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Synopsis of the Tenthredinidae (Hymenoptera) in Australia, including two newly recorded, introduced sawfly species associated with willows (*Salix* spp.)

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Abstract Two species of tenthredinid sawflies associated with willows are recorded from Australia for the first time: *Pontania proxima* (Lepeletier), which forms galls on *Salix fragilis* Linnaeus in Tasmania, and *Amauronematus viduatus* (Zetterstedt), which defoliates *Salix babylonica* Linnaeus in south-eastern New South Wales. A key to the five introduced and three endemic species of Tenthredinidae known from Australia is provided. Notes on biology and distribution are given for all species.

Key words *Amauronematus*, *Ametastegia*, *Caliroa*, *Cheilophleps*, gall maker, *Pontania*, *Priophorus*, *Senoclidia*, willow-feeding sawfly.

INTRODUCTION

In the most recent overview of the Australian sawflies (Naumann 1991) only four species of Tenthredinidae were recorded from Australia. These four included two endemic species belonging to *Cheilophleps* Benson and *Senoclidia* Rohwer, and two introduced species, the pear and cherry slug, *Caliroa cerasi* (Linnaeus), and the raspberry sawfly, *Priophorus morio* (Lepeletier).

Eight tenthredinid species are now known from Australia. An additional species of *Cheilophleps*, which is probably endemic to Australia, has been discovered in tropical Queensland and three species native to the Northern Hemisphere have recently been detected in south-eastern Australia. The latter group of apparently accidental introductions comprises the dock sawfly, *Ametastegia glabrata* (Fallén) (Malipatil *et al.* 1995), and two species associated with willows (*Salix* spp., Salicaceae), the gall-inducing *Pontania proxima* (Lepeletier) and *Amauronematus viduatus* (Zetterstedt), which has larvae that live first in the developing buds and are later free living. The two species associated with willows are recorded here from Australia for the first time.

As the Australian tenthredinid fauna now stands at eight species in seven genera, a key to species is overdue. We present a key that will enable the identification of adults, but defer a key to immatures until the larvae of *Cheilophleps* and *Senoclidia* are known. The key is followed by notes on the biology and distribution of each species. Since the number of publications on the various introduced species is large and often repetitive, we have cited selectively from this literature.

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The following abbreviations are used for collections: ANIC, Australian National Insect Collection, CSIRO Entomology, Canberra; DPIH, Insect Collection of the Department of Primary Industries and Fisheries, Hobart; MAW, Margaret A Williams; SS, Stefan Schmidt; UQIC, University of Queensland Insect Collection, Brisbane. F3, F4 and F5 denote flagellar segments three, four and five, respectively.

TAXONOMY

Key to Australian species of Tenthredinidae

1 Radial cell of forewing not divided by cross-vein 2r-rs (Figs 3,5,7) 2
– Radial cell of forewing divided by cross-vein 2r-rs (Figs 1,2,4) 4
2 Anal cell (1A) of forewing constricted medially (Fig. 5) ..... *Priophorus morio*
– Anal cell (1A) of forewing pedunculate (Figs 3,7) 3
3 Interantennal and adorbital areas distinctly produced (Fig. 12); frons produced (Fig. 11); legs predominantly pale coloured (orange, yellow or white with minor brown or black markings); clypeus dark coloured (brown or black) ..... *Pontania proxima*
– Interantennal area weakly produced, adorbital areas concave (Fig. 10); frons weakly produced (Fig. 9); legs predominantly dark coloured (brown or black); clypeus pale coloured (yellow or orange) ..... *Amauronematus viduatus*
4 Hindwing cell 1M closed, contiguous with cell R1 (Fig. 8); clypeal margin convex (Fig. 14); forewing infuscate, without sinuate vein (2A+3A) behind vein 1A (Fig. 8) ..... *Senoclidia furva*

– Hindwing cell 1M usually absent, if present, then not contiguous with cell R1 (Figs 1,2,6); clypeal margin bilobed (Fig. 13); forewing hyaline, with sinuate vein behind vein 1A (Figs 1,2,4) 5

5 M and 1m-cu of forewing converging (Fig. 1); hindwing with enclosed cell 1M (Fig. 1) .... *Caliroa cerasi*

– M and 1m-cu of forewing parallel (Figs 2,4); either hindwing without enclosed cell 1M (Fig. 2) or 1M closed by marginal vein (Fig. 6) 6

6 Body black; cross-vein *a* of forewing level with or distal to junction of M+Cu and M (Fig. 2)..... ..... *Ametastegia glabrata*

– Body extensively orange–yellow; cross-vein *a* of forewing proximal to junction of M+Cu and M (Fig. 4) 7

7 Labrum, posterior margin of pronotum, tegula, dorsal half of mesepisternum all cream-yellow; F3 1.5 times length of F4, 0.8 times length F4+F5 .... *Cheilophleps xantha*

– Labrum, pronotum, tegula, mesepisternum all brown to black; F3 1.2 times length of F4, 0.6 times length F4+F5 ..... *Cheilophleps* sp.

Subfamily Nematinae

Priophorus morio (Lepeletier) (raspberry sawfly)

Priophorus morio is a Holarctic species (Smith 1974) accidentally introduced to Australia and New Zealand (Callan 1978; Valentine & Walker 1991) and imported intentionally into Hawaii for the biological control of wild blackberry (Davis 1976). Larvae of *P. morio* feed on the leaves of various species of *Rubus* Linnaeus (raspberry, blackberry, youngberry, loganberry, small-leaf bramble) and *Sorbus* Linnaeus (Rosaceae) (Bruzzese 1980). In Australia, *P. morio* was first recorded from Tasmania in 1959 (as *Priophorus brullei* Dahlbom, a junior synonym) and is now known from Tasmania, southern New South Wales (Braidwood, specimens in ANIC), the Australian Capital Territory (Callan 1978) and Victoria (Bruzzese 1980).

Larvae of *P. morio* tend to feed from the underside of leaves and when numerous, more or less skeletonise the leaf. Mature larvae leave the host plant and spin a cocoon in plant debris or soil. Several generations per summer are possible in southern Australia. Males are unknown in Australia, suggesting that here (as in North America) the species reproduces by thelytokous parthenogenesis (Callan 1978).

Pontania proxima (Lepeletier) (willow gall sawfly, bean gall sawfly)

Pontania proxima is a widespread Northern Hemisphere species, common from western Europe (Liston 1995) through Siberia to the Kamchatka Peninsula. It has been introduced into North America where it is now known principally from the north-east (Ontario to Maine and south to New York). It was also accidentally introduced into New Zealand, where it is now widely distributed (Valentine & Walker 1991). *Pontania proxima* causes bean-shaped galls on the leaves of various species of willow (*Salix* spp.).

Pontania proxima appears to be a relatively recent, accidental introduction to Australia. It was first detected in 1994 when adults were reared from galls on the leaves of 'crack willow', *Salix fragilis* Linnaeus, at New Town, in the Hobart area of Tasmania (specimens reared by MAW in DPIH). More recently, in January 1998, the species was collected near St Marys, Tasmania, on *Salix balylonica* Linnaeus (SS in UQIC). At present, the species is not known from any other localities.

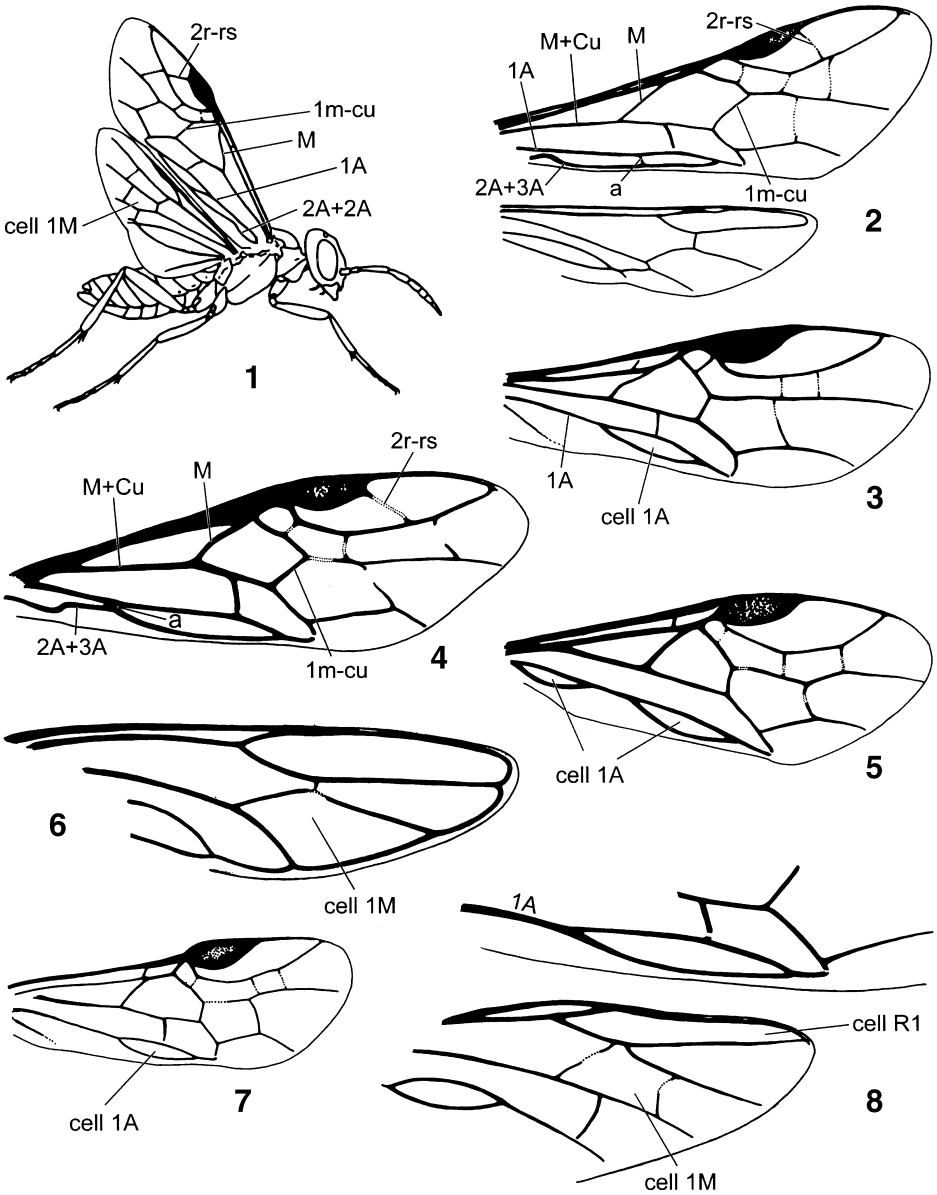
In the Northern Hemisphere the host range of *P. proxima* includes: white willow, *Salix alba* Linnaeus; one of the basket willows, *S. triandra* Linnaeus; *S. fragilis* and *S. fragilis* x *S. alba* hybrids; and common sallow, *Salix cinerea* Linnaeus. *Pontania proxima* is not known to develop upon weeping willow, *Salix babylonica* Linnaeus.

On suitable hosts, females of *P. proxima* prefer to oviposit in the leaf buds and galls and mature as the leaves grow (Carleton 1939). Eggs hatch after 12–19 days. The galls reach full size in about 14 days. They are bean shaped, about 7 mm long, 7 mm wide and 5 mm thick, red or pink on the upper surface of the leaf and pale or yellowish green below. Initially the galls are solid except for the small cavity containing the sawfly larva, but as the larva feeds the cavity enlarges until the walls of the gall are very thin. The larva chews a small hole in the gall on the lower surface at one end. It ejects frass through this hole and sometimes leaves the gall temporarily. The larva finally leaves the gall through this hole to form a cocoon in the soil or in a crevice in the bark of the willow. The five larval instars are completed in a total of about 18 days and the prepupal stage lasts for between 9 and 22 days in the case of a summer brood. In the case of the late summer–autumn brood the prepupa overwinters. The duration of the pupal stage varies between a few days and several months depending on temperature. At least two generations per summer should be expected in southern Tasmania. Warm days in winter can stimulate pupation, shortly followed by emergence of adults. Willows are deciduous in winter and provide no oviposition sites for females which emerge during unseasonal warm spells.

Pontania proxima is a common species over its natural range. It is not regarded as a serious pest even where rods of basket willows are harvested commercially. However, large infestations of galls probably do diminish host plant vigour. In Europe, the galls are attacked by about 20 species of parasitoids and parasitic inquilines (Carleton 1939; Kopelke 1994).

Amauronematus viduatus (Zetterstedt)

Amauronematus viduatus is widely distributed from northwestern Europe (including Britain and Ireland), to central Asia (Tien Shan) and Siberia (Benson 1958; Zhelokhovtsev & Zinovjev 1994). It also occurs in North America (Ontario,



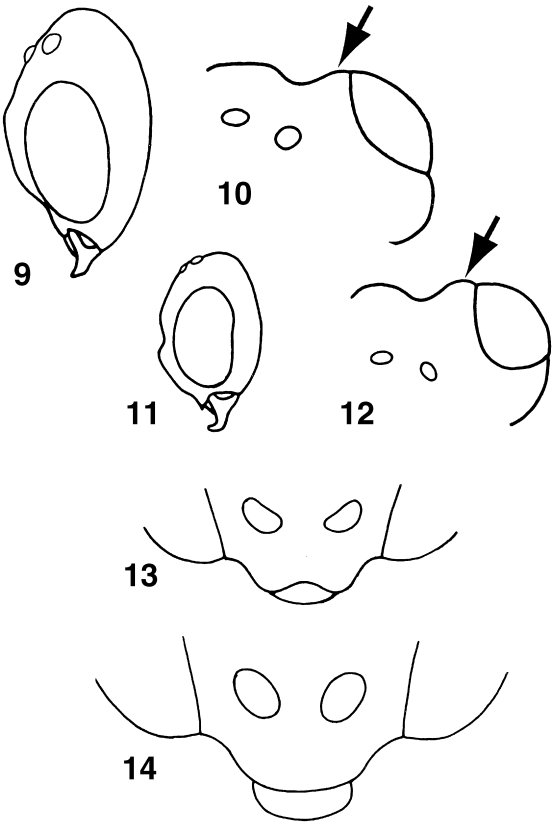
Figs 1–8. Adult Tenthredinidae. **(1)** *Caliroa cerasi*, female, lateral view. **(2)** *Ametastegia glabrata*, forewing and hindwing. **(3)** *Pontania proxima*, female, forewing. **(4)** *Cheilophleps* sp., female, forewing. **(5)** *Priophorus morio*, female, forewing. **(6)** *Cheilophleps xantha*, male, hindwing. **(7)** *Amauronematus viduatus*, female, forewing. **(8)** *Senoclidia furva*, female, portions of forewing and hindwing.

Saskatchewan) (Smith 1979). The larvae of *A. viduatus* feed on several willow species (*Salix* spp.). The early stages live inside the developing buds but late-instar larvae are free living (Zinovjev & Vikberg 1998). Infected willow buds show deformations that are similar to those made by some tortricid larvae, although the sawfly larvae do not use silk to fasten the leaves. The bud galls are made by the ovipositing female and in some *Salix* species they are very similar to normal buds (Zinovjev & Vikberg 1998).

Amauronematus viduatus was first detected in Australia in 1992 at Batehaven, on the south coast of New South Wales. Larvae were locally abundant feeding on weeping willow, *Salix babylonica* (JAL Watson, pers. comm., 1992; specimens in ANIC). Little is known of the biology of this species in Australia, but in northern Europe, one generation per summer is the norm (Benson 1950). At Batehaven, larvae were common in the early spring. Mature larvae left the host tree in September and immediately spun cocoons among plant debris. Adults did not emerge from these cocoons until the following spring.

Although *A. viduatus* is not regarded as a pest in the Northern Hemisphere, its distribution and status in Australia should be monitored, especially where willows are valued as ornamental and shade trees. *Salix babylonica* flourishes along watercourses in the cooler, wetter parts of southern Australia. It is sometimes regarded as an undesirable tree because it increases the quantity of plant material falling into aquatic habitats and alters the physical characteristics of streams. However, *S. babylonica* probably also serves a useful purpose in reducing soil erosion.

There is an earlier (1978) record of sawfly larvae defoliating *S. babylonica* in Australia. The sawfly was referred to



Figs 9–14. Adult Tenthredinidae, heads. **(9,10)** *Amauronematus viduatus*, female, lateral and dorsal views. **(11,12)** *Pontania proxima,* female, lateral and dorsal views. **(13)** *Cheilophleps xantha*, female, frontal view. **(14)** *Senoclidia furva*, female, frontal view.

simply as an unidentified species of Tenthredinidae found on the tips of *S. babylonica*, adjacent to an apple orchard, Glen Huon, Tasmania (Hardy *et al.* 1980). Only larvae were collected (by MAW; preserved in DPIH); these are very similar to larvae of *A. viduatus* but cannot be identified reliably. There are over 100 species of *Amauronematus* Konow in the Northern Hemisphere and the larvae of few have been described. In the absence of adult sawflies, all that can be stated unequivocally for the present is that a species of *Amauronematus* or a related tenthredinid genus is present in Tasmania.

Coincidentally, *Nematus oligospilus* Förster, another Northern Hemisphere tenthredinid species which defoliates willows, has recently been discovered in South Africa (Urban & Eardley 1995) and New Zealand (Berry 1997).

Senoclidia furva (Konow)

Senoclidia furva is known only from Milne Bay, Papua New Guinea and Darwin, Northern Territory (Benson 1935, 1938). The Darwin record is based on a single female specimen (in Queensland Museum, Brisbane) collected by FP Dodd. The specimen label bears no date, but it is known that FP Dodd visited the area between 1908 and 1909 (Monteith 1991). In the absence of more recently collected specimens, the question arises as to whether *S. furva* is indeed established in or endemic to the Darwin area, or whether it is an entirely exotic species intercepted once at the port of Darwin while Dodd was a temporary resident of the city. Other species of *Senoclidia* Rohwer are known from the Philippines, the Malay Peninsula and Java (Konow 1905; Rohwer 1912), but nothing has been recorded of their host plants or biology for any member of the genus.

Cheilophleps xantha Benson

Cheilophleps xantha is known only from the type material collected in New South Wales at East Dorrigo, in the north-east and Bulga, immediately inland of the central coast. Nothing is known of its biology (Benson 1938).

Cheilophleps sp.

A second species of *Cheilophleps* Benson is represented by a single female collected at an altitude of about 825 m near Ravenshoe, north Queensland (specimen in ANIC). It differs from *C. xantha* in having less extensive pale markings and in the proportions of the antennal segments. Nothing is known of its biology.

Subfamily Allantinae

Caliroa cerasi (Linnaeus) (pear and cherry slug)

Caliroa cerasi is widespread throughout the Northern Hemisphere (Europe, North Africa, Uzbekistan, Altai region, Taiwan, Japan, North America) and has been introduced accidentally to Australia, New Zealand, South Africa, Colombia, Chile, Uruguay and Argentina (Hill & Valentine 1989; Valentine & Walker 1991). The green or black, mucus-covered, slug-like larvae feed initially on the upper surfaces of leaves causing a scorched or curled appearance. Third and later larval instars cause 'windowing' and heavy infestations result in comprehensively skeletonised leaves. Host plants include various species of *Prunus* Linnaeus (cherry, pear, almond and plum), *Pyrus* Linnaeus (pear), *Cydonia* Miller (quince), *Cotoneaster* Medikus and *Crataegus* Linnaeus (hawthorn) (all Rosaceae). There are also unconfirmed reports of larvae feeding on species of *Juglans* Linnaeus (walnut) (Juglandaceae), *Salix*, *Quercus* Linnaeus (Culpuliferae) and *Betula* Linnaeus (Betulaceae) (Carl 1972; Liston 1995).

In southern Australia there are two adult emergences each spring and summer. Adults emerging in the spring give rise to a November–December brood of larvae. There is a second, late summer emergence of adults and it is their offspring which usually are more injurious. Evidence from European ecological studies suggests that both univoltine and partially bivoltine populations of *C. cerasi* coexist, albeit with considerable interchange (Carl 1972). At the sixth moult, larvae turn into a yellow-coloured, non-feeding instar which leaves

the host tree and forms a cocoon in an earthern cell in the soil. Adults from the first summer brood emerge after 18–28 days. Larvae from the second summer brood overwinter in the earthen cells and pupate in the spring. Males of *C. cerasi* are unknown in Australia and the species is assumed to reproduce by thelytokous parthenogenesis. Males are common at some European localities and it appears that the sex ratio is genetically fixed in different populations of the sawfly (Carl 1972).

Caliroa cerasi was first recorded in Australia from Tasmania in 1889 (Froggatt 1901) and is now widespread across southern Australia (New South Wales, Australian Capital Territory, Victoria, Tasmania, South Australia and south-west Western Australia) (Jenkins 1945).

Large numbers of larvae are injurious and are currently controlled by the application of pesticides (Hely *et al.*1982). In Europe, the eggs are attacked by trichogrammatid wasps, and the larvae and cocoons by a variety of ichneumonid parasitoids (Carl 1976). In 1928 and 1931 there were abortive attempts at the biological control of *C. cerasi* in Australia and several ichneumonids were brought from Europe to New South Wales. However, it is not clear from available records whether any of the parasitoids were released in the field (Wilson 1960) and the biological control of *C. cerasi* in Australia may warrant further investigations. Three ichneumonid parasitoids of European origin have been introduced into New Zealand and one species has certainly become established (Hill & Valentine 1989). However, the impact of parasitoids on the population dynamics of *C. cerasi* in New Zealand has not been determined.

A protist, *Blastocrithida caliroae* Lipa, known from both Europe and New Zealand, is also a promising biological control agent (Hill & Valentine 1989). In Europe *B. caliroae* can cause up to 48% larval mortality and subsequent decline in *C. cerasi* populations.

Ametastegia glabrata (Fallén) (dock sawfly)

Ametastegia glabrata occurs widely throughout the Northern Hemisphere (temperate Europe, the Mediterranean region, east to Siberia and North America) (Smith 1979) and has recently been recorded from Chile (Carrillo *et al.* 1990) and Australia (Malipatil *et al.* 1995). Larvae ('dock false-worms') feed on a range of herbaceous plants, in particular Polygonaceae (*Rumex* Linnaeus, *Polygonum* Linnaeus, *Rheum* Linnaeus etc.) and Chenopodiaceae (*Chenopodium* Linnaeus) (Benson 1952; Smith 1979; Liston 1995). While larval feeding on leaves may be of some slight concern to commercial raspberry growers, the major damage by this sawfly is caused by the mature larvae tunnelling into canes and fruit (e.g. apples growing above sawfly host plants) in search of pupation sites.

DISCUSSION

Most tenthredinids can form their cocoons in loose plant material or small cavities, and undergo an inactive phase lasting several months. Transport in the prepupal stage is eminently feasible and it is somewhat surprising that only five species of tenthredinid sawflies reached Australia. Any form of crates, packing material, cases or machinery standing near a host plant could offer suitable cavities for the pupae. Furthermore, unlike most tenthredinids, which form rather fragile cocoons, species of the subfamily Nematine, including *Pontania proxima*, *Priophorus morio* and *Amauronematus viduatus*, produce cocoons with rigid walls, thus facilitating their transport without being damaged. As an example of how these insects can be moved around, at Batehaven, NSW, large numbers of *A. viduatus* larvae fell from the host tree onto a canvas tent and crawled into folds in the canvas and into boxes, and eventually cocoons were even found between sheets of paper towel (JAL Watson, pers. comm., 1992). This demonstrates the ease with which cocoons could be acquired and transported without detection. Cocoons of non-native species dealt with in this paper could have originated from either the Northern Hemisphere or from one of the other Southern Hemisphere countries in which several of these tenthredinids have become established.

At present each of the two sawfly species associated with willows occupies a very restricted distribution compared to the wide geographical range of its host plant in Australia. *Pontania proxima*, which forms galls on *S. fragilis*, is restricted to Tasmania and *A. viduatus*, which feeds on leaves of *S. babylonica*, is known only from south-eastern New South Wales. This suggests that these two species of sawfly are relatively recent introductions to Australia.

Males are unknown in Australia for *P. morio*, *C. cerasi* and *A. viduatus*, although they do occur in some Northern Hemisphere populations of these species. Parthenogenesis is common among the Symphyta and particularly so in populations of species which have colonised new continents (Smith 1993).

Priophorus morio, *Pontania proxima* and *Amauronematus viduatus* will key to Pergidae rather than Tenthredinidae in Naumann (1991). These species can be identified to the correct family if couplets four and five of this key are modified slightly and an extra couplet is added as follows:

4(2)	Radial cell of forewing divided by cross-vein 2r	Tenthredinidae (part)
–	Radial cell of forewing not divided by cross-vein	5
5(4)	Antennae three-segmented, apical segment very long and sometimes bifid	Argidae
–	Antennae with more than three segments, apical segment not unusually long	6
6(5)	Hindwing with cell M	Tenthredinidae (part)
–	Hindwing without cell M	Pergidae (part)

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