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Bachelor thesis in Biology

The Hymenopteran subfamily Adeliinae (Braconidae)

A morphological and ecological study of specimens collected in Sweden

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Abstract

Insects are the most numerous and species rich group of animals on Earth. One of the four mega diverse orders within the class Insecta is Hymenoptera which include ants, bees and parasitic wasps. One of the many Hymenopteran subfamilies is Adeliinae, a group of tiny wasps that parasitize leaf mining Lepidoptera larvae. Only one described species of Adeliinae is hitherto known to occur in Sweden. However, this known species exhibits a wide range of polymorphism. In fact, the hypotheses if Adeliinae constitute a subfamily with just a few, but very variable species or if it is composed by a rich number of very similar species have never been tested before. The results in this study confirm the variation, but cannot state which of the hypotheses that is the most correct. Furthermore, the processed information from the traps in which the wasps were caught show that the Adeliinae are spread throughout Sweden and appear in a wide variety of habitats.

Sammanfattning

Insekter är den mest artrika och talrika djurgruppen på jorden. En av de fyra enormt artrika insektsordningarna inom klassen Insecta är Hymenoptera, eller steklar, som bland annat består av myror, bin och parasitsteklar. En av de många underfamiljerna bland steklarna är Adeliinae (dvärgmalsteklar), en grupp med små steklar som lägger ägg inuti larver av minerare. Det finns hittills endast en känd beskriven art i Sverige av dvärgmalsteklar. Den sedan tidigare kända arten uppvisar dock en stor variation i utseende. Faktum är att det aldrig tidigare har testats om denna underfamilj endast består av några få men mycket varierande arter eller många arter med lite skillnad. Resultatet från denna studie bekräftar den stora variationen men kan inte avgöra vilken av hypoteserna som är korrekt. Dessutom har den bearbetade informationen från de fällor där steklarna har fångats visat att underfamiljen Adeliinae är spridd över hela Sverige och förekommer i ett stort antal olika habitat.

Key words

Adeliinae, Braconidae, Hymenoptera, Parasitoid, Leaf miners, Morphology, Polymorphism, Characters, Distribution, Ecology

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1 Introduction

The aim of this study was to investigate the morphological variation, biology and occurrence in Sweden of the Hymenopteran subfamily Adeliinae (Braconidae). Adeliine wasps are seldom caught and are therefore rarely found in collections. A unique opportunity to study the group was given by the Swedish Malaise Trap Project (SMTP) in which 140 undetermined specimens are hitherto found. This study has obtained new knowledge concerning a poorly studied but truly fascinating group of tiny and beautiful wasps.

1.1 The order Hymenoptera

One of the most species rich orders of insects is Hymenoptera with approximately 115 000 described species (Grissell 1999) placing them only behind Coleopterans (beetles) and Lepidopterans (butterflies). However, there are estimates that there could be as many as 1 000 000 species or more worldwide which means that more than 80 % of the species are yet undescribed and that Hymenopterans would make up about 10 % of the total number of species on Earth (Sharkey 2007). Furthermore, they come in huge numbers, a classical example being the estimate that there are over one million ants per every human being on this planet. Their great diversity and numbers means that Hymenopterans have a profound effect on the world's ecosystems and ecology. Honey bees (genus *Apis*) pollinate important agricultural plants providing crops as well as producing honey to an estimated value of 14.6 billion U.S. dollars (Morse & Calderone 2000). Parasitoid Hymenoptera, since they have a wide variety of other insects as hosts, can be used as indicators of changes in the environment. Finally, the parasitoids can also be used as biological control agents against other insects that threaten biodiversity or crops (Sharkey 2007).

The order Hymenoptera is divided into two suborders: Symphyta and Apocrita. Symphyta is commonly known as sawflies and contain both herbivores laying eggs in vegetation which the larvae later consume and parasitoids. Apocritan adults have a characteristic wasp waist and the group is further divided into Aculeata (stinging wasps) and Terebrantes (also known as Parasitica). Aculeata contains many of the most well known Hymenopterans such as ants, bees and yellow-jackets (Sharkey 2007). Terebrantes, originally known as Parasitica based on its biology is probably a paraphyletc group (Sharkey et al. 2011) meaning that it contains ancestral species but not all of their descendants (Campbell et al. 2008). There are about 10 superfamilies within Terebrantes of which one is Ichneumonoidea; a very species rich group containing the two families Ichneumonidae and Braconidae (figure 1) (Sharkey 2007).

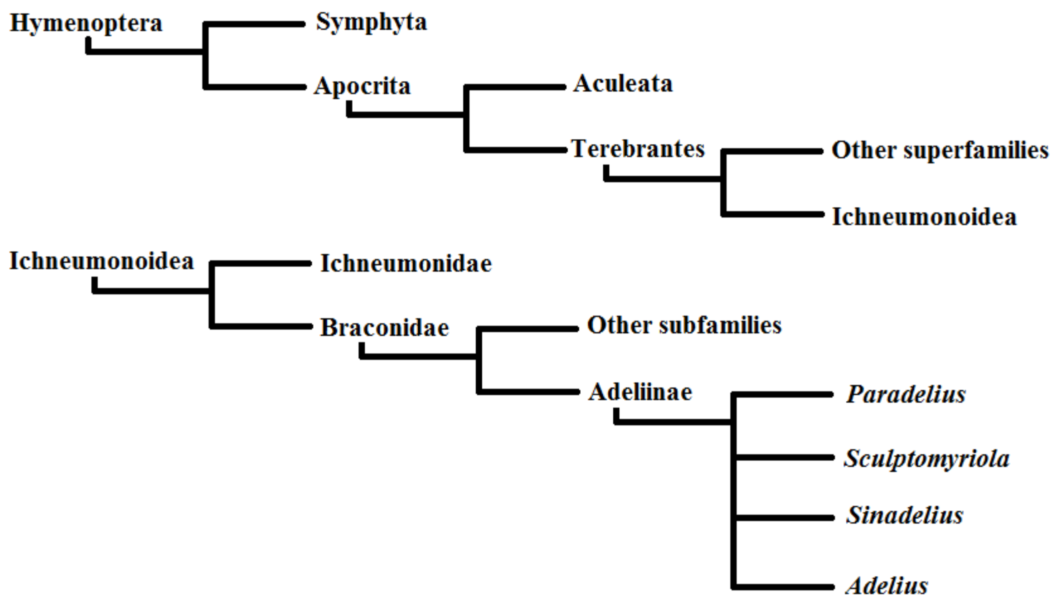

Figure 1. A derivation from the insect order Hymenoptera to the four genera of the subfamily Adeliinae. Adeliinae belongs to the family Braconidae which together with Ichneumonidae makes up the superfamily Ichneumonoidea. Ichneumonoidea is placed within the group Terebrantes which is separated from Aculeata based on the ecology of the groups. Parasitica and Aculeata together make up Apocrita which is one of the suborders of Hymenoptera, the other being Symphyta (Sharkey 2007).

1.1.1 Morphology of the Hymenopteran suborder Apocrita

The orientation description here follows Goulet & Huber (1993). That means that the anterior end is at the front with the head and the posterior is the rear end. Dorsal means above, ventral below and lateral means the sides. If something is placed apically it means furthest away from the body and basal parts are closest to the body. The body of apocritan wasps is divided into: head, mesosoma and metasoma, instead of head, thorax and abdomen which is valid for other insects. This is due to the fact that the first abdominal segment in Aculeata has become immovably merged to the posteriormost segment of the thorax and is known as the propodeum. Therefore, the thorax and the propodeum together are called mesosoma and the abdomen minus the propodeum is the metasoma (Goulet & Huber 1993). The so called wasp-waist clearly divides the mesosoma from the metasoma (figure 2).

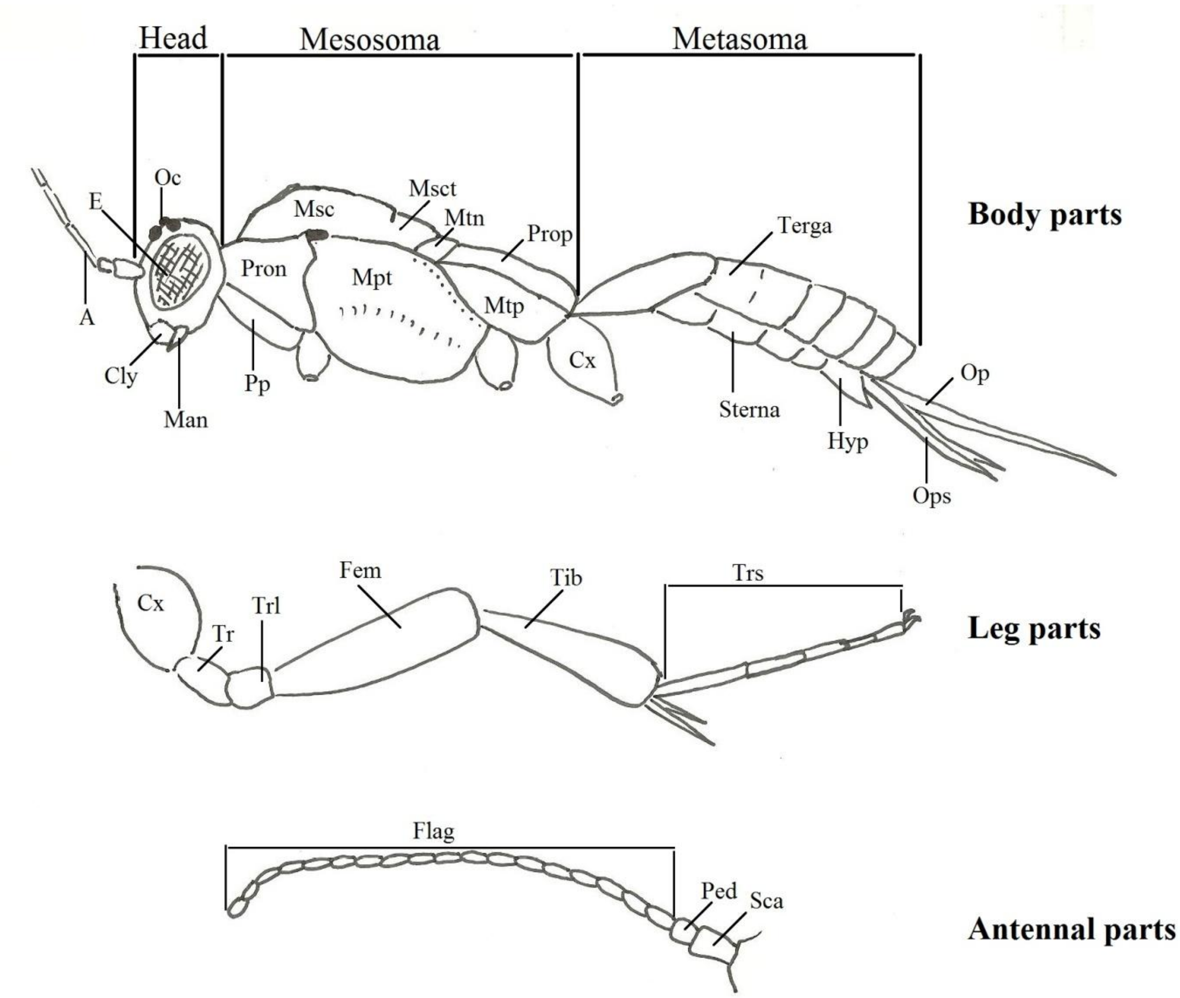

Figure 2. Body parts: A= antenna; Cly= clypeus; Cx= coxa; E= compound eyes; Hyp= hypopygeum; Man= mandibles; Mpt= mesopectus; Msc= mesoscutum; Msct= mesoscutellum; Mtn= metanotum; Mtp= metapectus; Oc= oceli; Op= ovipositor; Ops= ovipositor sheaths; Pp= propectus; Pron= pronotum; Prop= propodeum. Leg parts: Cx= coxa; Fem= femur; Tib= tibia; Tr= trochanter; Trl= trochantellus; Trs= tarsus. Antennal parts: Flag= flagellum; Ped= pedicel; Sca= scape. Inspired by Achterberg 1993.

The head embrace the head capsul, an internal skeleton part called “tentorium”, the two compound eyes, three oceli, mouthparts and antennae. The mouthparts comprise mandibles, maxillae, stipes, glossa, labium, palpi and are covered anteriorly by the clypeus. In some insects there is a malar suture, which is the groove that runs from the clypeus to the compound eyes. The antennae can be divided into scape, pedicel and flagellum. The scape is the most basal antennal segment, the pedicel is the second antennal segment and is followed by the flagellum which is made up by a number of flagellomeres. At the occiput at the back of the head facing the mesosoma there can sometimes be a small ridge tracing in a more or less complete circle, this ridge is known as the occipital carina (Goulet & Huber 1993); an important character among braconid wasps.

The mesosoma can be divided into a number of different sclerites. From the anterior part towards the posterior part of the dorsal area comes fist the pronotum, second the mesonotum which can be divided into mesoscutum and mesoscutellum, third is the metanotum and lastly is the propodeum (Goulet & Huber 1993). Since the lateral pleura and ventral sterna have merged in wasps these segments are known as (anterior to posterior) propectus, mesopectus and metapectus (Karlsson 2010). The three pairs of legs are each made up by (basal to apical) coxa, trochanter, trochantellus, femur, tibia and tarsus. The two wing pairs are dispended by the longitudinal veins (anterior to posterior): costal- radial- medial- cubital- and the analveins. The wings are either entirely transparent (hyaline) or somewhat smoke coloured and can contain a pterostigma which is a coloured field (Shaw & Huddleston 1991). In this study 3 particulate areas in the forewing were of certain interest because of their varying morphology: Area 1. Where the two veins reached the pterostigma. Area 2 & 3. If the veins met to form a cross or not (figure 3). The hind wing contains basal and apical hamuli which are tiny hooks that are used to link the fore wing with the hind wing letting them work as one, however, the basal hamuli are missing in Braconidae (Sharkey & Wahl 1992).

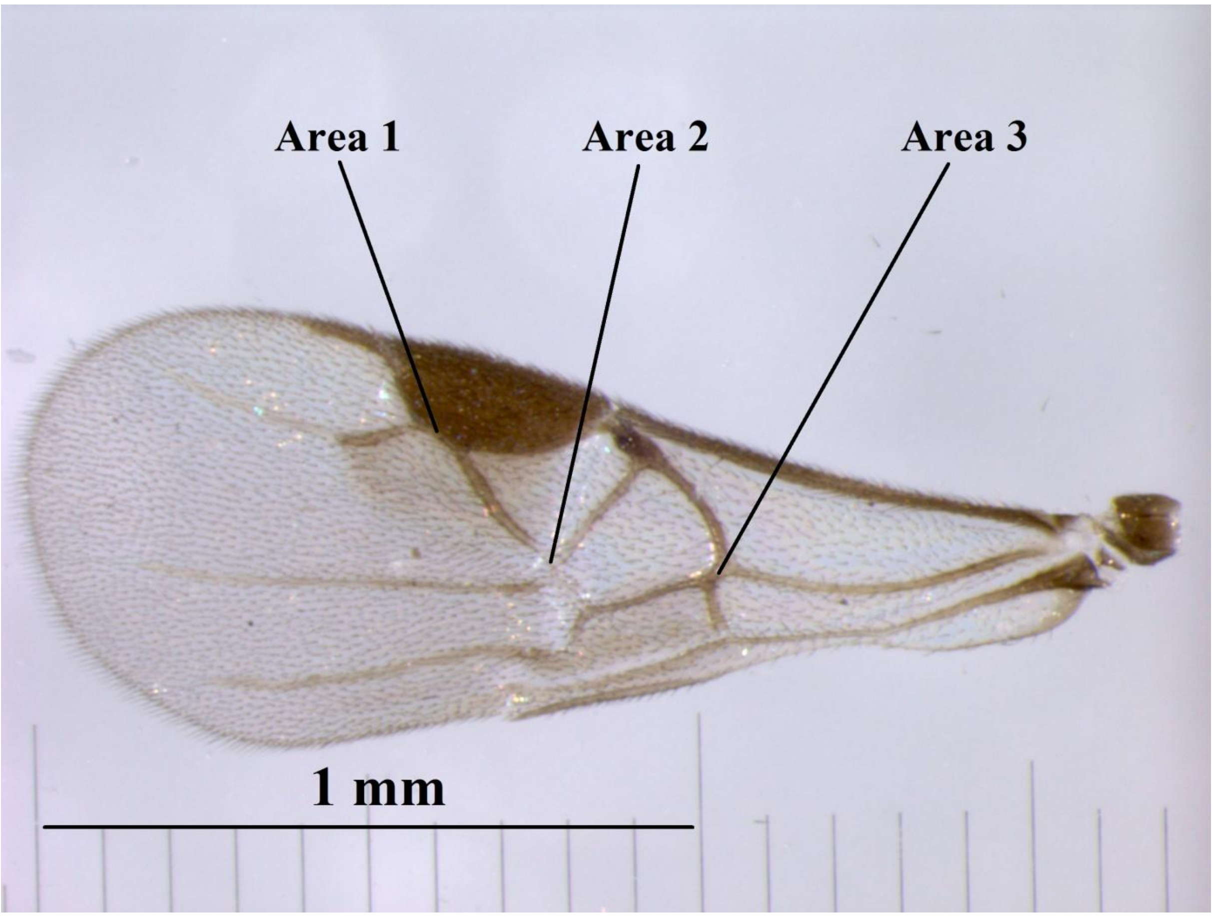

Figure 3. Forewing of male *Adelius subfasciatus* showing three areas of particular interest used in this study because of their varying morphology. In Area 1 the veins would either meet at the pterostigma or not. In both Area 2 and 3 the veins would either form a cross or not. The scale bar shows tenths of a millimetre. Pictured by M. Eriksson.

The dorsal plates of the metasoma are called terga and ventral plates are called sterna (Goulet & Huber 1993). In females the posteriormost sterna is the hypopygeum and is often elongated or shaped differently compared to the other metasomal terga. The terebra is externally protected by a pair of ovipositor sheaths and these structures together make up the ovipositor which is used for laying eggs (Karlsson & Ronquist 2012). The external male genitalia is made up of a basal ring or cupula which is derived from four sclerites on the metasoma. These sclerites come together to form a penis valve as well as a pair of clasping claws which surrounds the penis (Karlsson 2010).

1.2 The family Braconidae

Braconidae is separated from Ichneumonidae by a number of different characters. The second and third terga of the metasoma have been fused into a synterga, the basal hamuli are absent on the hind wings and lastly the veins of the wings are arranged in ways that are unique for the family (Sharkey & Wahl 1992). There are about 1000 species of Braconidae found in Sweden representing 31 subfamilies (dyntaxa.se 2013-05-27), however, there are more than 13 000 species described worldwide (Shaw & Huddleston 1991). One of the subfamilies is Adeliinae which is the main subject of this essay but first we will look in to the biology of Braconidae.

The vast majority of members of Braconidae are parasitoids meaning that they lay their eggs either inside or on top of other insects so that the larvae can grow by consuming nutrition from its host, this eventually leads to the death of the host which separates parasitoids from parasites (Townsend et al. 2008). If the egg is injected into the host the wasp larva is endoparasitic whilst if the larva feeds from the outside it is ectoparasitic. If the host insect can continue to live and grow after it has gotten the parasitoid then the wasp larva is koinobiont. However, if the host is paralyzed and stop growing after it has been stung by the parasitoid then the wasp larva is idiobiont. Ectoparasitism is usually coupled with idiobionts whilst endoparasitism is usually coupled with koinobionts. Idiobionts have the potential of being more generalized in their host range than koinbionts which has to specialize in order to overcome their host’s immune defenses (Shaw & Huddleston 1991). Recent studies support this specialization amongst parasitoid Braconidae in which 90 % of about 300 species of Microgastrinae (a subfamily in Braconidae) only parasitized 1 or 2 species of Lepidopterans. Furthermore, wasps that looked morphologically identical and determined as a species were with DNA analysis and ecological studies proved to be different species, so called cryptic species. This resulted in an increase of species from 171 morphologically determined species to 313 species considering DNA and ecology as well (Smith et al. 2008).

1.3 The subfamily Adeliinae

The subfamily Adeliinae was fist named in 1918 by Henry Viereck in order to place the genera *Adelius* which was named by Haliday 1833 (Haliday 1833, Viereck 1918). The name *Adelius* was actually a type error that Haliday later corrected to *Acaelius* in 1834. Further confusion was added when there was yet another type error in the same article spelling the genera *Acoelius* (Haliday 1834). In order to create consistency within the taxonomy Mason determined *Adelius* to be the proper spelling since it was first mentioned (Mason 1985). There are 3 other genera in the subfamily namely: *Paradelius* (de Saeger 1942) *Sculptomyriola*

(Belokobylskij 1988) and *Sinadelius* (He & Chen 2000) (figure 1), however, *Adelius* is the most species rich with 20 described species (taxapad.com 2013-05-07). In Sweden there is only one recorded species: *Adelius subfasciatus* (dyntaxa.se 2013-05-07) which was first found by C. G. Thomson (1895).

1.3.1 Placement of Adeliinae within Braconidae

The placement of the subfamily Adeliinae within the family Braconidae and the relationship between the different subfamilies have long been contested. The earlier attempts to work out the phylogeny were mainly based on either the biology of the groups or the difference in characters between the groups (van Achterberg 1984). In a character matrix the different taxons are graded based on their morphology, for example: wings present =0 wings absent =1. This data is later used in a phylogenetic study in order to separate the different taxons and to examine their relatedness. The more characters the greater the probability of placing the taxons correctly, assuming of course that the characters are relevant (Campbell et al. 2008). Cees van Achterberg created a phylogeny for Braconidae in 1984 based on a character matrix which placed Adeliinae (in article Acaeliinae) closest to Miracinae based on common characters in the wings (van Achterberg 1984). This relationship was later changed when another analysis was performed using more characters and new computer programs which placed Adeliinae closest to Cheloninae (Quicke & van Achterberg 1990). Although this analysis was criticized for its usage of characters without grades for many subfamilies as well as not showing the simplest (most parsimonious) relationship, and later reassessed to correct the previous errors, the relationship between Adeliinae and Cheloninae remained (van Achterberg & Quicke 1992, Wharton et al. 1992). This has been further supported where Adeliinae is a clear member of the so called microgastroid assemblage, which contains the braconid subfamilies Microgastrinae, Miracinae and Cheloninae, of which the last mentioned once again was the closest relative (Whitfield & Mason 1994).

There have also been several phylogenetic studies based on genetic information which have attempted to confirm the relationships between the subfamilies of Braconidae. An early study using 28S rRNA sequences placed Adeliinae closest to Cheloninae and strengthened the grouping of the microgastroid assemblage (Belshaw et al. 1998). Adeliinae have also been placed within the group of Cheloninae, as opposed to being a sister group, in a study using both 16S and 28S rDNA sequences (Dowton & Austin 1998). This placement has been confirmed using an extended data set of 16S and 28S rDNA as well as combining 28S rDNA sequences with life history traits (Belshaw & Quicke 2002, Dowton et al. 2002). Furthermore, in an extensive study by Shi et al. 2004, which combined the study of 16S, 28S and 18S rDNA sequences with morphological characters, the relationship between Cheloninae and Adeliinae remained strong and Adeliinae was proposed to be treated as a tribe within the subfamily Cheloninae (Shi et al. 2005). However, these results could not be replicated by a controlling study and the subfamily level for Adeliinae remains (Pitz et al. 2007).

1.3.2 The biology of Adeliinae

The hitherto described species within Adeliinae are between one and two millimeters in length. All Adeliinae have 20 antennal segments and the first 3 metasomal terga are fused into a synterga (van Achterberg 1993). They are solitary koinbiont endoparasites of small leaf mining Lepidopterans meaning that they lay only one egg inside each host and that the host continues to live and grow with the parasitoid larva living and growing inside of it (Shaw & Huddleston 1991, Achterberg 1993, Warton et al. 1997). The main host and perhaps the exclusive one is Nepticulidae (Lepidoptera) where both the genera *Adelius* and *Paradelius* have been described to parasitize the genera *Stigmella* (incorrectly known as *Nepticula*) (Whitfield 1988, Medvedev 1997). *Adelius* has also been reported parasitizing on other leaf mining Lepidopterans such as Gracillariidae (Medvedev 1997). However, these reports have been determined as incorrect since parasitized Nepticulidae sometimes enter leaf mines of other leaf mining Lepidopterans before the wasp kills them. Then the wasp is seen erupting from the leaf mine of another type of Lepidopteran and mistakenly assumed to be parasitizing it as well (Shaw & Huddleston 1991). Adeliinae wasps have quite robust hind legs and several species have been described as resembling ants when running through vegetation (Warton et al. 1997). There is even one reported species of the genera *Paradelius* that can produce and emit a substance that resembles formic acid, further adding to the proposed mimicry of ants (Whitfield 1988).

Adeliinae wasps are quite rare in collections (the Swedish museum of natural history only have 3 determined individuals in their collection) and little is known about them. The genus *Adelius* has often been claimed to need revision and there are no present keys available to determine the species of this group (Shaw & Huddleston 1991). This might explain why many of the species have been described more than once, for example, the recorded Swedish species *A. subfasciatus* has also been called *A. minutissimus* (Zetterstedt 1838) and *A. parvulus* (Förster 1851) (taxapad.com 2013-05-12). There is a substantial morphological variation within the genus *Adelius* in both color and wing venation which has caused some to question whether there are 20 species or just a very variable one (Medvedev 1997). There is also variation in morphology within the species *A. subfasciatus* and other studies discuss the possibility of this being a number of different species under the same species name (Thomson 1895). Furthermore, there is a clear dimorphism within the genera *Adelius* where the females' wings often are more or less dark and sooty whilst the males' wings are clear or hyaline (Shaw & Huddleston 1991). This has not always been known and in early studies such as C. F. W. Muesebeck's in 1922 he separates two species that resembles each other (*A. nigripectus* and *A. fasciipennis*) based on the color of the wings. In this case *A. nigripectus* has clear wings and is based on a male as type individual whilst *A. fasciipennis* (in article *Anompterus fasciipennis*) has sooty wings and is based on a female as type individual (Rohwer 1914, Muesebeck 1922). These might be the same species that has been described as one species for the males and one for the females illustrating that there is quite a lot of work to be done with this group of wasps.

1.3.3 The material for this thesis work

The material for this study was provided by the Swedish Malaise Trap Project (SMTP) which has during a 3 year period collected approximately 80 million insects from 75 malaise traps throughout Sweden. This was done in order to cover as much of the Swedish insect fauna as possible, to know which species that are present and where the biggest gaps in knowledge are. Although only a small portion of the material have so far been determined 1000 new species have been recorded for Sweden, half of which are new for science. Most of the discoveries are made within Hymenoptera and Diptera (mosquitoes and flies). There were 140 sorted specimens of Adeliinae available from the project that was used in this thesis. The majority of the wasps were dark and presumed to be the described species *A. subfasciatus* but a small portion had red heads and radiant yellow legs. These had been determined as *A. clandistinus* by Cees van Achterberg who had prior to this study been sent a photograph of the colored variant. If this is the true identity of the species or not remains to be proved but for the sake of separating the two variants the colored one will be called *A. clandistinus* henceforth in this thesis.

1.3.4 Description of the species relevant for this project

Adelius subfasciatus has been described as small with black feet, quite thick antennal segments and with two darker bands on the wings divided by a white line (Haliday 1834). The head is black with red mandibles and pale yellow palpi. The antenna is black or brown with the first two basal segments more red in color. The legs are brown with yellow tarsus except for the most apical segment which is black. Joints between the segments of the legs are red or yellow (Förster 1851). The entire body seems to be black or dark brown (Thomson 1895). *Adelius clandistinus* is described as having a black head with red mandibles and clypeus. The antennae are black with two red segments basally. The first and second pair of legs are red whilst the third are brown. Finally there is a dark area under the pterostigma (Förster 1851).

1.4 Nepticulidae

The host family of Adeliinae wasps: Nepticulidae is a globally distributed family of leaf mining moths (Lepidoptera) with approximately 600 species. Leaf miners lay their eggs on plant leaves and when the larva hatches it begins consuming the tissue inside the leaves leaving characteristic tunnels or mines behind (Labandeira et al. 1994). The most species rich genus within Nepticulidae is *Stigmella* which has a known association with Adeliinae (Whitfield 1988, Medvedev 1997). There are records of *Stigmella* mining on leaves as early as the Cretaceous period and this co evolution with plants have lead to them having a quite narrow span of host species (Labandeira et al. 1994). In Sweden there are 61 species represented from the genera (dyntaxa.se 2013-05-22) with various host plants. For example, *Stigmella aceris* (Frey 1857) lives on *Acer* species and flies from May to September. *Stigmella salicis* (Stainton 1854) lives on *Salix* and flies between May and August. Finally, *Stigmella dryadella* (Hoffman 1868) lives on *Dryas* that can only be found high up in the mountains and the species flies in July (nrm.se 2013-05-22). The Nepticulidae are sometimes considered as pests when they attack ornamental plants and coffee and Adeliinae have been proposed as a potential biological control against this (Warton et al. 1997).

2 Method

2.1 Introduction to hymenoptera and an overview of the material

The first week of the thesis work was used for sorting of hymenopterans to get an overview of this mega-diverse group of insects and to understand where the small group of wasps that was to be the main focus of this project belonged. Firstly the order was separated into subgroups such as superfamilies and families (approximately 30 different) based on different characters. One of the families, Braconidae, was then further separated into its 31 Swedish subfamilies, one of which is the Adeliinae. This sorting was performed using a “dual-microscope” where two persons simultaneously can watch through the same lens of the microscope. By taking turns of being the observer and the sorter with an SMTP expert I could sort out myself Adeliinae wasps from a large sample of other hymenopterans to be used later in this study. The SMTP had from about six million Hymenopterans and half a million Braconidae separated 140 specimens of Adeliinae wasps which would be used in this project.

2.2 Preparation of material and mounting of insects

The entirety of the SMTP Adeliinae wasps were contained in ethanol 95 % since that is the liquid in which the insects are trapped and killed when collected. The decision was early made to mount the wasps on paper triangles in nearly identical poses since that would make it easier to quickly go through all the material and compare the individuals. Approximately a week was used for the mounting of the 140 specimens of Adeliinae attained from the SMTP collection. The process of mounting insects can be performed in many different ways such as piercing the insects with needles or by gluing them to a piece of paper. Since the Adeliinae are small wasps of only a couple of millimeters glue was favored over needles. Each of the wasps were removed from the ethanol and placed on a piece of paper to dry, every one of them with their heads facing right. The tip of a paper triangle was dipped in glue (a starch based wallpaper glue), the excess removed with a needle, and then very carefully pressed down upon the dried wasp gluing the tip together with the mesosoma and the wings of one side of the wasp. Thereafter, the paper was lifted and flipped upside-down showing the attached wasp, in these moments before the glue dried small adjustments could be made to make sure that all the vital parts were showing and that the animal was properly attached. A needle was then thread through the base of the paper triangle as well as through other papers containing information about individual number, trap of origin and who had determined it to Adeliinae.

2.2.1 Determination of sex

Since there can be a substantial difference in morphology between the different genders of wasps it was essential to determine the sex of the wasps before any conclusions considering appearance was made. The determination was performed before the mounting of the wasps whilst they were still in ethanol. The females can be separated from the males by examining the posterioventral part of the metasoma. The female hypopygeum is clearly elongated and easily separated from the males. The males on the other hand have a fork-like structure covering the penis. Finally, the male sterna were divided in two creating a longitudinal line tracing from the anterior to the posterior of the ventral part of the metasoma which could be seen when examining the wasp from below.

2.3 Examination of material and creation of a matrix

The mounted wasps could now be examined for differences in order to decide which species that were present. It quickly became apparent that two rough groups could be created, one containing the vast majority of wasps that were considered as the *Adelius subfasciatus* group with very dark specimens. The other group contained a few individuals (about 10) which had red/brown colors on their faces and parts of mesosoma as well as radiant yellow legs. This group was preliminary considered as another species and called *A. clandestinus*. The large group of presumed *A. subfasciatus* seemed to contain a lot of polymorphism which was consistent with previous descriptions of the genera (Thomson 1895, Medvedev 1997). There were also individuals who seemed to resemble both groups, for example with black bodies and yellow legs, intermediates that could belong to either group. In order to find any general patterns between the different groups as well as trying to define if certain individuals had the same appearance a matrix was created in Excel. The matrix was made up from a list of the different individuals with columns containing different characters. For each character numbers were given based on which morphology the individual presented. An example: If the tibiae of the first pair of legs were black/brown the column is marked with a zero, if the tibiae is yellow the column is marked with a one. This was performed with more than thirty characters to try to find differences between individuals and similarities that grouped some together. Furthermore, in order to be able to compare differences within *Adelius* an outgroup was needed. Since Cheloninae has been suggested as being to be the closest related subfamily it was used as outgroup by examining 4 individuals (2 males and 2 females) from the genera *Chelonus* in the matrix. The Cheloninae were identified as *Chelonus sp.* using Landin (1971).

2.3.1 Creation of trees using the character matrix

Finding patterns in an extensive character matrix is difficult for the human brain and there are several benefits in using a computer program instead. Mesquite is a free program available online that can handle simple analyses of characters, DNA and more. The character matrix from Excel was first saved as a fasta file, containing only the names of the individuals and the numbers, in order to be imported into Mesquite. The program contains several tools for handling and creating character matrixes but these were not used, the matrix was merely controlled to see that it had been imported correctly. The program also contains tools for the creation of trees that based on the characters places the most similar individuals closer together. In order to find the most parsimonious tree, that is the tree that best explains the relationship with the least amount of changes, a tree search was made. First “Heuristic (Add & rearrange)” was selected in “Tree Search” in “Make new trees block from” which was selected from the folder “Taxa & Trees”. Secondly “Treelength” was selected as the criteria for the search followed by “SPR” (Subtree Pruning and Regrafting) as the type of rearranger.

100 trees were selected in "(MAXTREES)" where you determine how many trees that will be stored during the search. The more trees the greater the chance of finding the best one but the time also increases, 100 were selected since it was the default number. The largest tree took about 30 hours for the program to create. Three trees were created, one for males, one for females and one for all individuals. All characters were used except for the color of the wings, since it was dependent on the sex of the wasps. The finished trees needed to be rooted at the base with *Chelonus* as an outgroup to get a proper orientation of the tree. This was performed by first selecting the *Chelonus* in the tree and then pressing the "Root tree with selected taxa as outgroup" button, which could be found in "Alter/Transform tree" under the folder "Tree" (Maddison & Maddison 2011).

2.4 Mounting and photographing of wings and wasps

The wings of all insects including wasps can be very helpful in determination of species since the wing venation usually vary a lot between different species. In order to be able to simultaneously compare a number of different wings the wings were photographed. This procedure was performed by first detaching one forewing and one hindwing from 24 selected wasps that seemed to differ in venation (all 9 specimens of the supposed *A. clandistinus* were a part of these wasps). The wings were then separately placed between two pieces of glass one containing a scale bar for measuring. Using the Leica DFC 420 camera inside the Leica MZ16 microscope together with the computer software Leica application suite the wings were put in focus with the right amount of light and then photographed. The entire body of some wasps were also photographed from where they were mounted taking several pictures at different focus to cover the entire wasp. All pictures were later put together in Photoshop to create pictures were the entire wasp seems to be in focus. Furthermore, all 3 specimens of *A. subfasciatus* present at the Swedish Museum of Natural History were borrowed as a reference and photographed. Finally, photographs of the holotype *A. subfasciatus*, that is the first captured specimen that was used to describe the species by Haliday 1833, were received from the Museum of Natural History in Dublin to further use as a reference.

2.5 Examining the ecology of Adeliinae

The trap and collection identification (ID) from the SMTP traps in which the wasps had been collected contained a great deal of information considering position of the trap, what kind of habitat it was placed in and at what time of year it was emptied. This information could be used to create maps of the distribution of the wasps, draw ecological conclusions from the types of habitats and calculate flight time of the adult wasps.

2.5.1 Calculation of flight time

The flight time was calculated using the dates when traps had been set up and emptied. This information was presented in dates of different years (for example 2003.iv.23-2003.v.13), however, in order to compare all dates for all the 140 wasps the dates had to be transformed into number of days of the year, for example: 2003.iv.23 becomes day 113. This also took into consideration the leap years of 2004 and 2008. All start and stop days of the 140 wasps were put into a graph in Excel where the distribution became apparent. Since some traps were collected during longer periods than 14 days, especially in spring and winter, there was a large uncertainty of the start and stop of the flight time during a season. Therefore, in the spring when the first individual wasp was collected the stop day or day of emptying was used since from that day one could be certain that a wasp had been flying. Whether the wasp was trapped 1 or 20 days before is unknown. The same procedure was used for the autumn but there the last start day of a trap was used.

2.5.2 Creating maps of distribution in GIS

In ArcMap, a component in Esri's ArcGIS, maps were created to show the distribution of Adeliinae in Sweden using the information from the SMTP traps. First, a layer was created showing the borders of Sweden with surrounding seas. The coordinate system RT90 2,5 gon V was added to the map so that the GPS coordinates from the traps could be added. However, the coordinates from the SMTP traps were in WGS 84, another system, and had to be converted into RT 90 first using the webpage rl.se/rt90 2013-05-20. The converted coordinates were then aligned in an Excel sheet before they were imported as a new dot layer in ArcMap using the “Add XY data” tool. 3 layers were created, one for the traps containing only *A. subfasciatus*, one for the traps only containing *A. clandistinus* and one layer for traps containing both species. By doing this each layer could be manipulated showing different colors for each species as well as altering the size of the dots depending on the amount of wasps trapped in each specific trap.

3 Results

3.1 Results concerning morphology

The study of the 140 Adeliinae wasps showed proof of the vast polymorphism of the group. It is though difficult to determine what is a morphologically separate species and what is only a different morph of a species. One group clearly stood out with their red heads and yellow legs, the group determined to *A. clandistinus* by Cees van Achterberg. This is clearly another species than *A. subfasciatus* and is thereby new for Sweden. However, the determination as *A. clandistinus* is not certain since the original description of that species by Förster 1851 states that it has got a black head and red legs, not a red head and yellow legs. Therefore, until further studies are made it can only be said that there are more than one species of Adeliinae in Sweden and it is unknown whether this species is known to science or if it is a hitherto undescribed species. For the remainder of this article the other species will be referred to as *A. clandistinus* for practical matters. The dimorphism between females and males were also clear with 98 % of the females having more or less dark sooty areas on their fore wings, under the pterostigma. There was only one female with hyaline wings.

There were a number of characters that did not vary between any of the specimens. All wasps had an occipital carina as well as a malar suture present on their heads. The three first terga on the metasoma were always fused into a synterga. Finally, the antennal segments were always 20, regardless of sex or species. The only exceptions were when the antenna was broken and the segments could not be counted. This fixed number of segments does not apply to all species of Braconidae. For example, within the Opiinae species *Opius dissitus* the number of segments can vary between 19 and 24 (Karlsson & Ronquist 2012).

The trees supplied from the character matrixes all support the suggestion of a new species placing the colored wasps closest to the outgroup *Chelonus* (figures 4, 5 and 6). There were also several specimens placed in the same groups as this supposed new species that had some resemblance with it but not as clear colors. These individuals seemed like a mix of the two species and it is difficult to say whether they belong to one or the other of the two species or if they belong to a third. Concerning the *A. subfasciatus* group there appeared to be several clusters in the large tree (figure 4) indicating that there were several distinct morphologies within the group. These clusters were more or less the same in the trees that separated males from females (figures 5 and 6) with a number of small changes of individuals being moved to other clusters. It remains uncertain if this indicates polymorphism within the species or that there are a number of different species and a molecular study of the DNA of the wasps is needed to be certain. For the complete character matrixes as well as explanations of the characters see appendix 1.

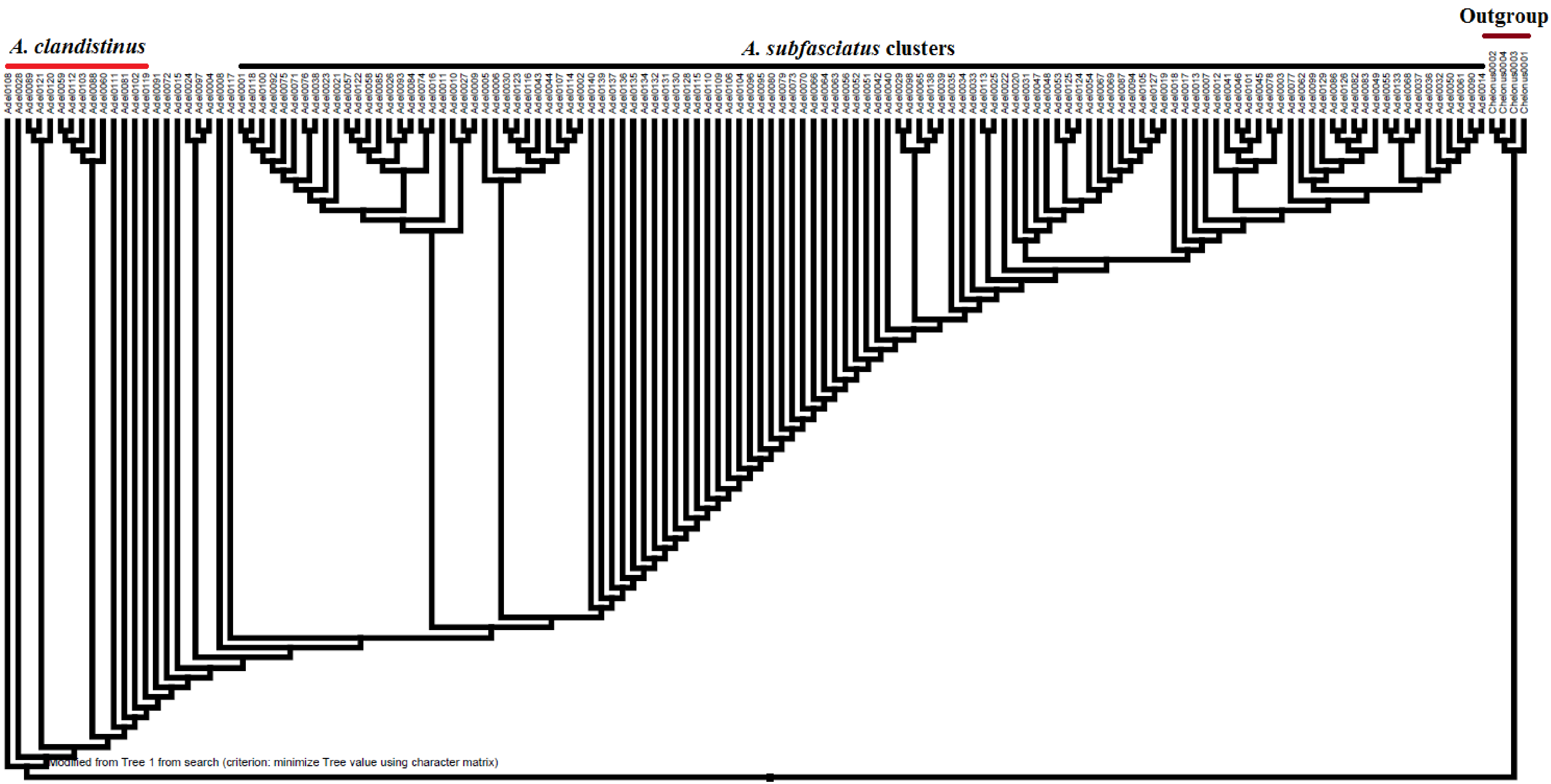

Figure 4. Tree created in Mesquite based on the character matrix showing the morphological relationships between all 140 specimens of Adeliinae and the 4 specimens of Cheloninae. Marked in red is the cluster containing the supposed new species temporarily called *A. clandistinus* as well as some individuals that resemble this species but with less vivid colors. Marked in black are the many clusters of *A. subfasciatus* showing the variety in morphology of that group. In between the two different species there is an unmarked group of wasps that could belong to either species. The outgroup of *Chelonus* is marked in brown on the far right.

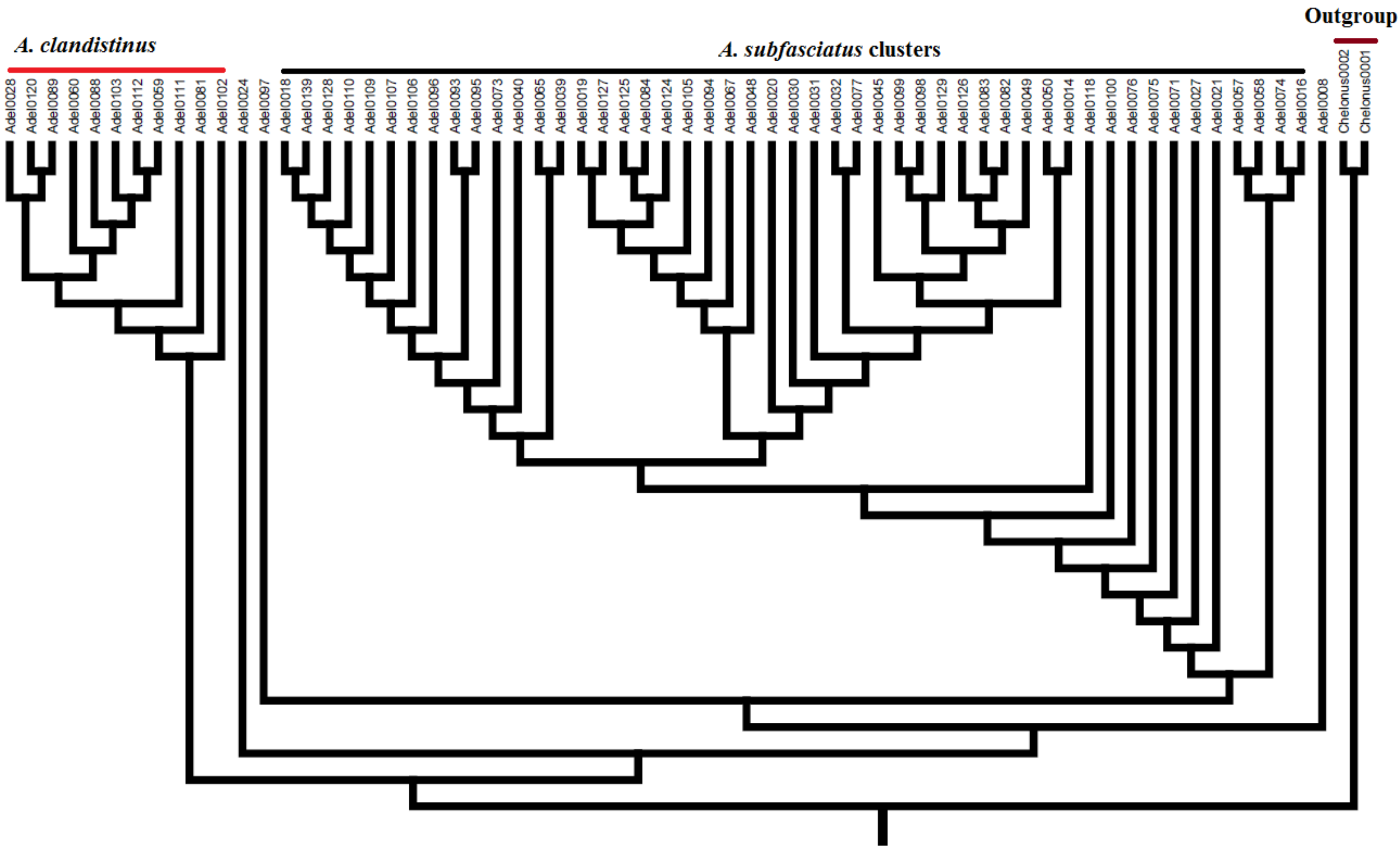

Figure 5. Tree created in Mesquite based on the character matrix showing the morphological relationships between all 63 female Adeliinae as well as 2 female Cheloninae. Marked in red is the cluster containing the supposed new species temporarily called *A. clandistinus* as well as some individuals that resemble this species but with less vivid colors. Marked in black are the many clusters of *A. subfasciatus* showing the variety in morphology of that group. All unmarked individuals are wasps that could belong to either species. The outgroup of *Chelonus* is marked in brown on the far right.

The male tree (figure 6) resembles the tree containing all Adeliinae (figure 4) to a great extent which is clearly visible. The female tree (figure 5) might first seem different from the others but this is mostly due to the fact that Mesquite has shifted the orientation of some of the branches and a closer look shows that many of the clusters are the same as in both figure 4 and 6. There appears to be a strange area in the middle of figure 4 and 6 which can also be found in figure 5 where there seems to be many individuals each separated by a single difference making the area in the tree look like a stairway. A closer look at the matrix showed that these individuals were very similar, many identical, and the shape is a result of Mesquites modeling of trees. This is just one of the many clusters that are more or less the same in all trees and indicates a clear morphological type of *A. subfasciatus* that for now remains within that species.

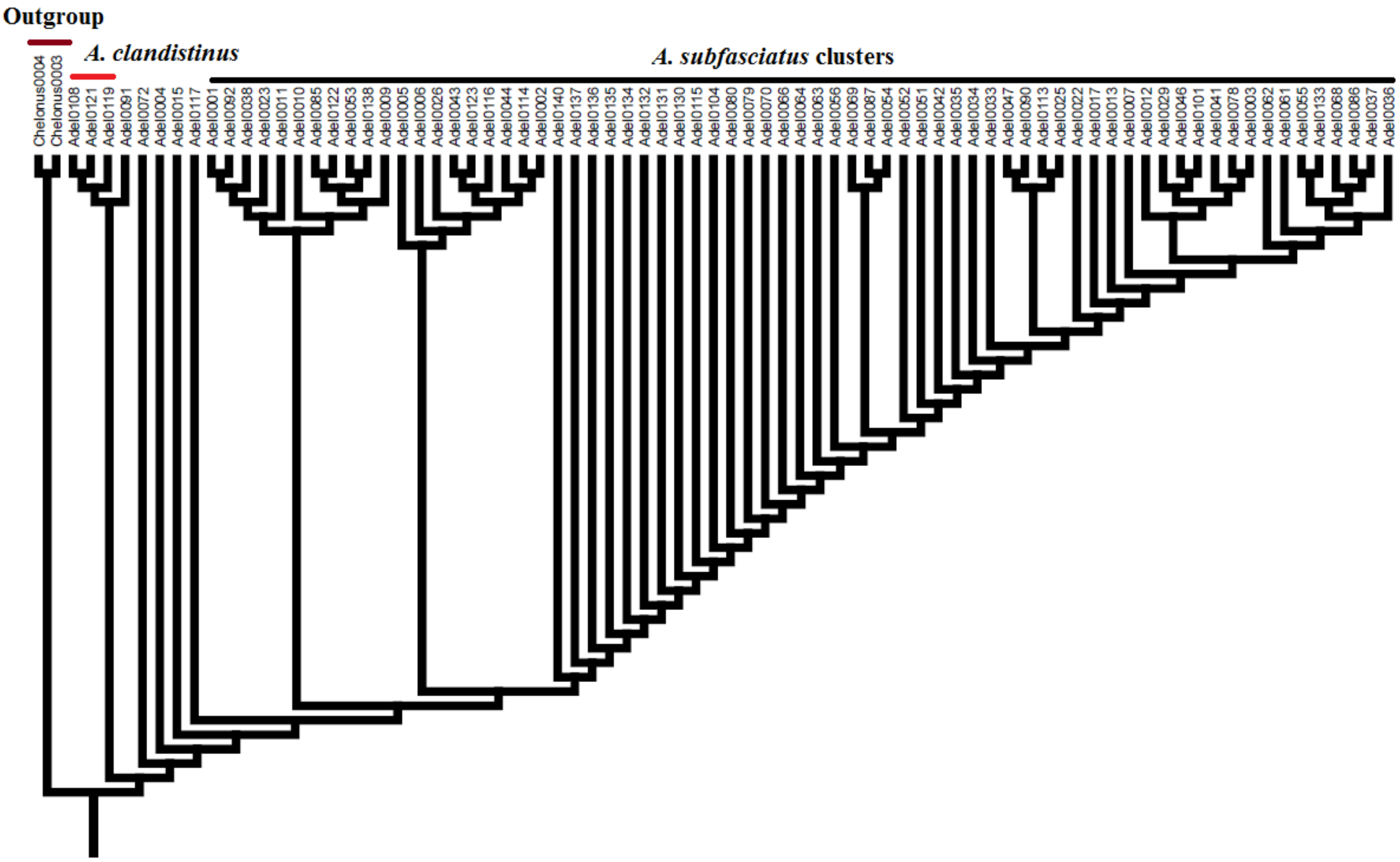

Figure 6. Tree created in Mesquite based on the character matrix showing the morphological relationships between all 77 male Adeliinae as well as 2 male Cheloninae. Marked in red is the cluster containing the supposed new species temporarily called *A. clandistinus* as well as some individuals that resemble this species but with less vivid colors. Marked in black are the many clusters of *A. subfasciatus* showing the variety in morphology of that group. In between the two different species there is an unmarked group of wasps that could belong to either species. The outgroup of *Chelonus* is marked in brown on the far left.

When comparing the SMTP material with the references from the Museums of Natural History from Sweden and Dublin there were clear differences between the collections. The holotype *A. subfasciatus* (figure 7C) was very dark almost compleatly black with evenly brown antenna which matched well with the supposed *A. subfasciatus* from the SMTP material (figures 7A and 7B). However, the *A. subfasciatus* from the Swedish Museum of Natural History (figure 7D) did not match the others since it had a brighter brown color with yellow front and middle legs as well as a brighter base of the antenna (all 3 specimens were the same). These did more seem to resemble the supposed *A. clandistinus* (figures 7E and 7F) which also had brighter bases on the antenna, browner color of the mesosoma, yellow front and middle legs as well as red heads. Whether this means that the collection of the Swedish Museum of Natural History is incorrectly determined or that the species has a huge variance in color is also something that future molecular studies will have to tell.

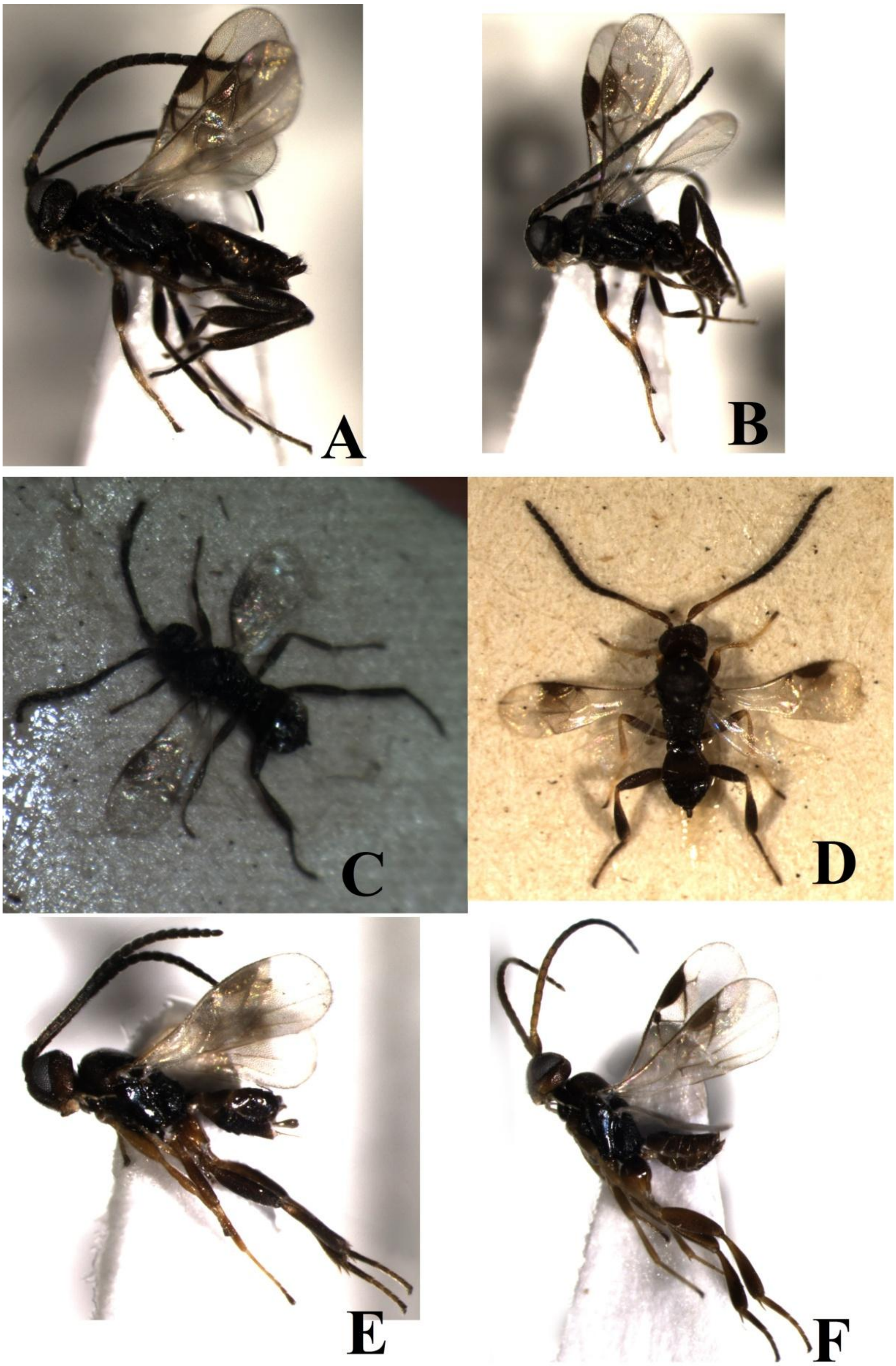

Figure 7A-7F. A: Female *A. subfasciatus*. B: Male *A. subfasciatus*. C: Holotype of a female *A. subfasciatus* from the Museum of Natural History in Dublin. D: Female *A. subfasciatus* from the Swedish Museum of Natural History. E: Female of the supposed *A. clandistinus*. F: Male of the supposed *A. clandistinus*. Note that the pictures are of different magnification and that the color is much less apparent than it is in the microscope. Figures A, B, D, E and F photographed by M. Eriksson.

3.1.1 Variation in wing venation

There were several interesting characters in the wings that varied a lot between the different specimens, three of which have been described in figure 3. To illustrate this variety consider figure 8, A and B. In A the veins of Area 1 clearly reach each other at the pterostigma whilst in B they do not. In A the veins of Area 2 meet to form a cross but they do not in B. Finally, in A the veins of Area 3 form another cross which they do not in B. Both forewings are from males of *A. subfasciatus* and among the males and females of both species all kinds of combinations were present. Thereby, no clear patterns could be seen separating males from females or the two species from each other but the variation is clearly visible. No clear differences could be found on the hindwings either, mostly since the venation is reduced and barely visible. For all wings see appendix 2.

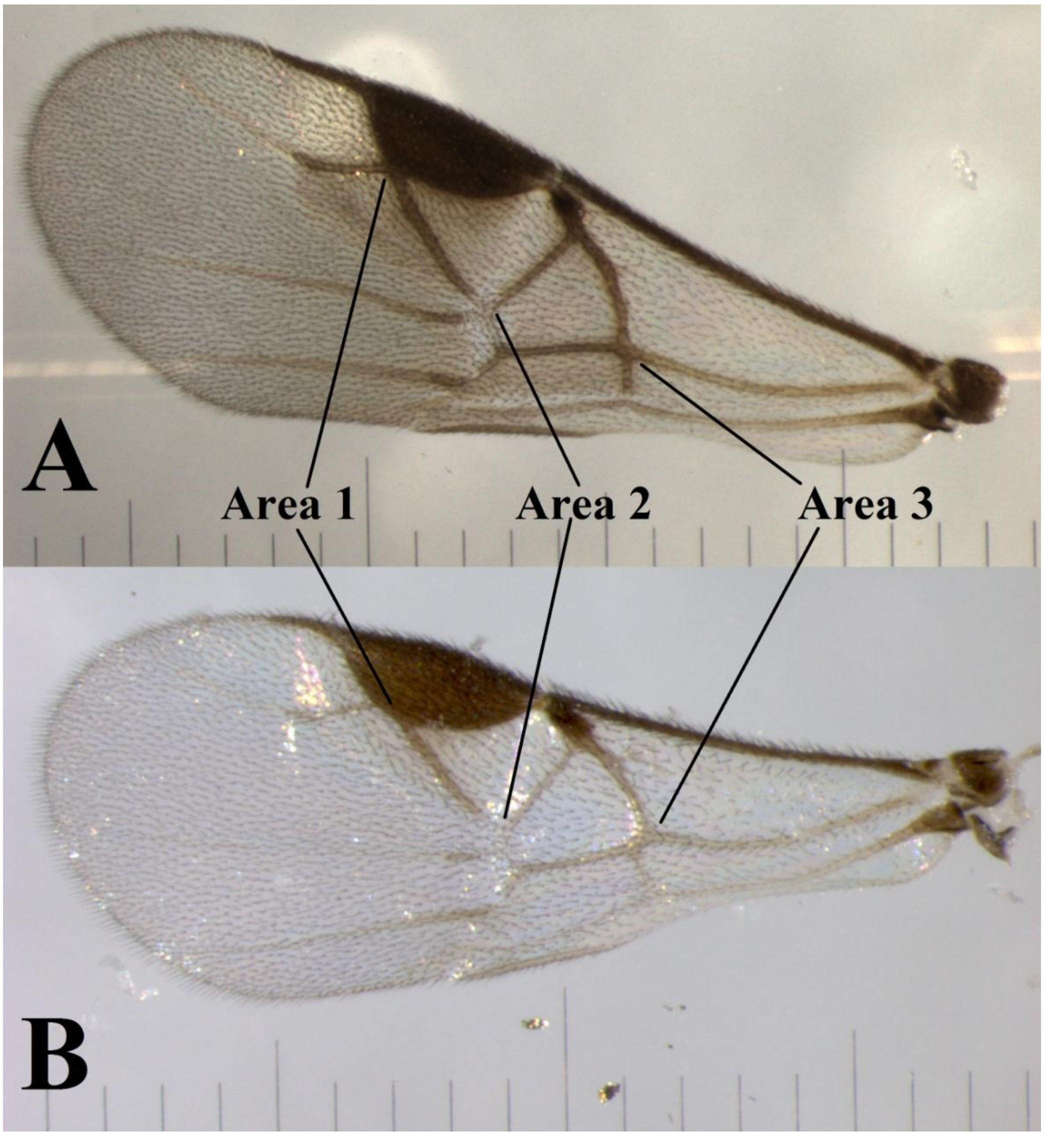

Figure 8. Two forewings of male *A. subfasciatus* showing differences in venation at three particular sites where A is clearly different from B. In Area 1 the veins reach each other at the pterostigma in A but not in B. In both Area 2 and 3 the veins form crosses in A but not in B. The scale bar shows tenths of a millimetre. Photographs by M. Eriksson.

3.2 Distribution, habitat type and flight time

The maps over the distribution of the Adeliinae wasps showed that they are spread all throughout Sweden, from Sandhammaren in the southern tip to the bare mountains of Abisko in the north (figure 9). They are found both near the coast and far from it. However, since it is difficult to cover such a large area as Sweden with only 75 traps there are several gaps in the data, for example in the western part of Sweden along the border to Norway. Nevertheless, the data available is quite evenly spread indicating that the wasps are present in all of Sweden. When comparing the distribution of the different species it seems that both are spread widely although there is significantly more data for *A. subfasciatus*. The supposed *A. clandistinus* is only found in 6 traps but these cover the south, east, west, north and middle of Sweden giving a similarly wide range making the two species overlap in distribution. There were only 2 traps in which only *A. clandistinus* was found but these were not far from traps where *A. subfasciatus* had been found. The Adeliinae have been found in 30 of the 75 traps and this will probably increase when more of the SMTP material is sorted.

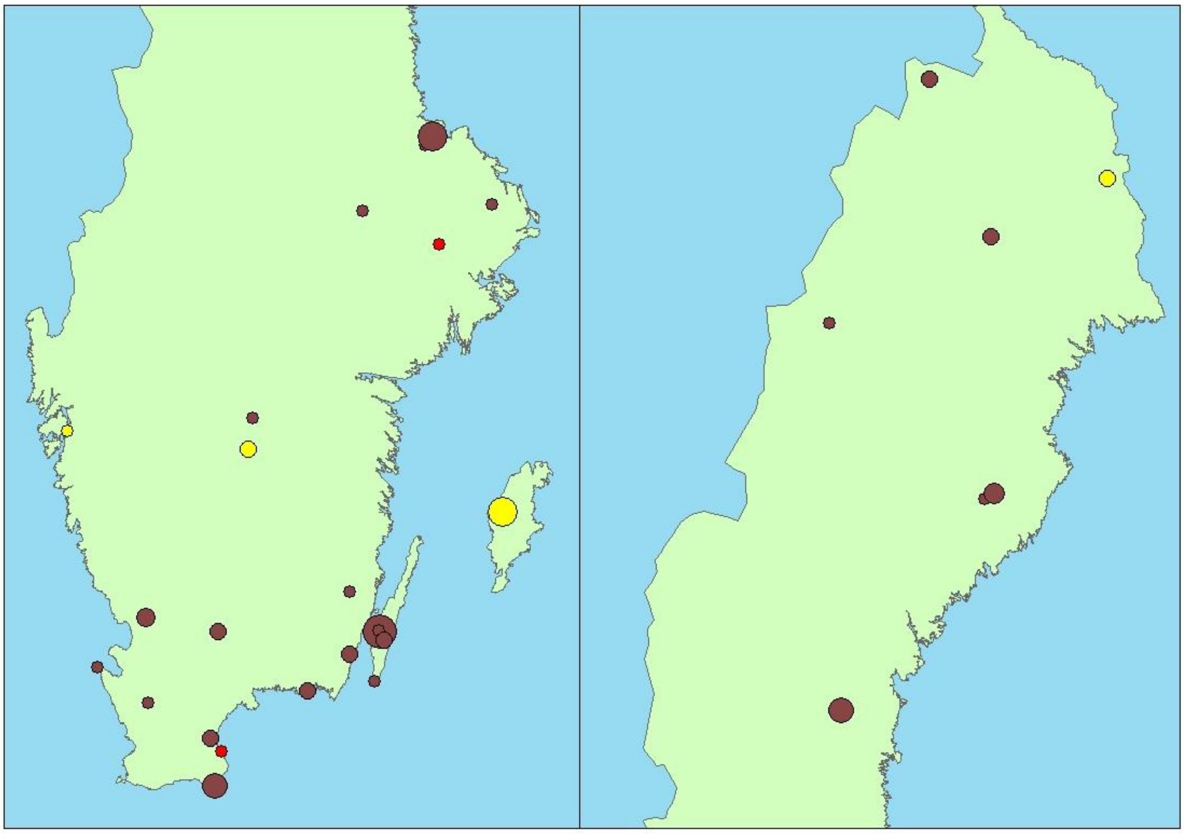

Figure 9. Distribution map for Adeliinae in Sweden. Brown dots show traps in which *A. subfasciatus* have been found, red dots where the supposed *A. clandistinus* have been found and yellow dots where both species have been found. The size of the dots indicates the number of wasps caught in each trap the largest being 17 in a trap on Öland.

Concerning the habitats in which the Adeliinae were caught there were no clear patterns for the entire group or for the different species. Examples of habitat types where the wasps were caught are: marsh, pine, spruce, heath, meadow, bog, beech forest, ash forest, lichen heath, garden, bare mountain, birch forest, pastures, oak forest, mixed forest, alvar and elm forest. Truly a huge variety of different ecosystems that probably contain a wide variety of leaf mining Lepidopterans.

The flight time of the Adeliinae wasps was calculated to stretch from the middle of June to the beginning of September, a total of 84 days. However, when considering the outliers the start of the season could increase to the ending of April. Furthermore, the flight period was different when dividing the different parts of Sweden. The southern part Götaland had the longest flight period of 84 days as described above. The middle part Svealand had a flight period from the beginning of July to the ending of August, a total of 57 days. Lastly, the northern part Norrland had the shortest flight period of 30 days from the middle of July to the middle of August.

4 Discussion

The morphological variation present within the Adeliinae collection could be explained in two ways. There is either a single species with a very large amount of polymorphism as supposed by Medvedev (1997) or there is a whole number of species with quite little polymorphism as supposed by Thomson (1895). The first suggestion is supported by the fact that there were specimens that appeared to be intermediates between the two supposed species that could mean that there is only a gradient of morphological difference between two extremes. However, there are several more arguments that support the other suggestion that will be listed below.

The trees show clear clusters formed within the species *A. subfasciatus* that are based on a number of characters keeping these groups together. In theory it would be enough to have two characters that co-vary to separate a species, for example if all individuals in one cluster have both yellow tibia and a similar wing venation they would be considered a separate species. Unfortunately, there were too much data and too little time to consider this and look for characters that were coupled but it would definitely separate the supposed *A. clandistinus* from *A. subfasciatus* since they all had both red heads and yellow fore and middle legs.

An interesting aspect is the fixed number of segments on the antenna. This trait, which is not present in all species of Braconidae (see Karlsson & Ronquist 2010), indicates that there is little variation within the group of Adeliinae. Why should not the number of the antennal segments vary to a similar extent as most other characters? This could mean that every little difference, be it in color or wing venation, would separate that individual as a new species with very little polymorphism within each species. In that case, instead of one or two species it could reach more than twenty.

The variation in wing venation also supports the suggestion of several species of Adeliinae. Wing venation is of course important for the function of the wings and is often used in keys for determining species. Variation in wing venation should be reduced by the fact that the wings have such an important function and mutants with useless wings should be selected against. In the sample of 24 forewings there were variation in at least three different characters but no clear patterns could be seen linking any of the characters or separating the sexes and species from each other. Unfortunately, there was not time to examine the wings of all 140 wasps and to include the results in the character matrix. Still, the wings could prove to be the key in separating the supposed different species from each other.

Apart from the differences in morphology the ecology of the wasps could help in determining the number of species present. It has previously been shown that most parasitoid Braconidae are host specific and only attack one or two species of Lepidopterans (Smith et al. 2008). There are 61 species of *Stigmella* recorded in Sweden, each a potential host species for Adeliinae and these leaf mining moths are also quite specific in their choice of host plant. When considering the distribution of the wasps presented in this work one can state that the same plants are not present in the most Southern tip of Sweden as in the bare mountains of the north. Thereby, the same species of host Lepidopterans cannot be found in all of the areas where the Adeliinae wasps have been found. This could imply that the wasps are generalists that attack several species or more likely that they specialize in different species and that there are different species of wasps present in the north compared to the south. It must take a great deal of specialization for the wasps to be able to first find the proper plant, then detect a leaf mine that belongs to the right species and finally for the wasp larva to survive inside the host larva. There must be a huge selection on the wasp larva to survive the attacks from the host's immune system as well as a selection on the host to develop better defenses which would lead to an evolutionary arms race and further induce the creation of new species.

Concerning the types of habitats there was a huge variety. All kinds of deciduous forests were present, from elm and ash to oak forest presenting a number of different species of trees for the leaf miners to attack. In the coniferous forests with pine and spruce one can expect the leaf miners to mine on shrubs and the few deciduous trees present. However, there were several examples of traps far from forests such as alvar, bare mountain and pastures. Once again it is probably the smaller herbs and shrubs that are the main targets for the leaf miners in these areas. This variety of habitats further supports the suggestion of there being different kinds of *Stigmella* species present at the different traps, probably with different species of Adeliinae as a result.

If the suggestion of specialization is true there could be as many as 61 species of Adeliinae, one per each species of *Stigmella*, present in Sweden. This does not even have to be morphologically visible since there could be so called cryptic species, species that look the same but have different ecology and behavior which prevents them from mating with each other. The only way to detect these cryptic species is to perform a molecular analysis of the DNA of the wasps and combine it with ecological studies that prove that the host choice is different and that wasps with different hosts does not mate.

Concerning the dimorphism of the wasps it was clear that there is a difference with the wings. Females have a black sooty area under the pterostigma that the males lack. There was only one female out of 63 that did not show this dark area and whether this is due to a mutation or because that female belongs to a different species is unknown. However, except for this character there does not seem to be as much of a difference between the sexes as predicted. The trees created in Mesquite were based on all characters from the matrix except for the wing color. If there was a difference in morphology between the sexes we would expect to see the males and females separated in different clusters within the tree. There is one cluster where this seems to be true but over all there does not seem to be much of a separation. The separated trees for males or females showed a clear resemblance with the tree containing all individuals as well as with each other indication that there are groups of Adeliinae with both males and females that share the same morphology.

The meaning of the dimorphism seen in the wings is unclear. What benefit do the females get from having sooty wings and why do not the males share this trait? It could be coupled with mating and that the males are somehow attracted by the color or shade in the wings. This is not very likely though since smell is probably the strongest sense amongst insects and the vision might be limited. Another suggestion is that the dark wings help the females gather heat from the sunlight in order to warm up faster. This would have been supported if the females were clearly larger than the males and needed the extra heat but no such difference in size has been detected. A final possibility is that the dark wings further add to the supposed mimicry of ants. When the Adeliinae wasps run through the foliage with their wings over their backs the wings might separate them from the ants. However, when the wings are darkened by the sooty color they might be less apparent. This leads to the next question: why would the wasps want to mimic ants in the first place? Most ants have some form of protection from predators be it powerful mandibles, venom or formic acid. By resembling ants the Adeliinae wasps might escape predation. That only the females have increased their mimicry might be due to the fact that they are more prone to predation when searching for suitable hosts on plants. The males simply have to fly and find a mate and might not risk the same predation as the females do.

The flight time of the wasps is clearly dependent on the summer period when there are plants for the leaf miners to attack. Therefore, it is not surprising to see that the flight period is shorter in the northern part of Sweden compared to the south. The flight time of the Adeliinae matches the flight time of the *Stigmella* quite well. *Stigmella* attacking *Acer* and *Salix* flies from May to August or September whilst Adeliinae in the south of Sweden flies from June to September. It is during this time that the adult *Stigmella* flies to find a mate and to lay eggs and that is when the adult Adeliinae needs to find hosts for their offspring. *Stigmella* attacking *Dryas* herbs in the bare mountains of northern Sweden only flies in July and the Adeliinae from northern Sweden only flew between July and August, once again matching well.

An interesting aspect of the Adeliinae wasps concerns their numbers and just how rare they are. The subfamily has been described as containing very rare species which is not strange considering that there are only 3 specimens in the collections of the Swedish Museum of Natural History in Stockholm. Since they are very small it is hard to spot them and as a result difficult to catch them with an insect net. This has been one of the major sources for catching and describing insects for the latest centuries and could explain why there are so few specimens of Adeliinae in collections. The malaise traps used in SMTP are passive and capture all insects that fly or crawl into their nets, thereby not discriminating between sizes. This explains why there has been a substantial number of Adeliinae caught in these traps but they are still quite rare compared to many other subfamilies sorted from Braconidae. However, the morphology and behavior of the Adeliinae wasps could indicate that they are more common than previously thought. They have very robust hind legs that suggest that they are good runners and studies have recorded them as running through the vegetation resembling ants (Warton et al. 1997). What if these wasps prefer running over flying and seldom take to flight? This would greatly reduce the probability of Adeliinae wasps being caught in the malaise traps and could indicate that they are more common than was previously thought.

The importance of a study such as this is firstly to prove that even in a country as Sweden, where we assume that most of the flora and fauna is known, there are still massive gaps of information that needs to be filled. Furthermore, the basis for all ecological and conservational studies is the knowledge of what we have, which species that are present and where they are present. Without this knowledge we cannot continue to study their ecology and importance to the ecosystem. Who knows how much some species of tree are dependent on the population of Adeliinae wasps to keep the leaf miners under control? And how can we conserve when we do not know the interactions of the species within an ecosystem or even which species that are present in that ecosystem?

The leaf miners that the Adeliinae wasps parasitize are considered as pests of several ornamental plants and also on some economically important plants such as coffee (Warton et al. 1997). Therefore, Adeliinae wasps have the potential of being used as biological control agents against these leaf miners in order to reduce the damage they do to the vegetation. There are several benefits to using a parasitoid wasp over an insecticide, for example, most parasitoid wasps are very specific in their selection of host. This means that the introduction of such a control agent will only affect a few species of insects, mainly the once that are considered as pest. An insecticide on the other hand will kill most species of insects that are in the area, the majority of the species might not even affect the plant that is being treated. However, a potential risk with a biological control agent is that they could spread and if they are newly introduced to the environment they could have unpredicted effects to the ecosystem possibly causing the extinction of species that for example predated on the pest. Therefore, it is crucial to have an extensive knowledge of the biology of these control agents before they are used to handle pests.

4.1 Possible sources of error

Although the trees give some appreciation of the morphological diversity within Adeliinae there were several problems with them. Unfortunately, trees created in Mesquite cannot show bootstrap values for the different branches, that is measurements of how certain the positioning of the different branches are. Without these we cannot assume that any of the clusters are correct since they might have low bootstrap values. Nevertheless, the trees can give a taste for the variation of the group and are most probably not far from the truth and are good start for this examination. Another thing that would have been good to have is a consensus tree, a combination of all three trees combining the best branches from each tree, selecting branches with the highest bootstrap values. Due to a lack of time and proper computer programs these analyses were not included in this rapport.

Another issue with the work has been selecting valuable and relevant characters for the matrix. Since the most apparent differences seemed to be in color this has been the base for most of the characters. Color can have a substantial role in determining species in some groups whilst in others the color can vary greatly within the species. When wasps are newly hatched from their pupae they all have lighter colors until their exoskeleton has hardened. This leads to the concern of whether difference in color is only due to the age of the wasp and that the brighter colored individuals are simply newly hatched. The concern can probably be discarded though since the time it takes for the exoskeleton to harden is quite short, within an hour for such small wasps. Furthermore, until the exoskeleton has hardened it is unlikely that the wasps venture far and particularly that they would fly into a malaise trap.

Continuing with the characters this rapport has not weighed the characters against each other. This process makes some characters more important than others when determining the relations between the specimens in the trees. Some characters, such as wing venation, are probably more coupled with selection and genes that are more conserved than for example color and might therefore create fewer viable mutants. Therefore, changes in wing venation should have a heavier impact on the trees than changes in the color of the legs.

4.2 Future aspects and studies

It has become clear that a molecular study of the DNA of Adeliinae is necessary in order to determine the number of species present in Sweden. Unfortunately, the DNA of the holotype and the specimens from the Swedish Museum of Natural History cannot be used in such a study but it would be very rewarding to be able to study the morphology especially of the holotype more carefully. After the DNA has been examined and potential species have been separated one could go back to examining the morphology of the analyzed wasps and try to find characters that separate the species. It would also be interesting to try to hatch Nepticulidae and Adeliinae from leaves containing leaf mines and try to match which wasps that parasitize which leaf miner. This could prove if the Adeliinae wasps are generalists or specialists.

Conclusion

This study has shown that there is a distinctly separated variant of Adeliinae present in Sweden that does not resemble the known species *Adelius subfasciatus*. This is proposed as a new species for Sweden although whether it is known to science or not is unclear. The distribution of these minute wasps has shown that they are spread throughout Sweden and appear in a wide variety of habitats. Furthermore, the variation in morphology within *A. subfasciatus* supports the suggestion that there might be more than one species under this name and future molecular and ecological studies will hopefully indicate how many Adeliinae species that are present in Sweden.

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*"If we and the rest of the backboned animals were to disappear overnight, the rest of the world would get on pretty well. But if they (*the invertebrates*) were to disappear the lands ecosystems would collapse.//…// These small creatures are within a few inches* of our feet *wherever we go on land but often they are disregarded. We would do very well to remember them."* –Sir David Attenborough, Life in the Undergrowth

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Appendix 1

Character matrix presenting the ID of the 140 specimens of Adeliinae and 4 specimens of Cheloninae wasps in rows with the 38 characters in columns. ID presents the individual number given to each wasp. M/F is the gender of the wasps where M= male and F= female. The characters 1 to 38 are represented in the top and bottom rows and each individual is given a number for each character. Explanations of the characters as well as the numbers are

ID	M/F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
2	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
3	M	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
4	M	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
5	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
6	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
7	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
8	F	1	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
9	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0
10	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0
11	M	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
12	M	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
13	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
14	F	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
15	M	0	0	2	2	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0
16	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
17	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
18	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
19	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
20	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
21	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
22	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
23	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
24	F	1	0	0	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
25	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0	0
26	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
27	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0
28	F	1	2	2	2	2	2	2	2	1	1	0	1	0	1	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	0	3	0	0	0	0	0	0	0
29	M	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0
30	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	1	0	0	0	0	0
31	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
32	F	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
33	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
34	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
35	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
36	M	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
37	M	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
38	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0
39	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0
40	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
41	M	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
42	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
43	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0
44	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
45	F	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
46	M	0	0	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0
47	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	2	0	0	0	0	0
48	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
49	F	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0
50	F	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
51	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
52	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
53	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0	1	0	0	0	-	-	-	0	1	0	0	0	0	0	0	0
54	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
55	M	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
ID	M/F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38

ID	M/F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
56	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
57	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0
58	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0
59	F	1	2	2	2	2	2	2	2	1	0	0	1	0	1	1	0	1	0	0	0	1	1	1	1	1	1	1	1	1	0	3	0	0	0	0	0	0	0
60	F	1	2	2	2	2	2	2	2	1	0	0	1	0	1	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	0	3	0	0	0	0	0	0	0
61	M	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
62	M	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0
63	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
64	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
65	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0
66	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
67	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
68	M	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
69	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
70	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
71	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
72	M	0	0	2	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	1	1	0	2	0	0	0	0	0	0	0
73	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
74	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
75	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
76	F	1	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0
77	F	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
78	M	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
79	M	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
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81	F	1	2	2	2	1	1	2	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	0	1	0	0	0	0	0	0	0
82	F	1	0	1	2	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	1	1	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0
83	F	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
84	F	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0
85	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0
86	M	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0
87	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
88	F	1	2	2	2	2	2	2	2	1	0	0	1	0	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0
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92	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
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97	F	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	3	0	0	0	0	0	0	0
98	F	1	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0
99	F	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0
100	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	2	0	0	0	0	0	0	0
101	M	0	0	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	2	0	1	0	0	0	0	0
102	F	1	2	2	2	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	2	0	0	0	0	0	0	0
103	F	1	2	2	2	2	2	2	2	1	0	0	1	0	1	1	0	1	0	0	0	1	1	1	1	1	1	1	1	1	0	3	0	0	0	0	0	0	0
104	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
105	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
106	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
107	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
108	M	0	2	2	2	2	2	2	1	1	1	0	1	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	0	3	0	0	0	0	0	0	0
109	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
110	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
111	F	1	2	2	2	2	2	2	2	0	0	0	1	0	1	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	0	3	0	0	0	0	0	0	0
112	F	1	2	2	2	2	2	2	2	1	0	0	1	0	1	1	0	1	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
113	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0	0
114	M	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
115	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
116	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0
ID	M/F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38

ID	M/F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
117	M	0	2	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	2	0	0	0	0	0
118	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
119	M	0	0	2	2	0	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0
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121	M	0	2	2	2	2	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	2	0	2	0	0	0	0	0
122	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	0	1	0	0	0	0	0	0	0
123	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0
124	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
125	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
126	F	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0
127	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
128	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
129	F	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0
130	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
131	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
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137	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
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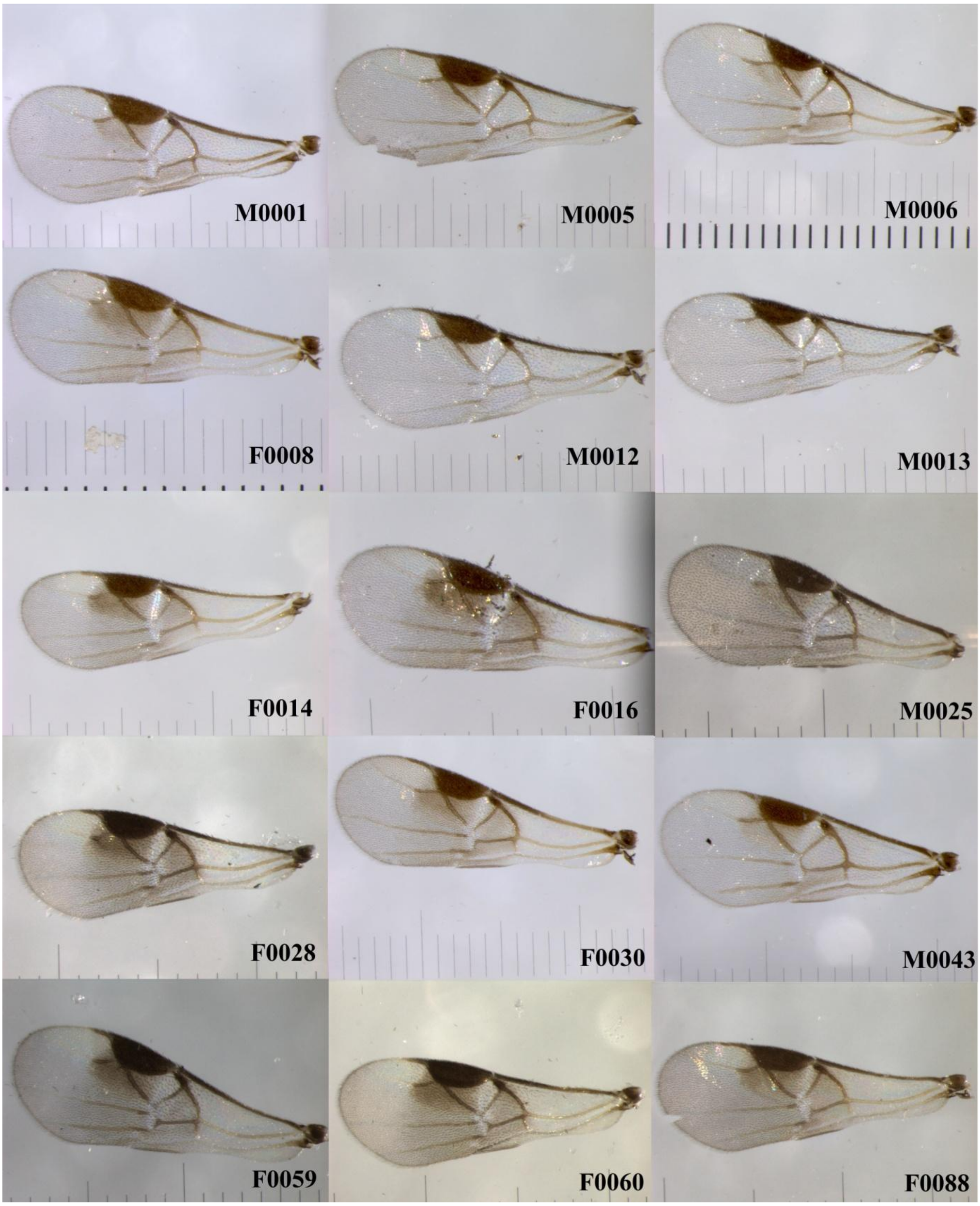
139	F	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
140	M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Ch1	F	0	2	2	2	2	2	2	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	3	1	1	1	1	1 -
Ch2	F	0	0	0	2	0	0	2	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	1	1	1	0	0	3	1	1	1	1	1 -
Ch3	M	0	0	1	2	0	1	2	0	1	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	1	1	1	0	0	3	1	1	1	1	1 -
Ch4	M	0	0	0	2	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	1	1	1	0	0	3	1	1	1	1	1 -
ID	M/F	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38

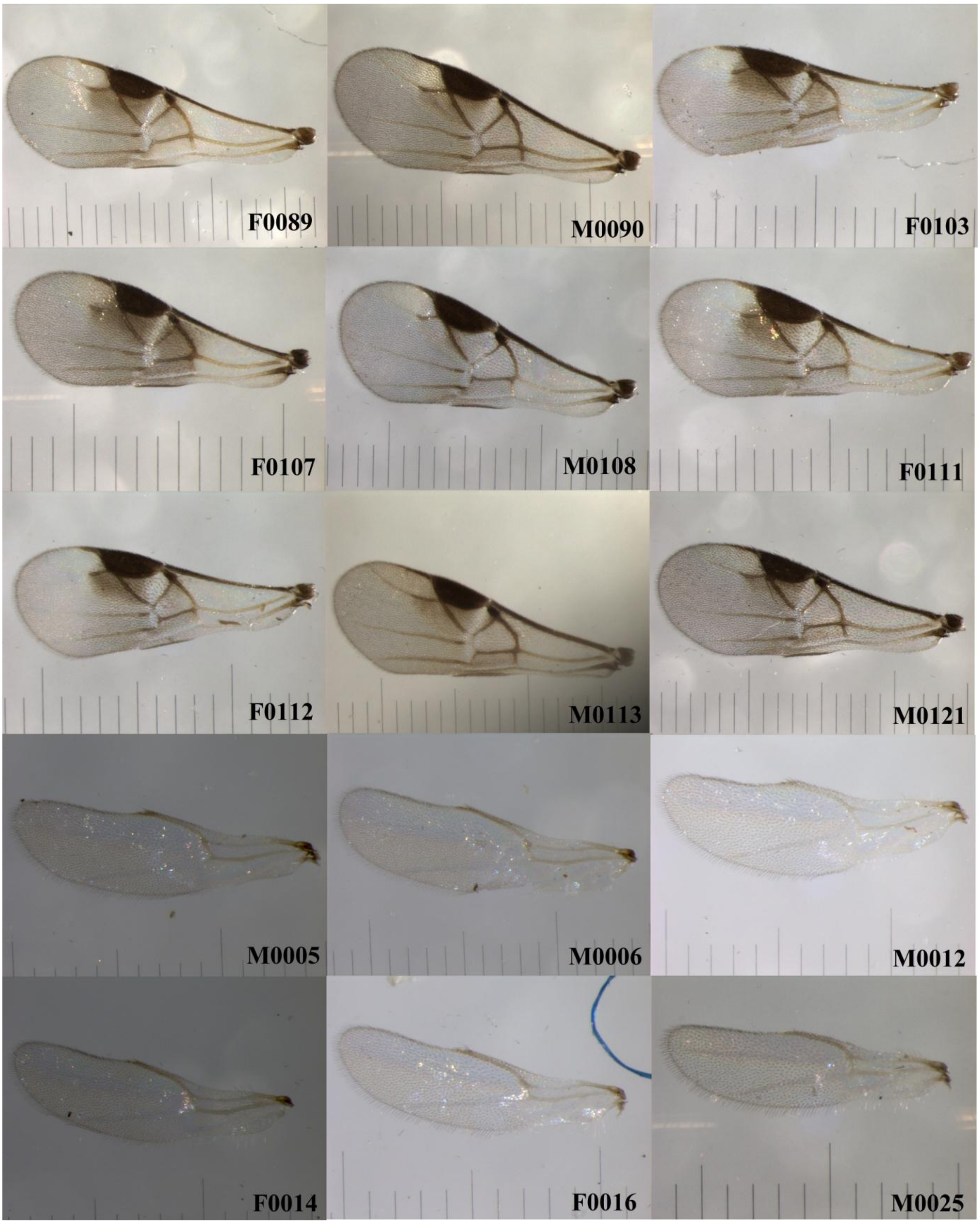
Definitions of characters.
1. Anterior wing 0=entirely hyaline or transparent 1=with fuscous spot/band, that is darker area usually under the pterostigma.
2-10. Color of the different parts of the front, middle and hind legs or pro, meso and meta which is used here. Brown with elements of yellow refers to parts that are not completely brown or yellow but a mix, usually a band of yellow on a brown part.
2. Color of procoxa 0=dark brown 1=brown with elements of yellow 2=yellow
3. Color of profemur 0=dark brown 1=brown with elements of yellow 2=yellow
4. Color of protibia 0=dark brown 1=brown with elements of yellow 2=yellow
5. Color of mesocoxa 0=dark brown 1=brown with elements of yellow 2=yellow
6. Color of mesofemur 0=dark brown 1=brown with elements of yellow 2=yellow
7. Color of mesotibia 0=dark brown 1=brown with elements of yellow 2=yellow
8. Color of metacoxa 0=dark brown 1=brown with elements of yellow 2=yellow
9. Color of metafemur 0=dark brown 1=brown with elements of yellow 2=yellow
10. Color of metatibia 0=dark brown 1=brown with elements of yellow 2=yellow
11. Number of antennal segments 0=20 1=other -=broken
12. Color of antenna 0=evenly black/brown 1=yellow/red/brighter at base
13. Shape of antennal segments 0=First flagellomere equal in length to scape; pedicel shorter than half of scape 1=other
14. Color of pronotum 0=black 1=red/brown
15. Color of mesopecta 0=black 1=red/brown
16. Color of metapecta 0=black 1=red/brown
17. Color of mesoscutum 0=evenly black 1=brighter red/brown anteriorly, usually the border between mesoscutum and pronotum is seen as brighter than the segments
18. Occipital carina 0=present 1=absent

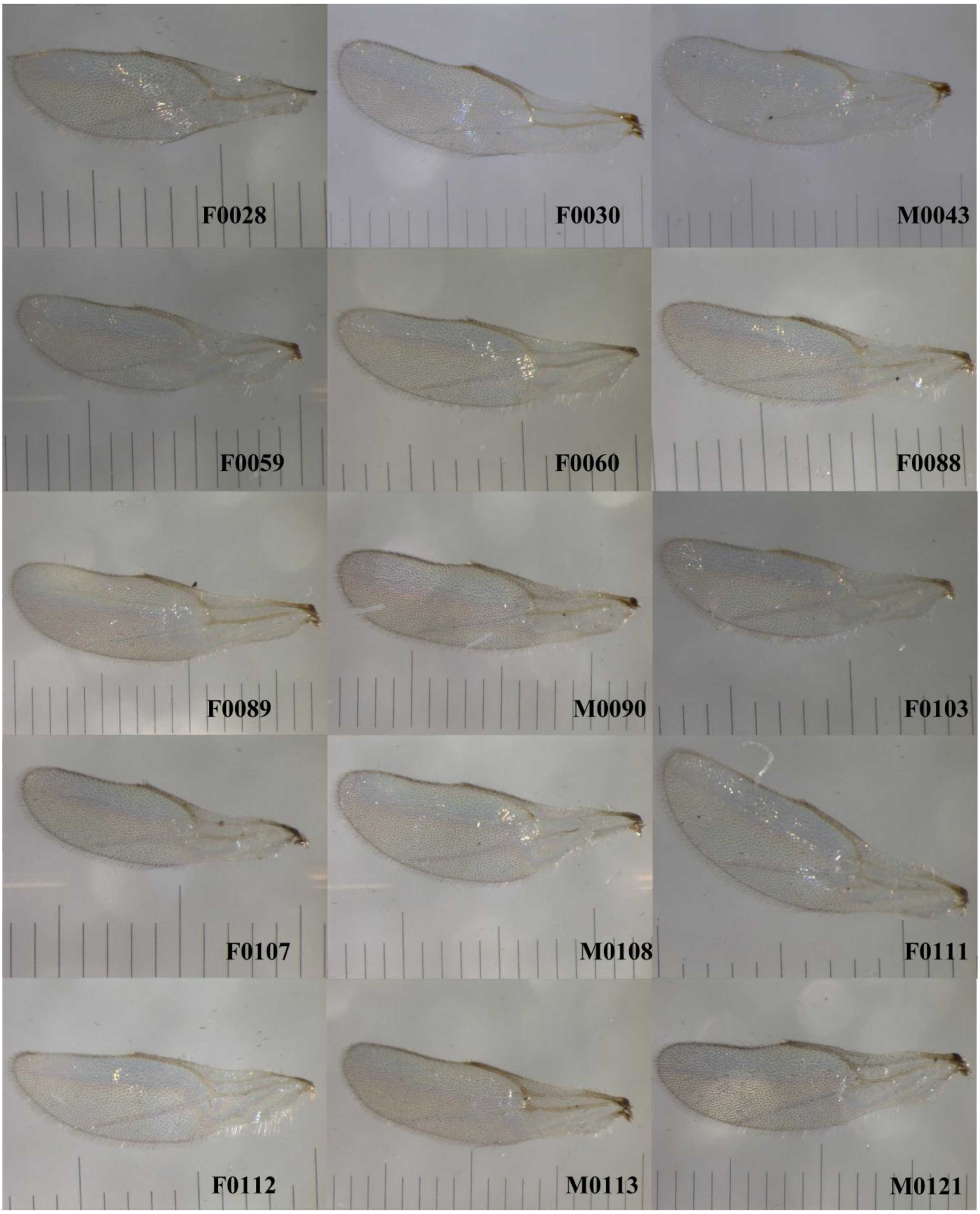
19. Spurs on mesotibia of 0=different length 1=equal length
20. Spurs on metatibia of 0=different length 1=equal length
21-29. The color of the joints between different parts of the front, middle and hind legs. When the joints are brighter this gives an appearance of striped legs. When the legs were yellow this was much harder to define and then the joints were usually described as being equal to the parts of the leg in color.
21. Joint between protrochantellus and profemur 0=brighter than trochantellus and femur 1=equal in color to trochantellus and femur
22. Joint between profemur and protibia 0=brighter than femur and tibia 1=equal in color to femur and tibia
23. Joint between protibia and protarsus 0=brighter than tibia and tarsus 1=equal in color to tibia and tarsus
24. Joint between mesotrochantellus and mesofemur 0=brighter than trochantellus and femur 1=equal in color to trochantellus and femur
25. Joint between mesofemur and mesotibia 0=brighter than femur and tibia 1=equal in color to femur and tibia
26. Joint between mesotibia and mesotarsus 0=brighter than tibia and tarsus 1=equal in color to tibia and tarsus
27. Joint between metatrochantellus and metafemur 0=brighter than trochantellus and femur 1=equal in color to trochantellus and femur
28. Joint between metafemur and metatibia 0=brighter than femur and tibia 1=equal in color to femur and tibia
29. Joint between metatibia and metatarsus 0=brighter than tibia and tarsus 1=equal in color to tibia and tarsus
30. Hair on eyes 0=numerous clearly visible 1=few hardly visible. The main difference here is between *Adelius* and *Chelonus* where the hairs are much finer and harder to detect as well as less numerous in *Chelonus.*
31. Color of clypeus and face 0=both black 1=face black clypeus brown 2=face black clypeus yellow 3=face red clypeus yellow
32. Malar suture 0=present 1=absent. This is the tiny groove that can be seen running between the edge of the clypeus and the bottom of the complex eyes.
33. Wing venation. 0=3RS & 2RS meets stigma far apart 1=3RS & 2RS meet stigma close together 2=3RS meets 2RS at stigma 3=other. These characters are further discussed in the section concerning wing characters.
34. Synterga 0=Present 1=Absent. The 3 first abdominal terga are fused into a synterga.
35. Carapax 0=Absent 1=Present. The abdominal terga are fused into a hard shell-like structure that is very easy to detect called a carapax.
36. Second sub marginal cell in forewing 0=Absent 1=Present
37. Anal vein in hind wing 0=Absent 1=Present
38. 3RS 0=Tubular part not reaching edge of forewing 1=Tubular part reaching edge of forewing. Tubular meaning that the structure of the vein 3RS is clearly visible and tube like. In *Adelius* the vein becomes almost invisible before reaching the edge of the wing.

Appendix 2

All the photographed wings are presented below starting with the forewings. Each wing is named with its individual ID as well as an M or F for male or female. Scale bar shows tenths of a millimeter. Photographs by M. Eriksson.




F0089
M0090
F0103
F0107
M0108
F0111
F0112
M0113
M0121
M0005
M0006
M0012
F0014
F0016
M0025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