquist et al., 1999: 150): situated dorsally of the bases of the antennae (Fig. 6B) = 0; situated ventrally of the bases of the antennae (Fig: 6A, C, D) = 1.

224. Number of larval antenna1 segments (Yuasa, 1922): seven = 0; six = 1; five = 2; four = 3; three = 4; two = 5; one = 6 (ordered). Vilhelmsen (1997a) chose not to order this character, in contrast to Ronquist et al. (1999: 152), who did not recognize as many states as in the present analysis.

225. Shape of larval antennae (Vilhelmsen unpubl.): erect, segments are well developed and situated concentrically = 0; flattened, except sometimes distal segment; segments are reduced and lie next to each other = 1.

226. Larval epicranial sulcus (Yuasa, 1922): fully developed = 0; reduced or absent = 1.

**Thorax**

227. Intrasegmental annulation (Ronquist et al., 1999: 148): thoracic and abdominal segments subdivided by superficial transverse grooves = 0; grooves on the body segments absent = 1.

228. Larval thoracic legs (Yuasa, 1922; Ronquist et al., 1999: 155): fully developed, segments of unequal size (Fig. 7A, B) = 0; reduced, segments of equal size (Fig. 7C) = 1; vestigial, unsegmented (Fig. 7D) = 2; absent = 3 (ordered).

229. Claws on larval thoracic legs (Kristensen, 1991 1: two claws present on each leg=0; one claw present (Fig. 7A, B) = 1; claws absent (Fig. 7C, D) = 2 (ordered).

**Abdomen**

230. Larval abdominal legs (Yuasa, 1922): present, well developed = 0; present as bulges = 1; completely absent = 2. In accordance with Smith (1967). I consider the larval abdominal legs in *Xyela* to be vestigial; Ronquist et al. (1999: 156) realized this, but still scored them as present in Xyelinae. [treated as ordered, after Schulmeister (2003a) treated it as unordered because the ordering was not the most parsimonious solution on her topology resulting from a completely unordered analysis]

231. Number of segments in larval abdominal legs (Ronquist et al., 1999: 157): one = 0; two = 1.

232. Larval supraspiracular glands (Königsmann, 1977): absent = 0; glands with openings situated dorsally of abdominal spiracles present = 1. Glands are present posteriorly of the abdominal spiracles in Sterictiphora (Lorenz & Kraus, 1957), but it is unlikely that they are homologous with the glands observed in Cimbicidae. Sterictiphora was scored as unknown for this character.

233. Larval supralanal hook: absent (Fig. 8A) = 0; hook-like cuticular structure present on supralanal lobe (Fig. 8B, C) = 1.
234. Larval suranal process (Yuasa, 1922): absent (Fig. 8A) = 0; present (Fig. 8E) = 1.

235. Larval subanal appendages (Yuasa, 1922): present (Fig. 8B, D, E) = 0; absent (Fig. 8A) = 1. In accordance with Smith (1967), I consider the larval subanal appendages in *Xyela* to be absent. Ronquist et al. (1999) also coded the position of the subanal appendages relative to the anal slit as a character. We consider the states of this character as delimited in Ronquist et al. (1999: 162, “removed from base of anal slit” vs. “situated at base of anal slit”) to be poorly defined and consequently have omitted the character from the present analysis.

236. Segmentation of subanal appendages (Ronquist et al., 1999: 161): unsegmented (Fig. 8D) = 0; segmented (Fig. 8B) = 1.

**Characters from Schulmeister (2003a): 237-266**

**Head**

237. Number of articles in female antenna (Ronquist et al., 1999: character 18): 0 = more than 15; 1 = 13–15; 2 = 12 or less. Ordered. The character state delineation was slightly changed compared to that of Ronquist et al. (1999) in order to optimize its usefulness for the taxon sample of this study.

238. Female antennae (Vilhelmsen et al., 2001): 0 = not modified; 1 = modified into ‘hammers’.

239. Maxillary palp: 0 = thin, not leg-like; 1 = thick, leg-like, with a setae-bearing distal part.

240. Number of maxillary palp segments: 0 = one to five; 1 = six. In *Xyela*, the fourth segment is further subdivided into about four subsegments. This is counted here as one segment. It seems that the reduction of the number of labial palp segments and the number of maxillary palp segments are dependent to some extent: they are often reduced in the same taxa (Table 1). It makes sense to assume that there is an adaptational pressure to shorten the palps which acts on both pairs of palps because they work in concert. However, in some taxa only one of the two is reduced, and the two characters in some cases are potential synapomorphies for different taxa. That the two pairs of palps do not always react simultaneously lies in the nature of evolution. Apparently, they are not completely dependent. Therefore I decided to code them as two separate but semi-independent characters. Because the number of both maxillary and labial palps is reduced in *Perga*, *Phylacteophaga* and *Decameria*, we decided to code the present character as inapplicable for these taxa, in order to prevent giving double weight to these reductions.

**Thorax and wings**

241. Forewing tegulae: 0 = absent; 1 = present, but small (and hidden under the pronotum in Hymenoptera); 2 = present, well-developed. (Unordered). In *Syntaxis*, the forewing tegulae are somewhat reduced in size and the front part is hidden under the pronotum, but the difference to the condition found in some Xiphydriidae is not significant. *Syntaxis* was hence coded as having state 2. In Siricidae, the small remnants of the tegulae are completely hidden under the pronotum, so that they cannot be seen without lifting the pronotum.

242. Radial cell of forewing: 0 = closed distally (Fig. 2A–E); 1 = open distally (Fig. 2F).

243. Tip (and ‘appendix’) of radial cell of forewing: 0 = on the wing margin (Fig. 2A,C–E); 1 = away from the wing margin (Fig. 2B,F).
244. Structure of forewing tip (Benson, 1945a): 0 = smooth or coriaceous; 1 = corrugated (wrinkled). Illustrated in Benson (1945a: figs 9,10). This character was included in the analysis particularly to provide information for the internal phylogeny of Pamphiliidae.

245. Crossvein in anal cell of forewing: 0 = oblique (Fig. 2A,C,D,F); 1 = at right angles to anal veins (Fig. 2E); 2 = absent even though anal cell is complete; — = not applicable because anal cell is incomplete (Fig. 2B). Unordered. This character has been used in various keys for the determination of Tenthredinidae.

246. Vein Sc +R of the hindwing: 0 = present, at a distance from C (Fig. 5A–D,F); 1 = present, running along the anterior wing margin, adjacent to C which is partly ‘dissolved’ (Fig. 5E); 2 = present, the basal half running along the wing margin, the distal half at some distance from the wing margin. Unordered.

247. Veins Cu and M of hindwing at the base of the wing (Sharkey & Roy, 2002: character 34): 0 = separate (Fig. 5A); 1 = completely fused (Fig. 5B–F). In eight out of nine hindwings of Xylelecia there were only traces left of the basal part of Cu, but it is clear that it was there. One of the nine hindwings had a clear basal part of Cu separate from M (H. Goulet, pers. comm.).

248. Crossvein 2r-m (= 2rs-m) in hindwing (Sharkey & Roy, 2002: character 35): 0 = present (Fig. 5A); 1 = absent (Fig. 5B–F).

249. Second anal vein of hindwing (Sharkey & Roy, 2002: character 36): 0 = present and complete (Fig. 5A,C–E); 1 = partly reduced or completely absent (Fig. 5B,F). There is some, but not complete, correlation of the absence of the second anal vein in the forewing and in the hindwing. The absence of the second anal vein in the forewing is often listed as a characteristic of Pergidae; however, the vein does occur in some Pergidae. We specifically included a pergid (Decameria) in this study that has at least part of the second anal vein of the forewing (state 3 of the revised version of character 171). Contrary to the second anal vein in the forewing, the second anal vein of the hindwing is absent from all Pergidae. Outside of Tenthredinoidea s.l., the second anal vein of the forewing is missing completely only from Apocrita, whereas the second anal vein of the hindwing is missing from Xeris, Tremex, Urocerus and Vespina.

250. Length of anal cell of hindwing: 0 = as long as cell 1Cu posteriorly, i.e. second anal vein joins first anal vein (almost) at the same point as cu-a (Fig. 5A,C,E); 1 = shorter than cell 1Cu, i.e. second anal vein joins first anal vein further proximal than cu-a and first anal vein extends beyond cu-a (Fig. 5D,F).

251. Mesopseudosternal sulci (Ronquist et al., 1999: character 48): 0 = present, delimiting a pseudosternal area of the mesopectus; 1 = absent. Vilhelmsen (2001) distinguished between the presence and absence of internal ridges on the mesopseudosternum. The absence of internal ridges – with or without external sulci – was found by Vilhelmsen (2001) in Tenthredinidae, Diprionidae, Cimbicidae, Blastocottidae and Phylacteophaga, resulting in this character showing no unambiguous changes in the analysis of Vilhelmsen (2001), Rasnitsyn (1988) and Ronquist et al. (1999), on the other hand, distinguished between external pseudosternal sulci present – with or without internal ridges – or absent. In their analysis, the absence of the sulci is a synapomorphy of Tenthredinidae (including Diprionidae) and Cimbicidae. In order to better test Rasnitsyn's hypothesis of a monophyletic Tenthredinidae+Diprionidae+Cimbicidae, we added Ronquist et al.'s character 48 to the present data matrix (see also comment under character 96).

Legs

252. Fore basitarsus of the female (Vilhelmsen et al., 2001): 0 = not drawn out; 1 = distally drawn out into a kind of ‘spur’. This is a synapomorphy of Orussus.
253. Female foretibia (Vilhelmsen et al., 2001): 0 = not divided; 1 = subdivided. This is a synapomorphy of Orussus.

254. Mesotibial apical spurs: 0 = two, 1 = one, 2 = none. Unordered. State 0 is found in all sawflies except for the examined Siricidae, all of which have state 1. This character hence provides a potential synapomorphy for Siricidae. State 1 was also found in Megalyra in this study and state 2 was found in Schlettererius cinctipes and Stephanus serrator. Outside of the taxon sample used for this study, we found state 1 in one examined specimen of Torymidae (Chalcidoidea) and some species of Apoidea and Vespoida and state 2 in one examined specimen of Chalcididae (Chalcidoidea). Brothers (1975: 523–524) mentions a number of aculeates that have state 1 and that state 2 is present in Bradynobaenidae and some Formicidae. According to Carpenter (1982: 20), the character shows considerable homoplasy within Vespoida. State 2 could hence be a synapomorphy of Stephanidae.

255. Metatibial apical spurs: 0 = two spurs; 1 = one spur; 2 = no spurs. Unordered. State 0 occurs in all taxa included in this study except for Xeris and Tremex. We included this character in the analysis to provide information for the internal phylogeny of Siricidae. Outside of the taxon sample used for the analysis, SS observed state 1 in Formicidae. According to Brothers (1975: 525), state 1 and 2 occur in some aculeates.

256. Plantulae (Schulmeister, 2003a): 0 = no plantulae; 1 = integrated; 2 = distal. Unordered. In Schulmeister (2003a: appendix 2), this character was coded in five states to maximize morphological information. However, as suggested by Schulmeister (2003a), it was coded in only three states for the cladistic analysis in the hope of obtaining unambiguously optimized changes.

257. Denticles on plantulae (Schulmeister, 2003a): 0 = no denticles on plantulae; 1 = denticles present somewhere on plantulae. The coding of this character differs from that in Schulmeister (2003a) in order to test the potential synapomorphy of state 1 for Tenthredinidae+Cimbicidae+Diprionidae.

258. Patch of bristle-shaped denticles on the ventral face of some or all plantulae (Schulmeister, 2003a): 0 = absent; 1 = present. Coding this character in more states would make it too variable to be of use in this analysis.

259. Secretion pores on plantulae (Schulmeister, 2003a): 0 = absent; 1 = present; –– = not applicable due to lack of plantulae.

Abdomen

260. Structure of anterolateral apophyses of abdominal sternum three (Ronquist et al., 1999: character 118): 0 = laterobasal corners of sternum slightly or not at all modified as apophyses; 1 = sternum with distinct horn-like or finger-like basal extensions directed forward or upward. The change in the coding of this character was adopted from a study by Basibuyuk et al. (2000). This and the next character were included to provide more information within Apocrita.

261. Structure of posterior margin of second abdominal sternum (Ronquist et al., 1999: character 116; Brothers & Carpenter, 1993): 0 = distinctly overlapping anterior margin of third abdominal sternum; 1 = weakly or not overlapping third abdominal sternum.

262. Anterior margin of abdominal sternites: 0 = straight or smoothly curved or forming a slight angle; 1 = with median incision/angular notch. Character 117 of Ronquist et al. (1999) is similar to this character (anterior margin of third abdominal sternum angularly notched), but they incorrectly code Cepheidae as having no notch. They observed this notch only in Dryinidae and Sclerogibbidae; maybe in these taxa the notch is really present only in the third sternite and is correlated with the petiolum. If this is the case, this could be coded as a third character state in a study that includes these taxa. The
presence of a notch in the anterior margin of most abdominal sternites in Cephidae is probably correlated with the lateral compression of the abdomen in this group.

263. Tergite nine of the female: 0 = not elongated; 1 = distal part distinguished from basal part of the tergite, distal part elongated into a tip that extends beyond the cerci; 2 = as previous state, but the tip is further drawn out into a long, pointed, strongly sclerotized structure: the cornus. Ordered.

264. Ovipositor (Vilhelmsen et al., 2001; L. Vilhelmsen pers. comm.): 0 = external; 1 = concealed (posterior part of the seventh sternite modified for gripping the ovipositor, median margins of the ninth tergite abut medially, hiding the third valvulae). This is a synapomorphy of Orussus.

**Larvae**

265. Labrum of the larva (Schedl, 1991): 0 = symmetrical; 1 = asymmetrical. According to SS’s own observations the larvae of *Cephus* and *Hartigia* have a symmetrical labrum. She did not find any explicit information for *Calameuta*. Larvae of *Xeris* and *Sirex* were observed to have an asymmetrical labrum (M. Jänicke, pers. comm.). The xyelid taxa were coded after Smith (1967), *Syntexis* after Middlekauff (1974). *Orussus* was coded after the figure of *O. occidentalis* by Rohwer & Cushman (1917). The other species were coded after Lorenz & Kraus (1957) and Yuasa (1922).

266. Larval abdominal legs (Lorenz & Kraus, 1957): 0 = present on abdominal segments 1–10; 1 = present on 2–8 and 10 (or only 2–8 (Caliroa and Fenusa); 2 = present on 2–7 and 10; 3 = present on 2–6 and 10. Ordered. All taxa were coded after Lorenz & Kraus (1957). Vilhelmsen (2001: character 231) coded the segmentation of the larval abdominal legs but not their distribution on the abdomen. However, this character constitutes potential synapomorphies not only for Nematinae, but also for Argidae+Pergidae.

**Characters from Schulmeister (2003b): Male terminalia, 267-353**

The characters of the terminal segments of the male abdomen, characters 267–353, were taken from Schulmeister (2003b). A few changes were introduced to the matrix of the characters of the terminal segments of the male abdomen for the purpose of the cladistics analysis, as proposed by Schulmeister (2003a). Figure references point to figures in Schulmeister (2003b).

**Muscles**

267. Muscles a and b: 0 = a absent, b muscles close together, i.e. there are no muscle fibers coming from the spiculum that insert directly on the gonocondyle, but the b muscles are inserting very close to the gonocondyle; 1 = a absent, b muscles widely separated, i.e. there are no muscle fibers coming from the spiculum that insert on or near the gonocondyle; 2 = a and b present. Unordered. The unpaired muscle a and the two muscles b often are not separable and have therefore been treated as one character.

268. Form of muscle a: 0 = straight, inserting only on spiculum; 1 = fan-shaped, inserting on speculum and to the left and right of the spiculum on the basal margin of the ninth sternite; = not applicable because a is absent.

269. Muscle c: 0 = present, inserting near the margin of the ninth sternite; 1 = present, inserting away from the margin of the ninth sternite; 2 = absent. Unordered.

270. Muscle running from the left to the right edge of the ninth sternite, across the external genitalia: 0 = absent; 1 = present.

271. Muscle d: 0 = present, inserting on or near gonocondyle; 1 = present, not near gonocondyle; 2 = absent. Unordered. This and the next character were coded as
inapplicable in those taxa in which the cupula is completely absent or fused with the
gonostipes ventrally, because the absence of muscles d and e is in these cases
dependent on the absence or fusion of the cupula.

272. Muscle e: 0 = present; 1 = absent. See previous character.

273. Muscle f: 0 = present; 1 = absent. This and the next character were coded as
inapplicable in those taxa in which the cupula is absent, because the absence of muscles
f and g is in these cases dependent on the absence of the cupula.

274. Muscle g: 0 = present; 1 = absent. See previous character.

275. Muscle h: 0 = present, straight, inserting on apex gonostipitis (Fig. 6D, E); 1 = present,
fanned out; 2 = present, but inserting on the gonostipital arm instead of the apex
gonostipitis. Unordered.

276. Muscle i: 0 = present (Fig. 6D, E); 1 = absent.

277. Muscle j: 0 = present. There is only one state for this character because muscle j was
found in all ex amined hymenopteran species, with little morphological variation other
than in size. The character is nonetheless included here to document which taxa this
muscle was found in.

278. Muscle k: 0 = present, inserting on the valvura, the ergot, or at the base of the
valviceps (Fig. 6E); 1 = present, inserting within the valviceps (in-between medial and
lateral side of one valviceps) (Fig. 6D); 2 = present, long, directed distally, inserting within
the valviceps; 3 = absent. Unordered.

279. Muscle l: 0 = present; 1 = absent.

280. Muscle m: 0 = present; 1 = absent.

281. Muscle n: 0 = only nl; 1 = completely absent; 2 = nb, nd, and nl present; 3 = nb and nd
present (Fig. 6D); 4 = nb and nl present. Unordered.

282. Muscles connecting the two volsellae: 0 = absent; 1 = present, between the two
digiurae; 2 = present, between the two basivolsellae (muscle y) (Fig. 3E). Unordered. The
frayed-out muscle connecting the left and right digiurae (state 1) in Arge was assumed to
be muscle nd; nd was hence coded as present for Arge in the previous character. The
frayedout muscle connecting the left and right basal ends of the basivolsella in some
pergids (Fig. 3E) was assumed to be new and not identical to muscle nl.

283. Muscle o: 0 = one muscle present, narrow or broad; 1 = two separate muscles present;
2 = muscle entirely absent. Unordered. Muscle o is usually one narrow muscle extending
from the basal end of the basivolsella to the distal end of the gonostipes. In some taxa,
however, its insertion on the basivolsella is clearly extending, sometimes covering the
lateral side of the entire basivolsella. In other taxa, muscle o can be split into a distal and
a basal part, as depicted in Schulmeister (2001: Figs. 8D, 9C).

284. Muscle p: 0 = present; 1 = absent.

285. Muscle qr: 0 = present; 1 = absent.

286. Muscles s and si: 0 = only si present (or si inserts between ergot and digiura); 1 = only
s present; 2 = both si and s present; 3 = both absent. Unordered.

287. Harpe and muscle t (which connects the harpe to the gonostipes) (Vilhelmsen 1997a:
83, 2001: 218): 0 = harpe present, t present (as one or two muscles); 1 = harpe fused to
gonostipes or absent, muscle t absent (Figs. 8B, 10C, 11); 2 = harpe present, but without
any muscles connecting it to the gonostipes. Unordered. Vilhelmsen (1997b, 2001)
recognized only the first two states. However, we found Gilpinia and Orthogonalys to lack
muscles t even though they do have harpes. Presence of the harpe and presence of
muscle t are here coded together because if the harpe is lost, muscle t must also be lost.
This means that muscle t and the harpe do not form independent characters, and that coding them separately would assign too much weight to their concerted loss.

288. Parts of muscle u: 0 = two parts which start next to each other basally, but are separate distally (Fig. 9E); 1 = two completely separate parts (Fig. 7C); 2 = one part (Schulmeister 2001: Fig. 8F); – = not applicable if muscle u is absent. Ordered.

289. Distal insertion point of muscle u: 0 = on medial face of harpe (Figs. 7C, 9E); 1 = on lateral face of harpe; – = not applicable.

290. Muscle v and gonomacula (Ronquist et al. 1999: 137; Vilhelmsen 1997a: 85, 2001: 219): 0 = both present and fully developed (e.g. Figs. 1F; 7C; 9A, E); 1 = gonomacula vestigial or absent, v absent. The two examined specimens of Runaria reducta were found to have tiny membranous areas at the tips of their harpes, which were interpreted as remnants of gonomaculae. Coded as inapplicable in those taxa lacking a (separate) harpe, in order to avoid placing double weight on the reduction of the harpe.

291. Muscle w: 0 = absent; 1 = present.

292. Muscle x: 0 = absent; 1 = present.

293. Muscle z: 0 = absent; 1 = present.

General genital characters

294. Orientation of the male genitalia (Königsmann 1977: 22; Ronquist et al. 1999: 133; Vilhelmsen 1997a: 86, 2001: 216): 0 = not inverted at rest (orthandrous); 1 = rotated 180 degrees around the longitudinal axis when at rest (strophandrous). Contrary to Ronquist et al. (1999) and in agreement with Vilhelmsen (1997b, 2001), I coded strophandry as one state in Xyelidae and Tenthredinoidea s.str., in order to provide a stronger test for (non-)homology of this state in the two taxa.

295. Left and right parts of the genitalia: 0 = cannot be folded towards each other; 1 = can be folded towards each other to hide the volsellae (see Functional morphology above, and Fig. 12).

296. Position of foramen genitale: 0 = dorsal (Fig. 5B); 1 = basal (Fig. 1A, B); 2 = ventral (Fig. 11C). Ordered.

297. Apex gonostipitis: 0 = proximal of parapenis; 1 = distal of basal margin of parapenis (Fig. 11C, D).

298. Ectophallic membrane: 0 = without pockets; 1 = forms two flat pockets on ventral side of genitalia (Fig. 4A).

Cupula

299. Cupula (Vilhelmsen 2001: 217): 0 = cupula present and circular; 1 = cupula present, but completely reduced dorsally (Figs. 3B, 7E); 2 = cupula absent (Fig. 3C, D). Ordered. Vilhelmsen (2001) distinguished only the two states “absent” and “present” and assigned the latter state to all hymenopterans. However, many hymenopterans have the cupula partly or completely reduced. Therefore, an intermediate had to be introduced.

300. Fusion of cupula (Ronquist et al. 1999: 135): 0 = free; 1 = very closely connected to or fused with the gonostipites ventro-medially (Fig. 3A); 2 = fused with the gonostipites ventro-laterally (Fig. 5C); – = not applicable. Unordered.

301. Distally directed branch on lateral side of cupula: 0 = absent; 1 = present (Fig. 3B); – = not applicable.

302. Gonocondyle: 0 = basally directed (Fig. 1C); 1 = distally directed loop (Fig. 11C).
**Gonostipes and harpe**

303. Apices gonostipitum respectively gonostiptal arms: 0 = pointing mediadly (Fig. 4D); 1 = pointing cranially (Fig. 9A, C).

304. Parapenis: 0 = antero-medial corner drawn out (Fig. 7B, E); 1 = not set off from the rest of the gonostipes (Figs. 1B, 3B); 2 = set off, but without constriction (Fig. 5B); 3 = with constriction, i.e. parapenisjugum narrowed (Figs. 4B, 6B). Ordered. The difference between states 0 and 2, which appear similar in Figs. 7B and 5B, is that in state 2 the entire parapenes, i.e. the entire insertion sites of muscles j, are slightly set off from the rest of the gonostipes and meet mediadly, whereas in state 0 only the antero-medial corners of the parapenes, containing maximally the insertion sites of muscles k, are drawn out to meet mediadly.

305. Basal margin of parapenis: 0 = more or less straight from left to right (Fig. 5B); 1 = drawn out basally (Fig. 5D). (The character is still applicable when the parapenes are fused to each other because if they are they can still be drawn out basally.)

306. Notch in the median margin of parapenis: 0 = absent; 1 = present (Fig. 2B, D).

307. Medial inflection of parapenis: 0 = absent; 1 = present. In state 1, the parapenis is inflected at the medial rim.

308. Basal inflection of gonostipes: 0 = absent; 1 = on gonostiptal arm; 2 = on gonostiptal arm and parapenis (Schulmeister 2001: Fig. 2D); 3 = on parapenis only. Unordered.

309. Inclination of parapenis: 0 = more or less parallel to the median axis of the genitalia (Fig. 6D); 1 = inclined (Fig. 6E).

310. Median fusion of parapenes: 0 = not fused basally (Fig. 8B); 1 = fused basally or completely (Fig. 3D).

311. Spine at the distal end of the gonoforceps (parameral spine (f) of Snodgrass 1941): 0 = absent; 1 = present.

312. Gonomacula: 0 = can be covered with a 'lid' (Fig. 1E, F); 1 = cannot be 'hidden'; = not applicable because gonomacula is lacking. Ronquist et al.'s (1999) character 138 distinguished gonomacularae situated either apically or subapically. I cannot see what was meant by this, but the distribution of states of their character 138 corresponds to the coding of my character 312.

313. Internal membrane between the harpe and the gonostipes (see above): 0 = present (Fig. 1G, H); 1 = absent; = not applicable because harpe is lacking.

314. Harpe: 0 = rather straight, about as broad as the distal edge of the gonostipes, dorsal and ventral edge more or less parallel (Figs. 3B, 4E); 1 = rather triangular, with a dorsal flap which extends into the gap created by the constriction between the parapenis and the rest of the gonostipes (Figs. 4B; 5B, D; 6B); = not applicable because harpe is lacking.

315. Ridge on distal edge of harpe: 0 = absent; 1 = present (Fig. 3A); = not applicable because harpe is lacking.

316. Median face of harpe: 0 = extends about as far cranially as the lateral face; 1 = extends much farther cranially (Fig. 7D).

**Penisvalvae and phallotrema**

317. Penisvalvae: 0 = completely separate (Figs. 1D, 3B); 1 = fused dorsally (Figs. 2B; 7B; 8B; 9B, D).

318. Hairs on valviceps: 0 = absent; 1 = present (Fig. 1A–D).
319. Tip of valviceps/penisvalva (viewed from medial): 0 = rounded, not drawn out (Figs. 1B, 3B); 1 = drawn out into a pointed thread-like structure (Fig. 2A–D).

320. Pseudoceps and valvispina: 0 = absent (Figs. 4C, 7F); 1 = present (Fig. 6C). According to Ross (1945), who introduced these terms, a pseudoceps and valvispina are present in some Nematinae.

321. Row of teeth on valviceps: 0 = absent; 1 = present (Fig. 4C).

322. Ergot on penisvalva: 0 = absent; 1 = normal: short tip (Fig. 6C); 2 = scale-like (Fig. 4C); 3 = very long; 4 = wing-shaped (Fig. 7F). Unordered.

323. Valvura: 0 = not broader at apex (Fig. 4C); 1 = flattened and broadened at apex (not depicted).

324. Phallotrema (Vilhelmsen 1997a: 84): 0 = situated ventrally (Figs. 1C, 4D, 6A); 1 = situated apically (Figs. 3A, C; 8A; 9A, C). This character was coded as inapplicable in those taxa that have a ventral sclerotized stylus, in order to avoid giving double weight to these correlated transformations.

Volsella

325. Volsella (Vilhelmsen 2001: 220): 0 = volsellae absent; 1 = volsellae present (Fig. 1A).

326. Digitus and basivolsella/parossiculus (includes Ronquist et al. 1999: 136): 0 = not fused (Fig. 3A); 1 = fused, but both digitus and cuspis are clearly present (Fig. 4A, D); 2 = either cuspis or digitus is missing, volsella ends in only one tip (Fig. 9C). Unordered.

327. Cranial end of basivolsella: 0 = not covering gonostipes; 1 = covering gonostipital arm (Figs. 4D, 11A).

328. Parossiculus/basivolsella: 0 = free (Fig. 3A); 1 = fused with gonostipes respectively gonoforceps (Figs. 8A, 9A); = not applicable because volsella is missing.

329. Position of volsella: 0 = on medial face of gonostipes or gonoforceps (Figs. 1C, 10C, 11A, 12A); 1 = on ventral side of genitalia; = not applicable because volsella is missing.

330. Basivolsellar apodeme: 0 = absent; 1 = present; = not applicable because volsella is missing.

331. Gonossicular apodeme (Snodgrass 1941): 0 = absent; 1 = present; = not applicable because volsella is missing. According to Snodgrass (1941), the gonossicular apodeme is a specialty of the Vespidae. However, I could not find a gonossicular apodeme in any of the examined specimens, including the vesps Dolichovespula and Polistes.

332. Basivolsellar bridge: 0 = absent; 1 = present (Fig. 11C); = not applicable because volsella is missing. The basivolsellar bridge is a sclerotized bridge between the cranial ends of the basivolsellae (“j” in the figures of Snodgrass 1941).

333. Extension of volsella: 0 = not beyond gonoforceps; 1 = well beyond gonoforceps (Fig. 10C).

334. Thorns on basivolsella: 0 = absent; 1 = present (Fig. 10C).

Additional sclerites

335. Fibula ducti: 0 = absent or small; 1 = large, on surface of ductus (Fig. 3B, D).

336. Ventral median sclerotized style: 0 = absent; 1 = present.

337. Dorsal rod: 0 = absent; 1 = present (Fig. 11D). The dorsal rod is a sclerotization of the aedoeagus (Snodgrass 1941).
Male internal reproductive organs
338. Glandulae mucosae: 0 = left and right; 1 = more or less dorsal and ventral, or distal and basal, of each other.
339. Form of glandula mucosa: 0 = more or less round, oval, or straight, or slightly curved (Fig. 13A, F, H); 1 = with a ‘bulbus’ at the side (Fig. 13C); 2 = U-shaped (Fig. 13D); 3 = sigma-shaped (Fig. 13E); 4 = with three blind ends (Fig. 13G); 5 = with a distal appendage (Fig. 13I). Unordered.
340. Ductus ejaculatorius: 0 = short; 1 = extremely long so that the glandulae mucosae are far away from the genitalia.
341. Coiling of the part of the vas deferens that forms the vesicula seminalis: 0 = coiled (Fig. 13B); 1 = zigzagging, but not coiled (Fig. 13C); 2 = straight (at least basally) (Fig. 13H). Unordered.
342. Relative size of vesiculae seminales: 0 = normal; 1 = very small, lumped together, squeezed between the glandulae mucosae (Fig. 13F). Sclerites of the terminal segments 1 of the male abdomen.

Sternites
343. Form of abdominal sternum eight in males: 0 = not constricted, almost rectangular, but in some cases distal margin concave; 1 = somewhat constricted medially or very narrow overall; 2 = strongly constricted, with scleritous bridge in the middle; 3 = separated into two sclerites connected only by membrane. Ordered.
344. Eighth and ninth sternite: 0 = separate, only connected by membrane (Figs. 14A–V; 1 = closely connected or fused (Fig. 14W).
345. Basal margin of ninth sternite seen from above: 0 = convex or triangular; 1 = rather straight from left to right, but each half concave; 2 = triangular, but clearly concave left and right (Fig. 14L–N); 3 = straight from left to right as in Cephidae and Siricidae (Fig. 14O). Unordered.
346. Distal margin of ninth sternite (ventral view): 0 = convex or triangular; 1 = drawn out into a long, pointed tip (Fig. 14P, Q); 2 = more or less straight from the right to the left side, as if cut off (Fig. 14C, R); 3 = concave. Unordered.
347. Spiculum: 0 = not prominent; 1 = drawn out (Fig. 14F); 2 = extremely long and directed cranially (Fig. 14T, W). Ordered.
348. Strengthened line on ninth sternite parallel to its basal margin: 0 = absent; 1 = present.
349. Strengthening of basal margin of ninth sternite: 0 = not strengthened; 1 = thickened; 2 = with inflection ventrally; 3 = with protruding inflection ventrally (Fig. 14F). Ordered.

Tergites and cerci
350. Eighth tergite: 0 = more or less rectangular (Fig. 15A); 1 = apically extended to cover anus; 2 = apically extended to cover male genitalia; 3 = with apical excision; 4 = with apical appendage (Fig. 15B). Unordered.
351. Ninth tergite: 0 = largely sclerotized (Fig. 15A); 1 = largely membranous, only very little sclerotized; 2 = sclerotized, but split into two widely separated lateral parts, which are connected only to the tenth tergite but not to each other (Fig. 15F). Unordered. (State 2 should not be coded as a separate character because the division into two lateral sclerites is caused by the middle part not being sclerotized. State 2 is hence similar to state 1.)
352. Tenth tergite: 0 = largely sclerotized (Fig. 15B); 1 = largely or completely membranous, but clearly distinct from ninth tergite; 2 = sclerite completely absent or indistinguishable due to fusion with ninth tergite (Fig. 15E). Unordered.

353. Cerci of male: 0 = present; 1 = absent.

References


