Phylogenetic analysis and revision of the Nearctic *Androprosopa* Mik (Diptera: Thaumaleidae) with an emphasis on the western species

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I am submitting herewith a thesis written by Robert John Pivar entitled "Phylogenetic analysis and revision of the Nearctic Androprosopa Mik (Diptera: Thaumaleidae) with an emphasis on the western species." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Entomology and Plant Pathology.

John K. Moulton, Major Professor

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(Original signatures are on file with official student records.)
Phylogenetic analysis and revision of the Nearctic *Androprosopa* Mik (Diptera: Thaumaleidae) with an emphasis on the western species

A Thesis Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Robert John Pivar
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Abstract

The family Thaumaleidae, also known as seepage midges, is an uncommonly encountered, understudied family of aquatic Diptera compared to its sister group, the Simuliidae. The goal of this project was to assess species diversity of the Nearctic Thaumaleidae and determine relationships among them. The western Nearctic fauna of Androprosopa Mik is revised to include twenty-eight species, six of which are described as new to science. Descriptions of the adult males of A. apache, A. arnaudi, A. magnipelvim, A. rainierensis, A. sierra and A. uvas are provided. Redescriptions of all remaining species are also provided, as well as genitalic illustrations, updated distribution maps, and a dichotomous key to males of all western Nearctic Androprosopa. Molecular phylogenetic analyses were conducted to determine relationships between eastern and western Nearctic Androprosopa species and between the more structurally heterogeneous western species. Fresh, molecular-grade material was gathered for all Nearctic species, except seven (A. arnaudi, A. fusca, A. sonorensis, A. schmidiana, A. uvas, A. zelmae and A. zempoala) that eluded capture. Molecular sequence data from two nuclear protein-coding genes, big zinc finger (BZF) and molybdenum cofactor sulfurase (MCS) were acquired using the polymerase chain reaction and Sanger sequencing methods. Analyses using maximum parsimony, maximum likelihood and Bayesian inference methods were conducted. Resulting phylogenies supported monophyly of the western Nearctic species; however, relationships between the western and eastern species were unresolved, as were the relationships between the eastern Nearctic, western Nearctic, and Palearctic species. Based upon both structural and molecular data, six new species groups within the western Nearctic fauna are proposed.
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Chapter 1:

General Introduction and Literature Review
The Importance of Diptera

The order Diptera (the true flies) is one of the four megadiverse insect orders, containing over 160,000 described species and comprising 10-15% of known animal species (Brown 2005; Courtney et al. 2009; Marshall 2012; Woodley et al. 2009; Yeates et al. 2007). Despite these numbers, experts believe that this represents only a small fraction of the diversity of the order and that the actual number of species may exceed one million (Hammond 1992). Flies are found worldwide on every continent and occupy, if not dominate, a wide variety of niches (Brown 2009; Marshall 2012). It is due to their ability to occupy seemingly endless niches, ability to disperse, small size and relative scarcity of researchers that Dipteran systematic research remains a discipline with vast opportunities for discovery.

Whether it is a negative or positive interaction, flies have a strong impact on humankind. No other group of animals has as much impact on human health than flies, mainly due to their ability to act as vectors for many pathogens, including *Plasmodium* spp. (Hall & Gerhardt 2009; Marshall 2012). Another way in which flies have a negative impact on humans is as plant pests. This effect is due to pathogen transmission and by being in direct competition for human food and forest crops (Curran 1965; Marshall 2012). Many species, however, play important positive roles for humankind, such as pollination, biological control, medical or forensic applications and the decomposition of plant and animal matter (Curran 1965; Brown 2009). Decades of extensive research have provided valuable knowledge on the economic importance of flies and this knowledge base continues to grow. However, in order to fully understand what pest is being dealt with or the ecology of a certain pollinator, we must attempt to realize the diversity and evolutionary relationships of Diptera. These two areas of study are only beginning to be understood for many dipteran taxa and continued systematic research will contribute to the knowledge base and reveal insight into how various species function within ecosystem processes.
Biology of Thaumaleidae

The Thaumaleidae, or madicolous midges, are a family of Diptera that is specialized for a specific type of aquatic environment. They are small (2-5mm long), stocky flies that are typically brown or black, though some may be orange or even bright yellow. They are found worldwide on all continents except Antarctica (Vaillant 1977; Sinclair & Saigusa 2002). Larvae are found in the madicolous habitat (Vaillant 1956; Sinclair & Marshall 1987; Sinclair & Stuckenberg 1995). These habitats are characterized by thin films (2 mm or less) of flowing water over various substrates (e.g., rock, mud or moss) and are also known as hygropetric zones (Vaillant 1956; Mackie 2004). Examples of such habitats include rock-face seepages (either natural or man-made), cascading streams, splash zones near waterfalls, and boulders in fast moving streams (Sinclair 2000). The larvae must be in films of no more than 1mm in depth, so the dorsum of the larva remains out of the water, which prevents drowning (Vaillant 1956; McLellan 1988). The morphological adaptations that permit thaumaleid larvae to both breathe and stay anchored within the flow are the presence of an unpaired prothoracic proleg, an unpaired anal proleg, and a pair of short respiratory tubes on the prothorax (Theischinger 2004). In addition, the larval integument is reported to be hydrophobic (Vaillant 1956; Hinton 1958), possibly as a result of the layered, reticulated ultrastructure of the dorsal cuticle visible in scanning electron microscope images as illustrated in Boussy et al. (1994). When reacting to disturbances, larvae will exhibit characteristic sidewinding behaviour, in an attempt to evade predators. Larvae feed on diatoms and other detritus that accumulates on the substrate (Hinton 1958; Sinclair 1990; Arnaud & Boussy 1994). Pupation occurs in damp moss, debris or mud that the larvae seek out near the madicolous habitat (Vaillant 1959). Adults are secretive and are infrequently seen. They are poor fliers and never fly far from the larval habitat. They may be seen resting on riparian vegetation or directly on the madicolous substrate or crevices therein (personal observation). The adult diet is unknown.

Due to the restricted habitat and weak flight dispersal ability of the adults, the Thaumaleidae are rarely encountered and understudied. Trapping does not
typically yield favourable results: they are not attracted to any coloured trap, nor are they active fliers; therefore, traps designed around flight interception prove ineffective. However, success has been achieved (albeit rarely) by placing Malaise traps directly above or in front of suitable habitat. New specialized traps may prove useful for collecting as well, such as the madicolous emergent trap developed by Shimabukuro et al. (2015). The best and most efficient method for collecting adult Thaumaleidae is to sweep riparian vegetation near the madicolous substrate. When swept, thaumaleids can often be found at the bottom of the net with their wings folded downwards across a transverse line of weakness near the apex of the subcosta (Theischinger 1986). If sweeping is unsuccessful, the madicolous substrate should be inspected for adults resting on moss, in cracks and crevices, or on the rock face itself, where they may be aspirated. Larvae can simply be plucked from the substrate using forceps or washed down into white pans.

Since the Thaumaleidae are rarely encountered and collected, much taxonomic work remains needed. In order to learn more about the behaviour, ecology and biodiversity of the group, as well as madicolous habitats in general, taxonomic studies are required. These studies are critical to providing stable classifications within the family Thaumaleidae and will serve as a foundation for future ecological studies.

**Classification of Thaumaleidae**

The family Thaumaleidae is a fairly easy group to recognize. Their general habitus, with a stocky build and somewhat humpbacked appearance, resembles that of the Simuliidae. The following characters are used to identify adult Thaumaleidae: uniform wing venation with six or seven veins reaching the wing margin, absence of ocelli, palpus five-segmented and short, and slender antennae that are roughly identical in length to the head (McAlpine 1981). Thaumaleids are generally brownish grey to black; however, there are a small number of species that exhibit orange or yellow colouration (Edwards 1930; Dyar & Shannon 1924; Arnaud &
Boussy 1994). Genitalic characters are the most useful way to distinguish between species, as other structural characters are notably uniform and differences of colour are usually indeterminate (Edwards 1929).

Thaumaleidae belong to the paraphyletic group Nematocera (Courtney et al. 2009; Pape et al. 2011), alternatively known as the long-horned flies or lower Diptera. Early studies aimed to determine the systematic position of the Thaumaleidae resulted in different schools of thought. One proposed classification system was that thaumaleids were most closely related to Psychodidae, based on the transverse line of weakness near the base of the wing, resulting in the characteristic folded wings in death that only these two families share (Bezzi 1913; Edwards 1929). The competing theory to the Thaumaleidae + Psychodidae notion was that thaumaleids are more closely related to Simuliidae and Ceratopogonidae (Saunders 1923; Crampton 1926), the latter studying the pleural sclerites and how they are similar to those of the Simuliidae and Ceratopogonidae. Edwards (1929) noted that the hypopygium of thaumaleids is similar to that of ceratopogonids and simuliids, as well as one genus of psychodid. Later studies have provided strong evidence to support Thaumaleidae + Simuliidae as sister families.

Hennig (1973) recognized four infraorders of lower Diptera, including the Culicomorpha, in which Thaumaleidae is strongly nested. Subsequent studies have agreed with this hypothesis and further placed Thaumaleidae within the superfamily Chironomoidea, together with Simuliidae, Ceratopogonidae, and Chironomidae (Wood & Borkent 1989; Oosterbroek & Courtney 1995; Sinclair et al. 2007). Wood and Borkent (1989) listed two morphological characters that support the inclusion of Thaumaleidae in Chironomoidea: abdominal spiracles with posterior flaps modified into cylindrical procerci and the presence of a prothoracic proleg. The latter character, however, has since been discovered in the first-instar larvae of Corethrella appendiculata Grabham, rendering the Chironomoidea paraphyletic (Borkent & McKeever 1990; Sinclair et al. 2007). A recent monograph by Borkent (2012) used pupal characters to propose a new superfamily known as the Simulioidea (Ceratopogonidae + Thaumaleidae + Simuliidae) where thaumaleids
and simuliiids are sisters. The characteristics that Borkent used to support the Thaumaleidae + Simuliidae group are as follows: egg swollen dorsally, larval stage with at least six instars, short pupal and adult antennae, and wing with fork of Cu situated less than 0.25 the total length of the wing.

Molecular studies of the phylogeny of Diptera have also supported a Thaumaleidae + Simuliidae clade. Pawlowski et al. (1996) were the first to recover this grouping by using partial 28S ribosomal RNA gene sequences, resulting in 100% bootstrap support for this clade, and was an interpretation also supported by Moulton (2000). Bertone et al. (2008) used four nuclear markers (28S rDNA, CAD, TPI and PGD) to resolve relationships among the lower Diptera. This approach resulted in the novel superfamily Simulioidea, consisting of Thaumaleidae + Simuliidae, again with 100% bootstrap support for this topology. This arrangement differs from the Simulioidea proposed by Borkent (2012) using morphology, which also included the Ceratopogonidae. More recently, Wiegmann et al. (2011) used a combination of 14 nuclear loci and complete mitochondrial genomes to provide a phylogenomic estimate of fly relationships, again recovering the Thaumaleidae + Simuliidae clade with >95% bootstrap support and excluding the Ceratopogonidae.

Currently, Thaumaleidae contains approximately 185 described species worldwide, classified within seven genera. The family is most speciose in the Palearctic Region, while the Neotropical and Afrotropical fauna are the least well known with six and three species described, respectively. There is one described extinct species, *Mesothaumalea fossilis* Kovalev, discovered in fossil deposits in Transbaicalia, east of Lake Baikal in Siberia, Russia (Kovalev 1989). These deposits contain fossils from the Upper Jurassic/Early Cretaceous, which date to 145mya. There is a simuliiid fossil from the Jurassic period (176mya), which likely indicates that thaumaleids were present as well (Borkent 2012). The origin and path of how Thaumaleidae may have radiated to their present day distribution remains unknown.

Ruthe described the first thaumaleid in 1831 when he described *Thaumalea testacea* Ruthe, at which time the family was known as Orphnephilidae. Bezzi (1913)
synonymized *Orphinphila* Haliday, 1832 with *Thaumalea* Ruthe, 1831 and adopted the family name Thaumaleidae. Bezzi's paper was the first detailed study of the Thaumaleidae, providing an extensive bibliography, discussing previous studies, as well describing new species. The next large revision of the family was Edwards' 1929 monograph. Edwards recognized the usefulness of adult terminalia in species identification. He also revised all known species at the time and assigned them to four genera: *Androprosopa* Mik, *Austrothaumalea* Tonnoir, *Thaumalea* Ruthe and *Trichothaumalea* Edwards (Edwards 1929). Vaillant and Schmid described most of the Palaearctic fauna, while other scientists described a smaller number of species. The Australasian species belong to three genera (*Austrothaumalea*, *Niphta* Theischinger and *Oterere* McLellan) and are relatively well-known, particularly because of work from Theischinger (1986), McLellan (1988) and Sinclair (2000, 2008a, 2008b). The Neotropics and Afrotropics still require much study. Only six species are known from the Neotropics, all confined to southern Chile and Argentina and sharing the same genera as those in Australasia (Edwards 1930; Schmid 1970; McLellan 1988). Only three Afrotropical species have been described; all are assigned to the genus *Afrothaumalea* Stuckenberg and known only from South Africa (Stuckenberg 1960; Sinclair & Stuckenberg 1995; Sinclair 2015). It is expected that focused collecting in appropriate microhabitats will continue to yield new species worldwide; particularly within the latter two understudied regions.

The Nearctic Region consists of three genera — *Androprosopa*, *Thaumalea* and *Trichothaumalea* — and 29 described species prior to this study. The earliest taxonomic work on the Nearctic Thaumaleidae dates back to Bezzi (1913) in which he described the first Nearctic species, *Androprosopa americana* (Bezzi). There have been numerous *Androprosopa* discoveries since then, which will be discussed later in this chapter. The genus *Trichothaumalea* is rare and it is difficult to predict where it will be collected; but when collected, it seems to be in small numbers. *Trichothaumalea* has an interesting distribution with two species found in western North America, one species in eastern North America, and one species in Japan, exhibiting a Trans-Pacific biogeographic vicariance (Sinclair & Saigusa 2002). The
third genus found in North America is represented by one species, *Thaumalea verralli* Edwards. *Thaumalea verralli* is primarily a Palearctic species whose presence in North America represents the sole Holarctic distribution for any thaumaleid (Sinclair 1996). Sinclair (1996) hypothesized that *T. verralli*'s occurrence in North America is likely due to artificial introduction via ship's ballast, as it has only been collected from one of the oldest seaports in North America, located in St. John's, Newfoundland.

No phylogenies of the Thaumaleidae have been constructed to depict generic or species relationships. Sinclair (pers. comm.) hypothesized generic relationships, indicating that *Thaumalea + Androprosopa* is the sister group to the remaining genera, and that the abbreviated Sc vein is a synapomorphy supporting the *Trichothaumalea + Afrothaumalea + Niphta + Oterere + Austrothaumalea* assemblage. Previously, Sinclair (2000) suggested that the absence of apical, spine-like gonostylar seta in *Afrothaumalea, Niphta, Oterere* and *Austrothaumalea* further supported this hypothesis, but the recent discovery of *Afrothaumalea stuckenbergi* (Sinclair 2015) put this older hypothesis into question. *Afrothaumalea stuckenbergi* has independently derived a crown of gonostylar spines. In *Androprosopa* and *Thaumalea* 1-2 apical spines are usually present. Developing a stable phylogeny of the Thaumaleidae would be extremely useful in testing generic concepts and relationships, particularly amongst the Gondwanan genera.

**Genus Androprosopa Mik**

*Androprosopa* Mik is a Holarctic genus with about half of the species distributed in the Nearctic Region and the remainder in the Palearctic Region. The type species, *Androprosopa larvata* (Mik), was described in 1888 originally under the genus *Orphnephila* Haliday. Ten years later, Mik described the new genus *Androprosopa* and subsequently designated *A. larvata* as the type species (Mik 1898). Subsequent new species were described in *Thaumalea or Orphnepilina* Enderlein. Martinovský and Rozkošný (1976) observed that the form of the genitalia of several species of *Thaumalea* resembled that of *Orphnepilina* and proposed that
eight species be reassigned to the genus *Orphnephilina*, including several Nearctic species. The assignment of species within *Androprosopa* continued to be problematic until Sinclair (1996) redefined the genus on the basis that gonostylar action is oblique in *Androprosopa* vs. horizontal in *Thaumalea*. This distinction resulted in the expansion of the genus to include 51 species, as well as the recognition that *Orphnephilina* is a junior synonym to *Androprosopa* as originally proposed by Wagner (1995). Despite the expansion of the genus, European workers continue to recognize two species of *Androprosopa* (*A. algira* (Vaillant) and *A. tarda* (Loew)) as members of the genus *Protothaumalea* Vaillant (Wagner 2002). As a consequence of the genus expansion, all native Nearctic species of *Thaumalea* were transferred to *Androprosopa* (Sinclair 1996). Up to the present, 52 species of *Androprosopa* have been described, the most recent being *A. zempoala* Sinclair & Huerta (2010).

Bezzi (1913) was the first taxonomic work on Nearctic thaumaleids where he described the eastern species, *A. americana*. The other two eastern species are *A. thornburghae* (Vaillant) and *A. vaillantiana* Sinclair. Sinclair (1996) dealt with all of the eastern Nearctic Thaumaleidae and provided excellent drawings and keys to the males, pupae and larvae.

*Androprosopa* is far more diverse in the western half of the Nearctic Region, with 22 described species (Dyar & Shannon 1924; Garrett 1925; Schmid 1970; Brothers 1972; Arnaud & Boussy 1994; Sinclair & Huerta 2010) compared to three species in the eastern half. Arnaud & Boussy’s 1994 treatment of the group is the most comprehensive to date. They described 17 new species, provided a diagnostic species key for males to all of the western Nearctic Thaumaleidae and described females for some species. Female specimens still pose a problem for identification, as they are difficult to associate with males. Gillespie *et al*. (1994) discussed the biology and taxonomy of larvae and pupae of ten *Androprosopa* spp. found in Idaho and California. They provided descriptions and drawings of both life stages. However no key was provided and this represents less than half of the western fauna. Descriptions of the larvae and pupae of remaining species would be useful
not only for identification, but also in the construction of a phylogeny to determine relationships between Nearctic species and Palearctic species.

Due to the absence of a phylogeny, the relationships amongst the Nearctic species of *Androprosopa* remain uncertain. The eastern species are characterized by short, blunt, apical gonostylar spines, tapering gonostyli and dense setae on the inner face of the gonocoxites, and may be related to *A. ericfisheri* (Arnaud & Boussy) (Sinclair 1996). Larval antennal characters may also have phylogenetic use (Sinclair 1996). Also, some species have only been collected on one occasion and are known from only a few specimens [*A. fusca* (Garrett) & *A. zelmae* (Arnaud & Boussy)], which make it difficult to assess intraspecific variation. Alternatively, species such as *A. gillespieae* (Arnaud & Boussy) have a very wide distribution encompassing varied habitats, which often indicates a species complex. Despite all of the work done on the Nearctic Thaumaleidae, they remain a very under-collected and understudied group with much to be learned about diversity and relationships at all levels of classification.

**Objectives**

Given that little has been done in regard to exploring the evolutionary relationships within the Thaumaleidae, the purpose of this thesis was to revise taxonomically the Nearctic species of *Androprosopa* and use molecular sequence data for the first time to infer evolutionary relationships among them, the latter a first for the family.

All western Nearctic species known prior to this work are redescribed and new ones identified herein are officially described, with the male terminalia illustrated (or photographed) and known distributions plotted. Molecular sequence data and features of the male terminalia are used to test and, where applicable, expand/contract existing species concepts. Molecular data is also used to associate sexes and larvae wherever possible. A revised key to males is provided to identify all known western Nearctic species based on new information on species limits and
useful characters. Molecular data are used to provide a hypothesis on relationships between the eastern and western faunas, as well as to propose species groups therein.
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Chapter 2:

Description of six new Nearctic Androprosopa Mik and a new diagnostic key for the males of the western Nearctic Androprosopa (Diptera: Thaumaleidae)
Abstract

The western Nearctic fauna of *Androprosopa* Mik is revised to include twenty-eight species, six of which are described as new to science. Descriptions of the adult males of *A. apache*, *A. arnaudi*, *A. magnipelvi*, *A. rainierensis*, *A. sierra* and *A. uvas* are presented. Redescriptions of all remaining western Nearctic species are provided, as well as genitalic illustrations/photographs and updated distribution maps for each species. A diagnostic key to the male western Nearctic *Androprosopa* is provided.

Introduction

The Thaumaleidae, or madicolous midges, are a family of aquatic Diptera that is found worldwide, except in Antarctica. The family consists of roughly 185 described species within 7 genera. As the common name suggests, thaumaleids are found in and around madicolous habitats. These habitats are characterized by thin films of flowing water over rock surfaces and are also known as hygropetric zones (Mackie 2004). The larvae of thaumaleids are restricted to these madicolous habitats, which may include seepages (either natural or man-made), cascading streams, and splash zones near waterfalls and boulders in fast moving streams (Sinclair 2000). The larvae are recognizable by the presence of an unpaired prothoracic proleg and an unpaired anal proleg, as well as a pair of short respiratory tubes on the prothorax (Theischinger 2004). The escape behaviour is also useful for identifying a larval thaumaleid, as they use a quick, sidewinding motion, seemingly gliding along the water surface to evade predation. The larvae feed on diatoms on the rock surface (Sinclair 1990). When ready to pupate, the larvae leave the madicolous habitat and seek out damp moss, debris or mud (Vaillant 1959). The adults are poor fliers and may be swept from riparian vegetation or aspirated directly off the rock surface or any moss growing on it. A combination of sweeping and aspirating is the most effective way of collecting adults, while trapping has very
limited use. They are not attracted to pan traps and are only collected in Malaise and emergent traps when placed directly in the appropriate habitat. Due to this habitat specificity and flying ineptitude, the Thaumaleidae are a rarely collected and understudied family.

There is one described extinct species, *Mesothaumalea fossilis* Kovalev, that was discovered in fossil deposits in Transbaicalia, east of Lake Baikal in Siberia, Russia (Kovalev 1989). These deposits contain fossils from the Upper Jurassic/Early Cretaceous, which date back to 145mya. There is a simuliiid fossil from the Jurassic period (176mya) and given their phylogenetic position as the sister family to the Simuliidae (Moulton 2000; Wiegmann et al. 2011), indicates that thaumaleids were likely present during that time as well (Borkent 2012). Where the Thaumaleidae originated from and how they radiated to their present day distribution is unknown.

Ruthe first described the Thaumaleidae in 1831, when he described *Thaumalea testacea* in what is now Germany (Arnaud & Boussy 1994). The family was known as Orphnephilidae until Bezzi (1913) synonymized *Orphnephila* Haliday, 1832 with *Thaumalea* Ruthe, 1831 and adopted the family name Thaumaleidae. The first Nearctic species, *Thaumalea americana* Bezzi, was also described in 1913, from Ithaca, New York. There are three Nearctic genera of Thaumaleidae: *Androprosopa* Mik, *Trichothaumalea* Edwards and *Thaumalea* Ruthe. *Thaumalea verralli* Edwards is the sole North American representative of the genus and a likely introduction from Europe (Sinclair 1996). *Thaumalea verralli* has only been recorded from St. John’s, Newfoundland, at one of the oldest seaports in North America (Sinclair 1996). There are three known Nearctic species of *Trichothaumalea*, two of which are found in the West and one in the East. *Androprosopa* is the largest genus in the Nearctic, containing 31 described species: 28 from the West and three from the East (Arnaud & Boussy 1994; Sinclair 1996).

*Androprosopa* was first described by Mik in 1898, with the type-species *Orphnephila larvata* Mik. Wagner (1995) proposed that *Orphnephilina* Enderlein be recognized as a junior synonym of *Androprosopa*. Sinclair (1996) officially recognized this change while also redefining the genus. This redefinition was
proposed on the basis that the genus *Androprosopa*, along with many species of *Thaumalea*, including all the Nearctic species assigned to *Thaumalea*, shared the synapomorphy of an oblique gonostylar action (Sinclair 1996). Therefore, all of the species with this synapomorphy are now included in *Androprosopa*, thus increasing the known species total for the genus to 52. This paper will focus on the western Nearctic fauna of *Androprosopa* as Vaillant (1959) and Sinclair (1996) have studied the eastern fauna in great detail.

The first description of a western Nearctic *Androprosopa* species was *A. elnora* (Dyar & Shannon) in 1924. This was followed by the description of *A. fusca* (Garrett) in 1925, *A. anolo* (Schmid) in 1970 and *A. sanaclaraensis* (Brothers) in 1972. Arnaud and Boussy (1994) treated the Thaumaleidae of western North America. In the largest study of western thaumaleids to date, the authors recognized 21 species of *Androprosopa* (at the time the genus was still treated as *Thaumalea*), 17 of which were new to science. They also included a key to species using male genitalia. The most recent species description was by Sinclair & Huerta (2010), where they described *A. zempoala* from Mexico. Herein, six new species of *Androprosopa* are described, the remaining species are redescribed, genitalic illustrations are provided, range expansions are noted and an up to date identification key to the male western Nearctic *Androprosopa* is provided.

**Materials and Methods**


For best results, thaumaleids were collected into 95% ethanol. They may later be critical-point-dried or dried using the hexamethyldisilazane (HMDS) method, as outlined by Brown (1993).
Table 2.1 Location and species names for Nearctic Thaumaleidae.

<table>
<thead>
<tr>
<th>Location</th>
<th>Western North America</th>
<th>Eastern North America</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genus</td>
<td>Androprosopa</td>
<td>Androprosopa</td>
</tr>
<tr>
<td>Species</td>
<td>anolo (Schmid, 1994)</td>
<td>americana (Bezzi, 1913)</td>
</tr>
<tr>
<td></td>
<td>apache sp. nov.</td>
<td>thornburghae (Vaillant, 1959)</td>
</tr>
<tr>
<td></td>
<td>arnaudi sp. nov.</td>
<td>vaillantiana Sinclair, 1996</td>
</tr>
<tr>
<td></td>
<td>becca (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>brothersi (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>buckae (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>chandlerorum (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>coloradensis (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>confracta (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>elnora (Dyar &amp; Shannon, 1924)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ericfisheri (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>falciformis (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>fusca (Garrett, 1925)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>gillespieae (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>idahoensis (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>lindsayorum (Arnaud &amp; Boussy, 1994)</td>
<td></td>
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<tr>
<td></td>
<td>magnipelvim sp. nov.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>melanderi (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>palouse (Arnaud &amp; Boussy, 1994)</td>
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<tr>
<td></td>
<td>rainierensis sp. nov.</td>
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</tr>
<tr>
<td></td>
<td>santaclaraensis (Brothers, 1972)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>schmidiana (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sierra sp. nov.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sonorensis (Arnaud &amp; Boussy, 1994)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>uvas sp. nov.</td>
<td></td>
</tr>
</tbody>
</table>
Table 2.1 Continued.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Thaumalea</th>
<th>Thaumalea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>verralli Edwards, 1929</td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>pilosa (Garrett, 1925)</td>
<td><em>elakalensis</em> Sinclair, 1992</td>
</tr>
<tr>
<td>Species</td>
<td><em>pluvialis</em> (Dyar &amp; Shannon, 1924)</td>
<td></td>
</tr>
</tbody>
</table>

The latter method was used in this study for the preparation of the newly described species. Males were identified by means of genitalic characters. Females and larvae were identified by association, when possible, as well as through molecular data (see Chapter 3).

Adult male genitalia were cleared in a hot, 85% lactic acid bath. Representatives of each available species were also cleared with the GeneJET Genomic DNA Purification Kit #K0722 (ThermoScientific, Waltham, MA) in order to extract DNA for future molecular study. The lysate preparation protocol was followed and the cleared voucher specimens were stored in 70% ethanol.

Distribution maps were created using SimpleMappr (Shorthouse 2010).

Label data for the primary types are presented exactly as they appear. Data are listed from the top downward on the staging pin, with data from each label enclosed in quotation marks; lines are delimited by a forward slash mark. The repository is given in parentheses.

Acronyms for specimen repositories are as follows: AMNH – American Museum of Natural History, New York, New York; BMNH – Natural History Museum, London, U.K.; CAS – California Academy of Sciences, San Francisco, California; CDFA – California Department of Food and Agriculture, Sacramento, California; CNC –
Androprosopa Mik

Androprosopa Mik, 1898: 65. Type-species: Orphnephila larvata Mik (original designation).

Orphnephilina Enderlein, 1936: 96. Type-species: Orphnephila nigra Loew (monotypy).

Psychothaumalea Vaillant, 1970: 166. Type-species: Orphnephila nigra Loew (original designation).


Diagnosis. Males are distinguished from Thaumalea by obliquely to dorsoventrally directed gonostyli. Androprosopa is distinguished readily from other thaumaleid genera, except Thaumalea, by a complete subcostal vein.
**Description. Male.** Scutum with rows of undifferentiated setulae; scutellum with row of marginal setae. Supralar region flat, not produced into prominent ridge. Wing membrane lacking macrotrichia; Sc complete; basal section of R proximal to origin of Rs straight, not weakened; R3(+R2+3) with macrotrichia along entire length; R2+3 situated close to base of R1; CuA1 branching close to CuA2; CuA2 lacking angular base and basal appendage. Abdominal sternite 8 rectangular with stout anterior margin projecting onto preceding segment. Terminalia: Hypandrium reduced to narrow sclerite. Epandrium often with posterolateral processes. Gonocoxite short, width subequal to length; gonocoxal plate normally broad, thinly sclerotized. Gonostylus articulate obliquely to dorsoventrally; usually apical spines present. Paramere divided into pair of long blades; dorsal parameral apodeme membranously connected to posterolateral margin of epandrium; membranous connection often sclerotized, forming pair of venterolateral epandrial plates.

**Female.** Similar to male except as follows: hypogynial valves generally truncate apically, often width of notch narrow. Tergite 9 lacking lateral projections.

**Distribution.** Known from the Nearctic, Palearctic and Oriental Regions.

**Remarks.** This description is cited from Sinclair (1996), where a new definition and description of the genus *Androprosopa* was provided.

**Key to adult males of the western Nearctic *Androprosopa***

See Figure 2.3 for illustration with characters labeled.

1. Body distinctly yellow .................................................................................................................. 2
2. Body brown, black or dark grey, at most brownish orange .................................................................. 3
3. Gonocoxite elongate with gonostylus extending beyond hind margin of epandrium; paramere distinct, with subapical projection (Fig. 2.19) ........................................................................................................................................... *A. elnora* (Dyar & Shannon)
- Gonocoxite short, quadrate, gonostylus not reaching hind margin of
  epandrium; paramere reduced (Fig. 2.21)... *A. ericfisheri* (Arnaud & Boussy)
3. Gonocoxal plate distinctly bi- or trilobed........................................................................4
- Gonocoxal plate without multiple lobes.............................................................................16
4. Gonocoxal plate bilobed, at most with indistinct median lobe...........................................5
- Gonocoxal plate trilobed, median lobe very distinct............................................................7
5. Apical epandrial processes produced into pointed, finger-like projections;
gonostylus densely setose, inner margin of apical third cleaved (Fig. 2.13)...........
........................................................................................................................................... *A. chandlerorum* (Arnaud & Boussy)
- Apical epandrial processes triangular, not produced into distinct
  projection..................................................................................................................................................6
6. Gonostylus lacking subapical spines; apex of paramere narrowed (Fig.
  2.11).................................................................................................................................................. *A. buckae* (Arnaud & Boussy)
- Gonostylus with two subapical spines; apex of paramere expanded (Fig.
  2.29).................................................................................................................................................. *A. idahoensis* (Arnaud & Boussy)
7. Gonostylus raptorial in appearance, outer margin bearing 2 setae, basal lobe
  setose, apex with a stout spine and longer, sickle-shaped process; paramere
  with small flange before apex (Fig. 2.41)........ *A. santaclaraensis* (Brothers)
- Gonostylus not as above..................................................................................................................8
8. Posterolateral epandrial processes simple, at most weakly curved toward
dorsum in lateral view....................................................................................................................9
- Posterolateral epandrial processes with apex ending in a beak-like shape in
  lateral view, appearing bifurcate in ventral view............................................................................12
9. Gonostylus lacking subapical spine-like setae; paramere with very strong
  lateral flange (Fig. 2.27).............................................................................................................. *A. gillespieae* (Arnaud & Boussy)
- Gonostylus with one or two subapical spine-like setae...........................................................10
10. Gonostylus with one subapical spine-like seta; paramere with apex bluntly
    rounded, rotated in appearance (Fig. 2.3)................................................................. *A. apache* new species
- Gonostylus with two subapical spine-like setae......................................................................11
11. Gonostylus expanded basally, tapered strongly at apex; paramere sinuous, apex arched medially (Fig. 2.55)..........................A. zempoala Sinclair & Huerta
- Gonostylus nearly equal in width for its entire length, gentle taper to apex; parameres diverge medially then remain parallel toward apex (Fig. 2.5)........

..........................................................A. arnaudi new species

12. Paramere with developed median, lateral flange (Fig. 2.43)..........................

..................................................................A. schmidiana (Arnaud & Boussy)
- Paramere lacking median lateral flange..........................................................13

13. Parameres sinuous and arched medially toward apex.................................14
- Parameres nearly parallel toward apex..........................................................15

14. Subapical spines located on outer margin of gonostylus; gonostylus tapered gently toward apex (Fig. 2.45).................................A. sierra new species
- Subapical spines located on inner margin of gonostylus; gonostylus expanded basally, narrowed sharply at apical third (Fig. 2.33).................................

..................................................................................A. magnipelvim new species

15. Subapical spines located on dorsal surface of gonostylus (Fig. 2.49)...........

..................................................................................................................A. uvas new species
- Subapical spines located on ventral surface of gonostylus (Fig. 2.37).........

..................................................................................................................A. palouse (Arnaud & Boussy)

16. Gonostylus with three to four elongated, claw-like spines at apex..............17
- Gonostylus with one or no apical spines......................................................18

17. Gonostylus weakly arcuate; gonocoxite with posterolateral process pointed; known from the Pacific Northwest (Fig. 2.31).................................

..................................................................................A. lindsayorum (Arnaud & Boussy)
- Gonostylus strongly arcuate; gonocoxite with posterolateral process rounded; known from Mexico (Fig. 2.47)........A. sonorensis (Arnaud & Boussy)

18. Gonostylus with distinct lateral peg-like projection or process near midpoint, nearly devoid of setae.................................................................19
- Gonostylus without lateral projection or process......................................20
19. Gonostylus strongly curved, with a large, thickened peg-like seta on medial inner margin, not elbowed; paramere without distinct bend (Fig. 2.39)..........
   .........................................................................................................................A. rainierensis new species
- Gonostylus elbowed at apical third with lateroventral process at elbow;
  paramere with strong bend apically (Fig. 2.23)......................................................
   ..............................................................................................................................A. falciformis (Arnaud & Boussy)

20. Gonocoxite with posterolateral process long, sharp, extending at least midway down laterad of gonostylus; paramere strongly curved.............21
- Gonocoxite without posterolateral process, at most bluntly lobed; paramere never strongly curved.................................................................24

21. Gonostylus with a distinct tip bearing a single seta at apex.........................22
- Gonostylus either expanding apically or with subapical seta.........................23

22. Gonocoxal process extending to about middle of gonostylus; distal half of gonostylus expanded (Fig. 2.1).................................................................A. anolo (Schmid)
- Gonocoxal process extending length of gonostylus; distal half of gonostylus narrowed (Fig. 2.25).................................................................A. fusca (Garrett)

23. Paramere bent apically at right angle, undivided at apex (Fig. 2.53)..........
   .............................................................................................................................A. zelmae (Arnaud & Boussy)
- Paramere bifurcate apically (Fig. 2.51).................A. wahana (Arnaud & Boussy)

24. Gonostylus broadest at basal fourth, remainder narrowed, spindly in appearance; apical epandrial processes heavily sclerotized, claw-like;
  paramere broad, simple (Fig. 2.15)..............A. coloradensis (Arnaud & Boussy)
- Gonostylus evenly tapered to apex; apical epandrial processes present or absent, but never heavily sclerotized; paramere slender, or broad but with ornamentation...................................................................................................................25

25. Gonostylus bearing long terminal claw-like seta, nearly half the length of gonostylus(Fig. 2.7).................................................................A. becca (Arnaud & Boussy)
- Terminal claw-like seta at most one-third of the length of gonostylus.............26

27. Lateral margin of paramere smooth (Fig. 2.35)...........................................
   .............................................................................................................................A. melanderi (Arnaud & Boussy)
Lateral margin of paramere irregular, serrate.............................................28

28. Paramere broad, cleaved on lateral margin near apex (Fig. 2.17)..............................A. *contracta* (Arnaud & Boussy)
- Paramere sickle-shaped (Fig. 2.9)..............................A. *brothersi* (Arnaud & Boussy)

**Species Diagnoses and Descriptions**

*Androprosopa anolo* (Schmid)

*Androprosopa anolo* (Schmid); Sinclair 1996: 376.

**Type Material**

**Holotype:** ♂ pinned with a minuten on a piece of card labeled, "U.S.A., Ore./Marion Co./French Creek/18-VI-1965/F. Schmid"; "HOLOTYPE/CNC No. 11.306/Thaumalea/anolo Schmid." (CNC) The abdomen and right wing are mounted on separate microscope slides and labeled with the same label data as the holotype.

**Recognition**

The species is recognized by its strongly recurved parameres and is distinguished from the closely related *A. falciformis* by lacking elbowed gonostyli.

**Redescription**

*Wing length:* 2.64-2.91 mm.

*Colouration:* Head blackish-brown. Mesonotum and pleura dark brown; abdomen blackish-brown, dull; halter and legs yellow-brown, tarsi darker; terminalia brown.
Wing: Lightly infuscate; R₁ (+R₂+3) with macrotrichia along entire length, remaining veins bare; R₂+3 situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ convergent toward wing margin, then slightly divergent just before margin.

Abdomen: Male abdominal sternites 2-7 rectangular with basal half well sclerotized, lightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 with few setulae, anterior margin strongly dipped into segment 7.

Male terminalia (Fig. 2.1): Epandrium nearly cylindrical, slightly longer than wide; posterior margin not indented; each posteroventral corner bearing a pair of double-dentate apical epandrial processes. Hypandrium convex medially, slightly arching into sternite 8. Gonocoxite longer than wide, with posterolateral process about half length of gonostylus. Gonostylus shorter than gonocoxite and bearing few setae; sudden thickened at midpoint, bearing single apical claw-like setae. Parameres paired; broad basally, narrowed sharply medially and distal portion strongly recurved laterally. Gonocoxal plate attaining length of posterolateral gonocoxal processes.

Additional Material Examined

Distribution (Fig. 2.2)

Known from the Cascade Mountain Range as well as the Columbia Plateau in Idaho.

Androprosopa apache sp. nov.

Type Material

Holotype: m# “USA: AZ: Apache Co.,/ Greer, Squirrel Spring/ 22.vii.2011 36°11'08"N/ 111°22'55"W/ J.K. Moulton”; “HOLOTYPE: / Androprosopa / apache Pivar”


Recognition

This species is recognized by the twisted shape of the parameres, along with the single subapical spine-like seta.

Description

Wing length: 2.83-2.99 mm.

Colouration: Head blackish-brown. Mesonotum and pleura brown to dark brown, shiny, though some specimens light brown to rufous in colour; abdomen
Figure 2.1 Ventral view of male genitalia of new specimen of *Androprosopa anolo*.

Figure 2.2 Distribution of *Androprosopa anolo*. 
dark brown, dull; halter cream coloured; legs pale brown, tarsi darker; terminalia pale brown, concolourous with legs.

**Description**

*Wing length*: 2.83-2.99 mm.

*Colouration*: Head blackish-brown. Mesonotum and pleura brown to dark brown, shiny, though some specimens light brown to rufous in colour; abdomen dark brown, dull; halter cream coloured; legs pale brown, tarsi darker; terminalia pale brown, concolourous with legs.

*Wing*: Infuscate; R₁(+R₂+₃) with macrotrichia along entire length, remaining veins bare; R₂+₃ situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ strongly convergent toward wing margin.

*Abdomen*: Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

*Male terminalia* (Fig. 2.3): Epandrium quadrate, wider than long; posterior margin strongly indented; apical epandrial processes triangular, rounded; posterolateral epandrial processes hook-like, longer than wide, with serrate inner margins in ventral view; angled toward dorsum and evenly tapered to apex in lateral view. Hypandrium thin. Gonocoxite quadrate, slightly longer than wide. Gonostylus shorter than gonocoxite; apical third tapered to apex; apex bearing strong terminal claw-like spine with one subapical spine-like anterolateral seta. Parameres paired, longer than gonostyli; U-shaped, apical half appearing twisted; with blunt, rounded apex. Gonocoxal plate extending past posterior margin of gonocoxites; distal margin trilobed.
**Additional Material Examined**

Known only from the type series.

**Distribution (Fig. 2.4)**

Known from two localities in southeast Arizona.

**Etymology**

*Androprosopa apache* is named after the county where the holotype specimen was collected.

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![Figure 2.3 Ventral view of male genitalia of holotype of *Androprosopa apache*.](image-url)

*epand, epandrium; gcx, gonoxite; gcx pl, gonocoxal plate; gst, gonostylus; hypd, hypandrium; plat epand proc, posterolateral epandrial process; pm paramere.*
**Androprosopa arnaudi sp. nov.**

**Recognition**

Differs from the closely related *A. zempoala* by the gonostyli nearly equal in width for its entire length and the parameres diverging medially and then remaining parallel toward apex.

**Description**

*Wing length:* 2.83-2.87 mm.

*Colouration:* Head blackish-brown. Mesonotum dark brown, shiny; pleura brown to dark brown, shiny; scutellum blackish-brown; abdomen dark brown, dull; halter pale yellow; legs pale brown, tarsi darker; terminalia pale brown.

*Wing:* Lightly infuscate; R₁(⁺R₂⁺³) with macrotrichia along entire length, remaining veins bare; R₂⁺³ situated at basal third of R₁; bend in R₄⁺₅ gentle; R₄⁺₅ and M₁ strongly convergent toward wing margin.
**Abdomen:** Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

**Male terminalia** (Fig. 2.5): Epandrium quadrate, wider than long; posterior margin strongly indented; apical epandrial processes triangular, rounded; posterolateral epandrial processes hook-like, longer than wide, with serrate inner margins in ventral view; angled toward dorsum and evenly tapered to apex in lateral view. Hypandrium thin. Gonocoxite conical, longer than wide. Gonostylus shorter than gonocoxite; apical third tapered to apex; apex bearing strong terminal claw-like spine with two subapical spine-like anterolateral setae. Parameres paired, longer than gonostyli; U-shaped, diverging medially then becoming parallel; with blunt, rounded apex. Gonocoxal plate extending past posterior margin of gonocoxites; distal margin trilobed.

**Additional Material Examined**

Known only from the type series.

**Distribution (Fig. 2.6)**

Known only from two adjoining creeks in Rio Grande Co., Colorado.

**Etymology**

*Androprosopa arnaudi* is named after the dipterist Dr. Paul Arnaud, Jr., whose research contributed a wealth of information to the knowledge base of the classification and natural history of Thaumaleidae, especially in North America. He also provided the authors with valuable information to aid in the production of the first world catalogue of the family.
Figure 2.5 Ventral view of male genitalia of holotype of Androprosopa arnaudi.

Figure 2.6 Distribution of Androprosopa arnaudi.
**Androprosopa becca** (Arnaud & Boussy)

_Thaumalea becca_ Arnaud & Boussy, 1994: 60.

_Androprosopa becca_ (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**


**Recognition**

This species is recognized by gonostyli armed with a long terminal spine (nearly ½ the length of gonostylus) and parameres with a subapical, lateral beak.

**Redescription**

*Wing length:* 2.86-3.51 mm.

*Colouration:* Head brown, dull. Mesonotum and pleura brown, shiny; abdomen dark brown to blackish-brown, dull; halter and legs light brown, tarsi darker; terminalia light brown.

*Wing:* Infuscate; R₁(+R₂+3) with macrotrichia along entire length, remaining veins bare; R₂+₃ situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁
convergent toward wing margin.

**Abdomen:** Male abdominal sternites 2-7 rectangular with basal half well sclerotized, not dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 with few setulae, anterior margin strongly dipped into segment 7.

**Male terminalia** (Fig. 2.7): Epandrium nearly cylindrical, slightly longer than wide; posterior margin not indented; without apical and posterolateral epandrial processes. Hypandrium strongly arching into sternite 8, distinct. Gonocoxite rectangular, longer than wide. Gonostylus shorter than gonocoxite; arched; apex bearing long, thin apical spine, nearly half length of gonostylus. Parameres paired, subequal in length compared to gonostyli; widening medially, rounded at apex, usually with subapical pointed process on lateral margin. Gonocoxal plate shorter than posterior margin of gonocoxites; with thin medial line.

**Additional Material Examined**

**CANADA:** **ALBERTA:** Canmore, Grassi Lakes Trail, 13.vii.2015, 51°04.87"N 115°23.64"W, 1420m, ex. streams, B.J. Sinclair (1♂, 8♀); Hwy. 40, LougheedPk., 20.viii.1987, 50°39′10″N 115°10′49″W, J. Troubridge (1♂; DEBU); **BRITISH COLUMBIA:** 13km W. Revelstoke, 20.vii.2012, 50°57′45″N 118°22′30″W, roadcut seep, 560m, B.J. Sinclair (1♂); East Kootenay Moyie R., Hwy. 3/95, 19.vi.2014, 49°10.279′N 116°00.487′W, 900m, ex. roadcut seeps, B.J. Sinclair (1♀, 7 larvae, 1 pupa); East Kootenay, Hwy. 3/95, 22.vi.2014, 49°10′18.4″N 116°00′31.9″W, ex. roadcut seeps, J.K. Moulton & R.J. Pivar (1♂, 2♀, 47 larvae); Moyie River, Hwy. 3, 12.vii.2012, 49°10′18″N 116°00′31″W, roadcut seep, 915m, B.J. Sinclair (11 larvae, 3 reared to adults); nr. Kimberley, Meachen Ck. F.R., 17.vii.2015, 49°36.21″N 116°13.45″W, 1027m, ex. roadside falls, B.J. Sinclair (1♂); nr. Kimberley, Meachen Ck. F.R., 17.vii.2015, 49°36.22″N 116°13.33″W, 1021m, ex. roadside falls, B.J. Sinclair (14♂); W. Creston-Hwy. 3, 18.vii.2015, 49°06.24″N 116°53.07″W, 1130m, ex. roadcut seep, B.J. Sinclair (2♂); **U.S.A:** **MONTANA:** Lincoln Co.: Hwy. 37, 24.vi.2014, 48°41′24.6″N 115°18′49.2″W, ex. roadcut seeps, J.K. Moulton & R.J. Pivar (13♂, 1♀, 7
larvae); **WASHINGTON:** Pierce Co.: Mt. Rainier N.P., Christine Falls, 2.vii.2014, 46°46’51.2"N 121°46’45.5"W, ex. small falls E of Christine Falls next to road, J.K. Moulton & R.J. Pivar (2♂).

**Distribution (Fig. 2.8)**

Known from the Cascade Mountain Range, Columbia Mountains and the Canadian Rockies.

![Figure 2.7 Ventral view of male genitalia of new specimen of *Androprosopa becca.*](image-url)
Androprosopa brothersi (Arnaud & Boussy)


Androprosopa brothersi (Arnaud & Boussy); Sinclair 1996: 376.

Type Material

**Holotype:** ♀ point-mounted with apex of abdomen removed is labeled: “Uvas Canyon/Santa Clara Co./Cali. XI-5-72”; “Swanson Creek”; “D.R. Brothers/Acc. No. 9758”; “Arnaud and Boussy/ Dissection No./23.04.93”; “HOLOTYPE Male/Thaumalea/brothersi/Arnaud and Boussy/1993; CAS Ent. Type No./17001.” Apical portion of the abdomen of the holotype is mounted on a microscope slide with equivalent label information (CAS Entomology Type #17001). **Allotype:** ♀ mounted on two microscope slides under three cover glasses is labeled: “ALLOTYPE Female/Thaumalea/brothersi/Arnaud and Boussy/1994”; “Swanson Creek/Uvas Canyon/County Park/Santa Clara Co., Calif., III-9-73/reared from/immature/D.R. Brothers/Acc. No. 10020”; Arnaud and Boussy/Dissection No./17-IV-1973”;
“Arnaud & Boussy/wing print, 1993” (CAS). **Paratypes: U.S.A: CALIFORNIA:** Santa Clara Co., 2♂ with same label data as holotype but dated “III-9-73” and “Acc. No. 10018” and “Acc. No. 10030”; 1♂ with same label data as holotype but dated “IX-21-72” and “Acc. No. 9748” (CAS, DRB). 2♀ with similar collection data as allotype but with accession numbers “10021” and “10022” (CAS, DRB).

**Recognition**

Distinguished from the closely related *A. melanderi* by the serrated lateral margin of the paramere, and from *A. contracta* by having a more sickle-shaped paramere.

**Redescription**

*Wing length:* 2.24-2.96 mm.

*Colouration:* Head dull, dark brown. Mesonotum and pleura dark brown and dull; scutellum slightly darker; abdomen blackish-brown; halter and legs pale brown, tarsi darker; terminalia brown.

*Wing:* Lightly infuscate; R₁(+R₂+₃) with macrotrichia along entire length, remaining veins bare; R₂+₃ situated at basal third of R₁; bend in R₄+₅ weak; R₄+₅ and M₁ convergent toward wing margin, then M₁ slightly divergent just before margin.

*Abdomen:* Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized and slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

*Male terminalia* (Fig. 2.9): Epandrium in form of truncated cone, slightly wider than long; posterior margin with shallow indentation; apical and posterolateral epandrial processes not produced. Hyandrium very slender, faint; slightly convex. Gonocoxite ovoid, slightly longer than wide. Gonostylus stout;
shorter than gonocoxites; base broad, tapering towards tip; apex bearing single, strong claw-like spine. Parameres paired, longer than gonostyli; lateral margin with irregular serration; pointed lateral projection at apex. Gonocoxal plate broad, extending past posterior margin of gonocoxites; produced into medial hourglass-like shape, ending near middle of gonocoxite.

Additional Material Examined

**U.S.A.: CALIFORNIA:** Nevada Co.: culvert along Sagehen Ck., 11.vii.2012, 39°26’04.4”N 120°16’52.2”W, J.M. Cumming (1♂, 1♀); Tahoe N.F., River Rd. Hwy. 89, 9.vii.2014, 39°15’56.3”N 120°12’37.1”W, ex. small roadside waterfall, J.K. Moulton & R.J. Pivar (1♂, 3♀).

Distribution (Fig. 2.10)

Known from the Santa Cruz Mountains and the Sierra Nevadas in California.

*Figure 2.9 Ventral view of male genitalia of new specimen of* Androprosopa brothersi.

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Figure 2.10 Distribution of *Androprosopa brothersi*.

*Androprosopa buckae* (Arnaud & Boussy)

*Thaumalea sp.*, Arnaud 1968: 83 (First record of the family in central California, at Marin County.)


*Androprosopa buckae* (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**

**Holotype:** ♂ mounted on a microscope slide under two cover glasses is labeled: “HOLOTYPE/Thaumalea/buckae/Arnaud & Boussy/1993/♂ KOH/USA: CALIFORNIA: Marin Co./Mill Valley, Lee Street, 360’ el./ex dripping cliff 22 III 1969/ coll. I. A. Boussy.” (CAS Entomology Type #17002). **Allotype:** ♀ mounted on a microscope slide under two cover glasses with same collection data as the holotype except the date and collector reads “17 May 1967 by Paul H. Arnaud, Jr.” There has been an incorrect wing association with the allotype (CAS). **Paratypes:** U.S.A.
CALIFORNIA: Marin Co.: Mill Valley, Lee Street, 360 feet: 13.v.1967, P.H. Arnaud, Jr. (2♂, 1♀; CAS); 15.v.1967, P.H. Arnaud, Jr. (4♂, 2♀; CAS); 17.v.1967, P.H. Arnaud, Jr. (6♂, 1♀; CAS); 21.v.1967, P.H. Arnaud, Jr. (2♂; CAS); 22.v.1967, PH. Arnaud, Jr. (12♂, 2♀; CAS); 24.ii.1969, I.A. Boussy (1♂; CAS); 2.iii.1969, I.A. Boussy (3♂; CAS); 22.iii.1969, I.A. Boussy (12♂, 3♀; CAS); 28.iii.1971, I.A. Boussy (1♂, 1♀; CAS); 8.xi.1971, I.A. Boussy (2♂; CAS); Sausalito, 27.v.1969, P.H. Arnaud, Jr. (1♂; CAS); Stinson Beach State Park, 2nd inlet S main beach, 16.iii.1969, overcast day, I.A. Boussy (2♂; CAS); Santa Clara Co.: Black Rock Falls, Uvas Canyon County Park, 27.v.1972, Accession #9026, D.R. Brothers (1♂; DRB); Uvas Creek, Uvas Canyon County Park, 27.v.1972, Accession #9029, D.R. Brothers (1♂; DRB); same locality, 1.viii.1972, Accession #9045, D.R. Brothers (1♂; DRB); same locality, 7.x.1972, Accession #9802, D.R. Brothers (1♂; DRB); Seep along Uvas Creek, Uvas Canyon County Park, 27.v.1972, Accession #9031, D.R. Brothers (1♂; DRB); Swanson Creek, Uvas Canyon County Park, 21.ix.1972, Accession #9748, D.R. Brothers (1♂; DRB); Santa Cruz Co.: Big Basin Redwoods State Park, Opal Creek, 5.viii.1972, Accession #9123, D.R. Brothers (1♂; DRB); Paratype males have also been deposited in the following collections: AMNH, BMNH, CDFA, CNC, FVC, JFM, LACM, SEM, SJSU, UCB, UCD, UCR, UIC, USNM, USU and WSU.

Recognition

Similar to A. idahoensis, but distinguished by the paramere widening prior to narrowed apex and lacking sub-apical spines on gonostyli.

Redescription

*Wing length:* 2.42-3.12 mm.

*Colouration:* Head dark brown. Mesonotum and pleura dark brown to blackish-brown and somewhat shiny; abdomen dark brown to blackish-brown, dull; halter pale yellow; legs brown, tarsi darker; terminalia brown.
Wing: Infuscate; \( R_1 (+R_{2+3}) \) with macrotrichia along entire length, remaining veins bare; \( R_{2+3} \) situated at basal third of \( R_1 \); bend in \( R_{4+5} \) gentle; \( R_{4+5} \) and \( M_1 \) strongly convergent toward wing margin.

Abdomen: Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 with few setulae, anterior margin strongly dipped into segment 7.

Male terminalia (Fig. 2.11): Epandrium quadrate, wider than long; posterior margin indented; apical epandrial processes triangular, shorter than long; posterolateral epandrial processes hook-like, longer than wide, with serrate inner margin. Hypandrium faint, thin. Gonocoxite quadrate, slightly longer than wide. Gonostylus slightly shorter than gonocoxite; gently tapering toward apex; apex bearing terminal claw-like spine. Parameres paired, longer than gonostyli; widening medially with slight arching, then narrowing toward apex. Gonocoxal plate extending past posterior margin of gonocoxites; distal margin concave creating two rounded lobes.

Additional Material Examined

**U.S.A: CALIFORNIA:** Contra Costa Co.: Tilden Regional Park, Wildcat Ck. @Grizzly Picnic area, 9.viii.2013, 37°52’56.03"N 122°13’35.79"W, 457m, R.I. Madriz & K. Lindsay (9 larvae); Tilden Regional Park @ Wildcat Ck. near Grizzly Picnic Area, 7.vii.2014, 37°53’00.8"N 122°13’40.7"W, ex. small seep (creek almost dried up), J.K. Moulton & R.J. Pivar (1 ♀, 3 larvae); Del Norte Co.: Gasquet, 18.ix.1934, A.L. Melander (1 ♂; USNM); Humboldt Co.: Trinidad State Beach, 4.vi.2009, 41°03’25.9"N 124°09’00.0"W, sea cliff face, B.J. Sinclair (4 ♂).
Figure 2.11 Ventral view of male genitalia of new specimen of *Androprosopa buckae*.

Figure 2.12 Distribution of *Androprosopa buckae*. 
**Distribution (Fig. 2.12)**

Known mainly from the Coastal and Santa Cruz Mountain Ranges of California. Four males were also collected in Wallowa Co., Oregon.

*Androprosopa chandlerorum* (Arnaud & Boussy)


*Androprosopa chandlerorum* (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**

**Holotype:** ♀ is point mounted with abdomen and right wing removed, labeled: “CAL: Nevada Co./ Sagehen Creek/ NE of Carpenter Ridge/8000’ el./ 23 VII 1970”; “Coll. I.A. Boussy”; “Arnaud & Boussy/Diss. No. 4VII70.1”; “HOLOTYPE Male/Thaumalea/ chandlerorum/Arnaud and Boussy/1993.” The right wing and abdomen of the holotype are mounted on a microscope slide under two cover glasses with label data equivalent to that cited above (CAS, Entomology Type #17003). **Allotype:** ♀ mounted under three cover slips on two microscope slides, same data as holotype (CAS). **Paratypes:** **U.S.A.: CALIFORNIA:** Nevada Co.: northeast Carpenter Ridge, Sagehen Creek, 8,000 feet, 22.vii.1970, D.S. Chandler (1♀; CAS); same locality but collected on 23-V-1970, I.A. Boussy (1♂, 3♀; CAS).

**Recognition**

This species is recognized by the parameres with a short, forked process dorsobasally, the distal third arcuate laterally and the apex produced dorsolaterally.

**Redescription**

*Wing length:* 3.04-3.33 mm.

*Colouration:* Head dull, ferruginous to dark brown. Mesonotum and pleura shining ferruginous to dark brown; abdomen dark brown and dull; halter and legs
pale yellow to brown; terminalia light brown.

Wing: Infuscate; $R_1(+R_{2+3})$ with macrotrichia along entire length, remaining veins bare; $R_{2+3}$ situated at basal third of $R_1$; bend in $R_{4+5}$ gentle; $R_{4+5}$ and $M_1$ strongly convergent toward wing margin.

Abdomen: Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

Male terminalia (Fig. 2.13): Epandrium spherical, wider than long; posterolateral process absent; posterior margin with broad indentation; apical epandrial processes produced into pointed, finger-like projections that may be simple or bifurcate. Hypandrium very slender, faint; slightly concave. Gonocoxite quadrate, slightly longer than wide; inner margin with strong setae. Gonostylus densely setose; four strong spines in a row on dorsal surface of the apex, most apical one being longest; inner margin of apical third cleaved. Parameres paired, longer than gonostyli; with short forked process dorsobasally and distal third arcuate laterally and apex produced dorsolaterally. Gonocoxal plate extending past posterior margin of gonocoxites; distal half produced medially into tear-drop shaped keel.

Additional Material Examined


Distribution (Fig. 2.14)

Known only from Carpenter Ridge on the eastern slope of the central Sierra Nevada of California.
Figure 2.13 Ventral view of male genitalia of new specimen of *Androprosopa chandlerorum*.

Figure 2.14 Distribution of *Androprosopa chandlerorum*. 
Androprosopa coloradensis (Arnaud & Boussy)

Thaumalea coloradensis Arnaud & Boussy, 1994: 79.

Androprosopa coloradensis (Arnaud & Boussy); Sinclair 1996: 376.

Type Material


Recognition

This species is recognized by the apically broadened parameres, narrow gonostyli and posteroventral corners of epandrium heavily sclerotized and claw-like.

Redescription

Wing length: 3.82-3.89 mm.

Colouration: Head blackish-brown. Mesonotum and pleura brown; abdomen dark brown, dull; halter light brown; legs pale brown, tarsi darker; terminalia brown.

Wing: Infuscate; R₁ (+R₂+3) with macrotrichia along entire length, remaining veins bare; R₂+3 situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ strongly convergent toward wing margin.

Abdomen: Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, not dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into
Male terminalia (Fig. 2.15): Epandrium spherical, wider than long; posterolateral process absent; posterior margin with broad indentation; apical epandrial processes heavily sclerotized, claw-like. Hypandrium very slender, faint. Gonocoxite rectangular, slightly longer than wide; inner margin concave. Gonostylus strongly narrowed beyond basal fifth; ending in terminal claw-like spine. Parameres paired, shorter than gonostyli; basal two-thirds widened; notched before rounded apex. Gonocoxal plate extending past posterior margin of gonocoxites; produced medially into long, thin rod.

Additional Material Examined

Distribution (Fig. 2.16)

Known only from the San Juan Mountains of southwestern Colorado.

*Androprosopa confracta* (Arnaud & Boussy)

*Thaumalea confracta* Arnaud & Boussy, 1994: 82.

*Androprosopa confracta* (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**

**Holotype:** ♂ pinned with a minuten pin and abdomen removed, labeled: “U. S.A., Ore./Linn Co./Lost Prairie/20-VI-1965/F. Schmid”, “CNC 121”; HOLOTYPE Male/Thaumalea/confracta/Arnaud and Boussy/1994.” The abdomen of the holotype is mounted on a microscope slide under a cover glass (CNC Type #21928).

**Allotype:** ♀ pinned with a minute and has its abdomen removed, labeled: “U.S.A.,
The abdomen of the allotype is mounted on a microscope slide without cover glass (CNC).

**Paratype:** U.S.A.: WASHINGTON: Yakima Co.: American River, 26.vi.1965, F. Schmid (1 ♂; CAS)

**Recognition**

This species can be distinguished from its close relatives, *A. melanderi* by the irregular serration of the lateral margin of the paramere, and *A. brothersi* by the paramere being broader and cleaved on the lateral margin at the apex.

**Redescription**

*Wing length*: 2.93-3.45 mm.

*Colouration*: Head dull, dark brown. Mesonotum, pleura and abdomen dark brown and dull; halter light brown; legs brown, tarsi darker; terminalia brown.

*Wing*: Lightly infuscate; R₁(+R₂+3) with macrotrichia along entire length, remaining veins bare; R₂+3 situated at basal third of R₁; bend in R₄₊₅ weak; R₄₊₅ and M₁ nearly parallel toward wing margin.

*Abdomen*: Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized and slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 with few setulae, anterior margin strongly dipped into segment 7.

*Male terminalia* (Fig. 2.17): Epandrium in form of truncated cone, wider than long; posterolateral process absent; posterior margin with wide, very shallow indentation; apical epandrial processes produced into tooth-like structure. Hypandrium very slender, faint; slightly convex. Gonocoxite rectangular, slightly longer than wide. Gonostylus stout; shorter than gonocoxites; base broad, tapered.
slightly midway; apex of right gonostylus bearing terminal claw-like seta and sometimes subapical spine, subequal in length to latter; left gonostylus bearing single apical claw-like seta. Parameres paired, longer than gonostyli; thickened along median margin; lateral margin with irregular serration. Gonocoxal plate broad, extending past posterior margin of gonocoxites; produced distomedially into median keel, ending near middle of gonocoxite.

Additional Material Examined


**WASHINGTON:** Lewis Co.: Gifford Pinchot N.F., Skate Ck. Rd. mile 14, 7.vii.2013, 46°40'00"N 121°46'24"W, 660m, roadside streams, B.J. Sinclair (3♂); Santiam S.F., Monument Peak Rd., 10.vii.2013, 44°42'34"N 122°22'16"W, 820m, B.J. Sinclair (3♂);

**Pierce Co.:** Mt. Rainier N.P., @ Longmire Meadow, 1.vii.2014, 46°45'13.9"N 121°48'46.7"W, ex. stream, J.K. Moulton (1♂); Mt. Rainier N.P., Narada Falls to Reflection Lk. tr., 6.vii.2013, 46°46'15"N 121°44'44"W, small stream, 1415m, B.J. Sinclair (1♀, 1 larva); Mt. Rainier N.P., S. of Nisqually River, 30.viii.2011, 46°46'55.2"N 121°45'58.9"W, J.K. Moulton (1♂); Mt. Rainier N.P., WA-123, 1.vii.2014, 46°49'33.4"N 121°32'36.1"W, ex. small waterfall, J.K. Moulton & R.J. Pivar (1♂);


**Distribution (Fig. 2.18)**

Known from the Cascade Mountain Range in Washington and Oregon.
Figure 2.17 Ventral view of male genitalia of new specimen of *Androprosopa confracta*.

Figure 2.18 Distribution of *Androprosopa confracta*.
**Androprosopa elnora (Dyar & Shannon)**

*Thaumalea elnora* Dyar & Shannon, 1924: 434.

*Androprosopa elnora* (Dyar & Shannon); Sinclair 1996: 376.

**Type Material**

**Lectotype:** ♂ mounted on a microscope slide, labeled:

“Thaumalea/elnora/Type D. & S./Moscow Mt., Ida/July 25. 1920/R.C. Shannon”;

“LECTOTYPE/Thaumalea/elnora ♂/Dyar & Shannon/Designated by/Arnaud and Boussy, 1994” (USNM). **Lectoallotype:** ♀ pinned, labeled: “Mts. Moscow/Ida. 7.25.20/RC Shannon”;

“LECTOALLOTYPE/Thaumalea elnora Dyar/ & Shannon ♀/Designated by Arnaud and Boussy, 1994” (USNM).

**Recognition**

Thorax yellow with abdomen yellow-brown. Distinguished from *A. ericfisheri* by distinct, broad parameres with subapical beak.

**Redescription**

*Wing length:* 3.06-3.38 mm.

*Colouration:* Head yellow with golden setae; mouthparts and antennae yellow-brown. Mesonotum and pleura yellow with humerus and sclerites below base of halter darkened; halter and legs concolourous with thorax; abdomen yellow-brown, some brownish-black colouration intermixed; terminalia yellow-brown.

*Wing:* Lightly infuscate; R₁ (+R₂+₃) with macrotrichia along entire length, remaining veins bare; R₂+₃ situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ strongly convergent toward wing margin.

*Abdomen:* Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized and slightly dipped into preceding segment, bearing microtrichia
and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

*Male terminalia* (Fig. 2.19): Epandrium quadrate, wider than long; posterolateral process absent; posterior margin strongly indented; apical epandrial processes triangular, somewhat produced. Hypandrium very slender, faint. Gonocoxite rectangular, wider than long; many setae on inner margin; with short posterolateral processes. Gonostylus with many setae; shorter than gonocoxites; base broad, tapering midway to narrow apex; apex bearing terminal claw-like seta and one smaller, dorsoapical spine. Parameres paired, blunt, very broad, distal third bearing subapical beak-like process. Gonocoxal plate broad, extending to posterior margin of gonocoxites; produced medially into nearly straight line.

**Additional Material Examined**

**CANADA: BRITISH COLUMBIA:** Perry Ck. Falls tr., 11.vii.2012, 49°32'58"N 115°59'50"W, cascade stream, 1095m, B.J. Sinclair (1♂, 4♀); **U.S.A.: IDAHO:** Latah Co.: Moscow Mountain: 4.vii.1915, A.L. Melander (1♀; USNM); 7.vii.1918, A.L. Melander (18♂, 5♀; USNM); 5.vii.1919, A.L. Melander (1♀; USNM); 10.viii.1924, A.L. Melander, (1♀; USNM); **WASHINGTON:** Pierce Co.: Mt. Rainier N.P., below Comet Falls, 16.vii.2012, 46°47'29"N 121°46'55"W, streams/seeps, 1350m, B.J. Sinclair (7 larvae); **Spokane Co.:** Bald Knob Campground, Mount Spokane S.P., 4800-5200 feet, 24.vii.1978, W.J. Turner, sweeping (16♂, 8♀; WSU, CAS); Mt. Spokane S.P., Deadman Ck., 12.vii.2012, 47°54'20"N 117°06'35"W, 1325m, B.J. Sinclair (16♂); **WYOMING:** Park Co.: Yellowstone National Park, Dunraven Pass, 28.vii.1934, A.L. Melander (2♂; USNM).

**Distribution (Fig. 2.20)**

Known from northwest Wyoming, to southern British Columbia and west to Mt. Rainier in Washington.
Figure 2.19 Ventral view of male genitalia of new specimen of *Androprosopa elnora*.

Figure 2.20 Distribution of *Androprosopa elnora*. 
*Androprosopa ericfisheri* (Arnaud & Boussy)


*Androprosopa ericfisheri* (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**

**Holotype:** ♂ is mounted on a microscope slide under two cover glasses, labeled: “HOLOTYPE Male/Thaumalea/ericfisheri/Arnaud and Boussy/1994”; “Alberta: Rocky Mtns./Grizzly Crk. at/Kananaskis Rd./18 mi. S. Hwy 1 5600’/17 Aug. 1969 E.M. Fisher” (CAS Entomology Type #17005). **Allotype:** ♀ pinned with left wing and abdomen removed, labeled: “CANADA: BRITISH COLUMBIA/Mount Revelstoke National/Park, small cascading creek 6.3 road mi below summit Mount Revelstoke/8 August 1986/Paul H. Arnaud, Jr./Calif. Acad. Sci. Coll.”; “Swept from pools and/cascades small creek,/sunny day, creek shaded/by mountain, 1630-1700/hours.”; “Arnaud and Boussy/Dissection No./042093”; “ALLOTYPE Female/Thaumalea/ericfisheri/Arnaud & Boussy/1994” (CAS). **Paratypes:** CANADA: ALBERTA: same collection information as holotype (7 ♂; CAS, CDFA, CNC, USNM); BRITISH COLUMBIA: same collection information as allotype (2 ♂, 3 ♀; CAS, CNC).

**Recognition**

Thorax light yellow-brown with abdomen blackish brown. Distinguished from *A. elnora* by having very short, pointed parameres with curved apex.

**Redescription**

*Wing length:* 3.90-3.95 mm.

*Colouration:* Head brownish black. Mesonotum yellow with tip of scutellum, sclerites below base of halter darkened; pleural area with some dark spots; halter and legs concolourous with thorax, tarsi slightly darker; abdomen blackish-brown;
terminalia brown.

Wing: Lightly infuscate; $R_1(+R_{2+3})$ with macrotrichia along entire length, remaining veins bare; $R_{2+3}$ situated at basal third of $R_1$; bend in $R_{4+5}$ gentle; $R_3$; $R_{4+5}$ and $M_1$ convergent toward wing margin.

Abdomen: Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized and slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

Male terminalia (Fig. 2.21): Epandrium quadrate, wider than long; posterolateral process absent; posterior margin without indentation; apical epandrial processes slightly produced. Hypandrium very slender, faint. Gonocoxite quadrate, slightly longer than wide; many setae on inner margin; with short posterolateral processes. Gonostylus with many setae; shorter than gonocoxites; base broad, tapered dorsally and slightly ventrally to blunt apex; apex bearing three short spines. Parameres paired, short, ending before middle of gonostylus; pointed and sinuous; curved ventrally. Gonocoxal plate weak, extending nearly to posterior margin of gonocoxites; apical margin trapezoidal.

Additional Material Examined

CANADA: BRITISH COLUMBIA: Golden, Quartz Creek, small tributary, 10.ix.2011, 51°27'55.2"N 117°21'03"W, J.K. Moulton (2♂, 1♀).

Distribution (Fig. 2.22)

Known only from the southernmost portion of the Canadian Rockies.
Figure 2.21 Ventral view of male genitalia of new specimen of *Androprosopa ericfisheri*.

Figure 2.22 Distribution of *Androprosopa ericfisheri*.
**Androprosopa falciformis** (Arnaud & Boussy)

*Thaumalea falciformis* Arnaud & Boussy, 1994: 91

*Androprosopa falciformis* (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**

date or name of collector; with identification label by A. Stone as *Thaumalea fusca* (Garrett) [1♂; CU]; 3.9 mi east of Laird Park, larva 19.iv.1970 [no date for adult], S.T. Elliott, J.M. Gillespie, F.W. Spray, code AS (1♂; CAS).

**Recognition**

Distinguished by the strongly recurved parameres (similar to *A. anolo*), gonostyli elbowed and bearing a distinct blunt, lateroventral process.

**Redescription**

*Wing length:* 2.60-2.86 mm.

*Colouration:* Head brownish black. Mesonotum and pleura light brown, scutellum brown; abdomen dark brown, dull; halter pale yellow-brown; legs brown, tarsi darker; terminalia brown.

*Wing:* Lightly infuscate; R₁(+R₂+₃) with macrotrichia along entire length, remaining veins bare; R₂+₃ situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ convergent toward wing margin, then slightly divergent just before margin.

*Abdomen:* Male abdominal sternites 2-6 rectangular with basal half well sclerotized, not dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 7 & 8 with few setulae, anterior margin strongly dipped into preceding segment.

*Male terminalia* (Fig. 2.23): Epandrium in form of truncated sphere, slightly longer than wide; posterolateral process absent; posterior margin not indented; each posteroventral corner bearing single, small tooth-like apical epandrial process. Hypandrium convex medially, arching into sternite 8. Gonocoxite longer than wide, with posterolateral process bluntly produced. Gonostylus slightly shorter than gonocoxite; bent laterally and apically elbowed dorsally with stout claw-like seta at apex, bearing blunt lateroventral process at elbow. Parameres paired; broad basally,
tapering medially then sharply produced laterally and curved anteriorly toward apex; protruding slightly beyond posterior epandrial margin. Gonocoxal plate exceeding length of gonocoxites.

**Additional Material Examined**

**U.S.A: IDAHO:** Boundary Co.: 2673 Moyie River Rd., next to Feist Creek Falls Resort, 23.vi.2014, 48°54'43.0"N 116°10'23.2", ex. small rock trickle at end of drive, J.K. Moulton & R.J. Pivar (3♂); same locality info as above except, ex. headwaters of small rock trickle at end of drive, J.K. Moulton & R.J. Pivar (8♂); same locality info as above except, ex. small waterfall passed base of driveway, J.K. Moulton (1♂); same locality info as above except, 24.vi.2014, ex. drain pipe under road, J.K. Moulton & R.J. Pivar (7 larvae); Kootenai Co.: St. Joe NF, Hwy. 97, F.R. 438, 19.vi.2014, 47°36.392’N 116°40.099’W, 660m, ex. trib of Beauty Ck., B.J. Sinclair (2♂); Latah Co.: Moscow Mt., 7.vii. 1918, A.L. Melander (1♂; USNM); Moscow Mt., Hatter Ck. Rd., 13.vii.2012, 46°49’16”N 116°49’28”W, 1075m, B.J. Sinclair (1♀); Moscow Mt., Moscow Mt. Rd., 22.vi.2014, 46°47.721’N 116°54.093’W, 1000m, ex. cascading str., B.J. Sinclair (3♂); Shoshone Co.: St. Joe N.F., Rd. 50, E. Calder, 20.vii.2014, 47°15.820’N 116°08.803’W, ex. roadside streams/seeps, 680m, B.J. Sinclair (4♂);

**WASHINGTON:** Mt. Spokane SP, Deadman Ck., 12.vii.2012, 47°54’20”N 117°06’35”W, 1325m, B.J. Sinclair (3♂).

**Distribution (Fig. 2.24)**

Known from northern Idaho and from one male in west-central British Columbia.
Figure 2.23 Ventral view of male genitalia of new specimen of *Androprosopa falciformis*.

Figure 2.24 Distribution of *Androprosopa falciformis*.
Androprosopa fusca (Garrett)

Orphnephila fusca Garrett, 1925: 10.

Thaumalea fusca (Garrett); Arnaud & Boussy 1994: 94.

Androprosopa fusca (Garrett); Sinclair 1996: 376.

Type Material

Holotype: ♂ is glued to a paper point with most of abdomen and left wing removed, labeled: “MARYSVILLE/B.C. 12-VIII/C GARRETT”; “HOLO/TYP/OREPHNPHILA/FUSCA ♂/CGarrett./C.B, D. GARRETT”; “Arnaud & Boussy/Dissection No./69III24-1.” The left wing and abdomen are mounted under separate cover glasses on a microscope slide with similar label data (CNC Entomology Type #7912).

Recognition

Readily distinguished with combination of gonocoxite with finger-like posterolateral process as long as gonostylus and paramere very broad basally and narrowed sharply with distal portion recurved laterally.

Redescription

Wing length: 2.99 mm.

Colouration: Head brown. Mesonotum and pleura brown; apex of scutellum blackened; abdomen brown; legs with coxae and trochanter brown, femora and tibia light yellow-brown, tarsi darker; halter pale yellow, knob with brown base; terminalia brown.

Wing: Lightly infuscate; R₁(+R₂+₃) with macrotrichia along entire length, remaining veins bare; R₂+₃ situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ convergent toward wing margin, then M₁ slightly divergent just before margin.
**Abdomen:** Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, 2-5 not dipped into preceding segment, 6-7 slightly dipped into preceding segment; sternites 2-7 bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

**Male terminalia** (Fig. 2.25): Epandrium spherical, slightly longer than wide; posterior margin without indentation; apical epandrial processes produced into short, double dentate processes; posterolateral epandrial processes absent. Hypandrium thin, convex and dipping into sternite 8. Gonocoxite broadly conical, longer than wide; bearing glabrous, finger-like, posterolateral process equal in length to gonostylus. Gonostylus shorter than gonocoxite; basal half wider, then tapering medially, apex bearing single apical claw-like spine; few setae on gonostylus. Parameres paired, longer than gonostyli; very broad basally, narrowed sharply at apical third with distal portion strongly recurved laterally. Gonocoxal plate extending to length of gonocoxal plate, including posterolateral process; produced into medial keel.

**Additional Material Examined**

Only the holotype male is known.

**Distribution** (Fig. 2.26)

Known only from Marysville, a small village just below Kimberley in the Canadian Rockies. The region was extensively re-collected, but specimens were not discovered. Possibly most attempts were too early in the season.
Figure 2.25 Ventral view of male genitalia of holotype of *Androprosopa fusca* (Illustration from Arnaud & Boussy, 1994).

Figure 2.26 Distribution of *Androprosopa fusca*.
Androprosopa gillespieae (Arnaud & Boussy)


Androprosopa gillespieae (Arnaud & Boussy); Sinclair 1996: 376.

Type Material

Holotype: ♂ male is mounted on a microscope slide under two glasses, labeled: “HOLOTYPE/Thaumalea gillespieae/Arnaud and Boussy, 1994/ Ore.: Linn Co./Monument Peak Guard/Sta. s.21, T105, R4E/4000’ E.M. Fisher/ ♂ July 28, 1969” (CAS Entomology Type #17007). Allotype: ♀ mounted on a microscope slide under two cover glasses with same label data as holotype (CAS). Paratypes: CANADA: BRITISH COLUMBIA: ca. 11 km east Lytton, waterfall, 12.viii.1974, P.H. Arnaud, Jr. (4♂; CAS); Cultus Lake, 24.v.1965, F. Schmid (1♂; CNC); Kinnaird, 21.v.1965, F. Schmid (1♂; CNC); Kitchener, 5.v.1965, F. Schmid (1♂; CNC); U.S.A.: IDAHO: Bonner Co.: Priest Lake, 1.viii.1916, A.L. Melander (2♂, 2♀; USNM); Priest Lake, Cavanaugh Bay, 18.viii.1919, A.L. Melander (2♂; USNM); Idaho Co.: Apgar Ck., U.S. Highway 12, 15.vii.1971, collection #24 specimen #1, J.M. Gillespie (1♂; CAS); Holly Creek, U.S. Highway 12, 33 miles NE Lowell, 2,600 feet, 19.viii.1969, E.M. Fisher (14♂, 2♀; CAS); Tumble Ck., Highway 12, 16 miles northeast of Lowell, 2,000’, 19.viii.1969, E.M. Fisher (1♂; CAS); Tumble Ck., U.S. Highway 12, 15.viii.1971, J.M. Gillespie (2♂, 3♀; CAS); 2.3 miles west of Lowell, larvae collected 5.iv.1970, adults emerged from 12 to 18.iv.1970, J.M. Gillespie, F.W. Spray, S.T. Elliott (8♂, 1♀; CAS, UIC); OREGON: Clackamas Co.: Eagle Ck., Forest “Res.”, 1.viii.1917, A.L. Melander (1♂; USNM); Lane Co.: w. side Cascade Mtns., Mack Ck., 20.vii.1982, 800-900m (1♂, 2♀; USNM); w. side Cascade Mtns., Mack Ck., 11.viii.1982, 800-900m (1♂, 1♀; USNM); Linn Co.: same locality information as holotype except 26.vii.1969 (3♀; CAS); same locality information as holotype (4♂, 5♀; CAS); same locality as holotype except 2.viii.1969 (1♂, 1♀; CAS); WASHINGTON: Pierce Co.: Mount Rainier, Hansen Camp, 31.vii.1922, A.L. Melander (1♂; USNM); Skagit Co.: Baker Lake, 27.v.1965, F. Schmid (1♂; CNC); Marblemount, 31.v.1965, F. Schmid (2♂; CNC).
Recognition

This species is recognized by the large, lateral triangular shaped flange on the apical third of the paramere, with apex narrowed and blunt.

Redescription

*Wing length:* 2.60-3.4 mm.

*Colouration:* Head dark brown to blackish-brown. Mesonotum and pleura dark brown to blackish-brown and somewhat shiny, however some specimens intensely black and others reddish-brown; abdomen blackish-brown, dull; halter pale yellow-brown; legs light brown, tarsi darker; terminalia lighter brown than abdomen.

*Wing:* Infuscate; R₁(+R₂+₃) with macrotrichia along entire length, remaining veins bare; R₂+₃ situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ strongly convergent toward wing margin.

*Abdomen:* Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

*Male terminalia* (Fig. 2.27): Epandrium quadrate, wider than long; posterior margin strongly indented; apical epandrial processes triangular, rounded; posterolateral epandrial processes produced as flattened flanges, longer than wide, with serrate inner margin. Hypandrium thin, slightly concave. Gonocoxite conical, slightly longer than wide. Gonostylus slightly shorter than gonocoxite; apical third tapered to apex; apex bearing strong terminal claw-like spine. Parameres paired, longer than gonostyli; very strong lateral flange on apical third, apex narrow and blunt. Gonocoxal plate extending past posterior margin of gonocoxites; distal margin three lobed.
Additional Material Examined

**CANADA: BRITISH COLUMBIA:** Cathedral Prov.Pk., 19.vii.2015, 49°08.52"N 120°01.66"W, 725m, ex. stream, B.J. Sinclair (1♂); Hwy. 23, 13km N. Revelstoke, 21.vii.2012, 51°04’03"N 118°10’31"W, 600m, B.J. Sinclair (1 larva); Manning Prov. Pk., Three Falls Tr., below Derek Falls, 20.vii.2015, 49°03.78"N 120°56.34"W, 1220m, B.J. Sinclair (1♂,1♀); nr. Kimberley, Meachen Ck., 17.vii.2015, 49°36.22"N 116°13.33"W, roadside falls, 1021m, B.J. Sinclair (7♂); nr. Kimberley, Meachen Ck., roadside falls, 17.vii.2012, 49°36.21"N 116°13.45"W, 1027m, B.J. Sinclair (1♂); Perry Ck. Falls, 11.vii.2015, 49°32’50"N 115°59’55"W, spray zone, 1105m, B.J. Sinclair (2♂); Perry Ck. Falls Tr., 49°32’58"N 115°59’50"W, 1095m, cascading str., 11.vii.2012, B.J. Sinclair (4♂, 2♀); W. Creston-Hwy. 3, Topaz Ck., 18.vii.2015, 49°08.76"N 116°45.65"W, 825m, B.J. Sinclair (1♂); **U.S.A: CALIFORNIA:** Monterey Co.: Los Padres N.F., Mill Ck. @ Mill Ck. trail, 6.viii.2013, 35°59’30.68”N 121°28’28.06”W, 165m, R.I. Madriz & K. Lindsay (1♂); San Bernardino Co.: Crestline, 4.vii.1942, A.L. Melander (1♂; USNM); **IDAHO:** Boundary Co.: N.F.R.-2517, 23.vi.2014, 48°58’46.3"N 116°09’26.5"W, ex. Brass Creek, R.J. Pivar (1♂, 2♀); Idaho Co.: Boise N.F., 10 Mile Cpgd., Hwy 21, 11.vi.2014, 43°53.840’N 115°42.669’W, 1470m, ex. 10 Mile Ck, B.J. Sinclair (6♂, 5♀); Boise N.F., East of Lowman, Chapman Ck., 12.vi.2014, 44°06.162’N 115°18.753’W, 1450m, B.J. Sinclair (9♂, 2♀); Hwy. 95, 23.vi.2014, 45°20.547’N 116°20.999’W, cascade at Rest Stop, 650m, B.J. Sinclair (5♀); Nez Perce-Clearwater N.F., Rt. 12, Apgar Ck., 19.vi.2014, 46°12’55”N 115°32’12”W, J.K. Moulton (1♀); **Latah Co.:** Moscow Mt., Moscow Mt. Rd., 22.vi.2014, 46°47.721N 116°54.093W, 1000m, ex. cascading str., B.J. Sinclair (4♂); St. Joe N.F., F.R.447, E. of Laird Pk., 12.vi.2011, 46°57’37.7”N 116°35’51.0”W, B.J. Sinclair (1♀); **OREGON:** Baker Co.: Wallowa-Whitman N.F. Bennet Ck., 29.vi.2014, 44°59’54.8”N 117°24’00.8”W, R.J. Pivar (1 larva); Linn Co.: Cascadia S.P., nr. Sweet Home, 9.vii.2014, 44°23’56.1”N 122°28’52.3”W, 261m, ex: along Soda Ck., S.E. Brooks (21♂); Willamette N.F., 1175m, fork of No. 410 & 420, small stream, Hackleman Ck. area, 11.vii.2013, 44°23’24”N 122°02’48”W, B.J. Sinclair (3♂); Willamette N.F., Rd.
Figure 2.27 Ventral view of male genitalia of new specimen of *Androprosopa gillespieae*.

Figure 2.28 Distribution of *Androprosopa gillespieae*.
Distribution (Fig. 2.28)

The most widespread of the Nearctic Androprosopa, its range encompassing British Columbia to the north, south to California and east to Utah. It is the most commonly encountered western Nearctic thaumaleid.

Androprosopa idahoensis (Arnaud & Boussy)


Androprosopa idahoensis (Arnaud & Boussy); Sinclair, 1996: 376.

Type Material

Recognition

Recognized by the shape of the apex of the paramere, which is twisted nearly 180° towards the laterad, as well as the strongly lobed base.

Redescription

*Wing length:* 2.68-3.38 mm.

*Colouration:* Head dark brown to blackish-brown, shiny near apical margin of eye. Mesonotum and pleura brown to blackish-brown and shiny; abdomen blackish-brown, dull; halter and legs light brown, tarsi darker; terminalia dark brown.

*Wing:* Lightly infuscate; R_1( +R_2+3) with macrotrichia along entire length, remaining veins bare; R_{2+3} situated at basal third of R_1; bend in R_{4+5} gentle; R_{4+5} and M_1 strongly convergent toward wing margin.

*Abdomen:* Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 with few setulae, anterior margin strongly dipped into segment 7.

*Male terminalia* (Fig. 2.29): Epandrium quadrate, wider than long; posterior margin strongly indented; apical epandrial processes triangular, shorter than long; posterolateral epandrial processes hook-like, partially arched, longer than wide, with serrate inner margin. Hypandrium thin, convex toward sternite 8. Gonocoxite broadly conical, slightly wider than long. Gonostylus nearly subequal in length to gonocoxite; gradual tapered to apex; apex bearing one large spine at apex and two smaller ones subapically on dorsal surface. Parameres paired, longer than gonostyli; with strongly developed basal lobe; apex expanded slightly and twisted toward laterad. Gonocoxal plate extending past posterior margin of gonocoxites; distal margin with two lateral lobes and a very lightly convex medially.
Additional Material Examined

**U.S.A.: CALIFORNIA:** Sierra Co.: Tahoe National Forest, waterfall 4 miles E of Downieville, 14.viii.2013, 39°33’31.97”N 120°45’40.48”W, 1001m, R.I. Madriz (15 larvae); **IDAHO:** Boise Co.: Hwy. 21, seep near hot spring, 11.vi.2011, 44°05’26.5”N 116°03’09.8”W, B.J. Sinclair (4 larvae); Nez Perce Co.: Juliaetta Falls, 19.v.1993, J.B. Johnson (2♂; UIC); Juliaetta Falls, 12.vi.2011, 46°31’22.2”N 116°44’49.7”W, B.J. Sinclair (2♂, 2♀); Juliaetta Falls, 14.vii.2012, 46°31’23”N 116°44’47”W, 286m, ex. roadcut seeps, B.J. Sinclair (14 larvae); Juliaetta Falls, Hwy. 3, 15.vi.2014, 46°31.394’N 116°44.798’W, 286m, ex. roadcut stream/seeps, B.J. Sinclair (3♀, 5 larvae). **WASHINGTON:** Lewis Co.: Gifford Pinchot N.F., Boulder Ck. @ Skate Ck. Rd., 15.vi.2011, 46°39’10.9”N 121°43’17.1”W, J.K. Moulton (2♂).

**Distribution (Fig. 2.30)**

Known from the Pacific Northwest in Washington (Mt. Rainier), Idaho and the northern Sierra Nevada mountain range in California.

![Figure 2.29 Ventral view of male genitalia of new specimen of *Androprosopa idahoensis*.](image-url)
**Androprosopa lindsayorum** (Arnaud & Boussy)


*Androprosopa lindsayorum* (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**


**California:** Del Norte Co.: Gasquet, 4.vi.1965, F. Schmid (2♂, 1♀; CAS, CNC);
OREGON: Benton Co.: Corvallis, 21.viii.1925, A.L. Melander (3♂; CAS, UCB, USNM);
WASHINGTON: Skagit Co.: Baker Lake, 27.v.1965, F. Schmid (3♂, 1♀; CAS, CNC);
Marblemount, 30.vi.1965, F. Schmid (1♂; CNC); Whatcom Co.: Glacier, 25.v.1965, F.
Schmid (2♂, 2♀; CNC).

Recognition

Recognized by the three to four long, dorsomedial claw-like spines on the
gonostyli. Differs from A. sonorensis by the following characters: gonostyli weakly
arcuate, gonocoxite with posterolateral process pointed, known from the Pacific Northwest

Redescription

Wing length: 3.27-3.61 mm.

Colouration: Head blackish-brown. Mesonotum and pleura ranging from
brown to orange-brown, shiny; scutellum light brown; abdomen blackish-brown,
dull; halter and legs light brown, tarsi darker; terminalia yellow-brown.

Wing: Infuscate; R₁(₊R₂₊₃) with macrotrichia along entire length, remaining
veins bare; R₂₊₃ situated at basal third of R₁; bend in R₄₊₅ gentle; R₄₊₅ and M₁
convergent toward wing margin, but M₁ slightly divergent just before margin.

Abdomen: Male abdominal sternites 2-7 rectangular with basal half well
sclerotized, not dipped into preceding segment, bearing microtrichia and numerous
setulae; sternite 8 with setulae, anterior margin strongly dipped into segment 7.

Male terminalia (Fig. 2.31): Epandrium nearly cylindrical, slightly longer than
wide; posterior margin not indented; apical epandrial processes with small,
sclerotized tooth. Hypandrium thin, faint, dipping slightly into sternite 8. Gonocoxite
rectangular, broad, longer than wide; with posterolateral process pointed.
Gonostylus broad, shorter than gonocoxite; slightly arched; apex bearing 3-5 long,
thin spines on dorsomedial side of apex, sometimes subapical; spines nearly half the length of gonostylus. Parameres paired, slightly longer than gonostyli; broad, smooth on inner margin, with slight distolateral projection. Gonocoxal plate shorter than posterior margin of gonocoxites; broad, hourglass figure.

Additional Material Examined

CANADA: BRITISH COLUMBIA: Nanaimo, 24.vii.26, (no collector information), (1♂; USNM); 5km E. Sicamous, 20.vii.2012, 50°53’19”N 118°51’19”W, roadcut seep, 360m, B.J. Sinclair (1♂); U.S.A.: CALIFORNIA: Del Norte Co.: Redwood N.P., Enderts beach, 3.vi.2009, 41°42’21”N 124°08’33”W, sea cliff seep, B.J. Sinclair (14♂, 2♀, 7 larvae); Siskiyou Co.: Klamath N.F., Beaver Ck. Rd., 7.vii.2014, 41°57’32.9”N 122°47’44.2”W, ex. seep, J.K. Moulton (2♀); OREGON: Benton Co.: Mary’s Peak, Parker Ck. Falls, 4.vii.2014, 44°30’15.3”N 123°33’47.6”W, J.K. Moulton & R.J. Pivar (1♂, 2♀); Mary’s Peak, 4.vii.2014, 44°28’28”N 123°31’38”W, ex. roadcut seep, J.K. Moulton & R. J. Pivar (1♂, 1♀, 15 larvae); Mary’s Peak, 4.vii.2014, 44°28’29.2”N 123°31’29.5”W, ex. roadside seep, J.K. Moulton & R.J. Pivar (7 larvae); Siuslaw N.F., Mary’s Peak Rd., Alder Ck. Falls, 12.vii.2013, 44°28’27”N 123°31’42”W, 675m, B.J. Sinclair (3♂, 1♀, 3 larvae); Clackamas Co.: Mt. Hood N.F., Hwy. 173, 9.vii.2013, 45°18’23”N 121°44’00”W, 1270m, B.J. Sinclair (2♂, 1♀); Clatsop Co.: Ecola SP, Indian Beach, 2.vii.2014, 45°55’52.1”N 123°58’37.3”W, ex: freshwater seeps, J.M. Cumming (1♂, 2♀); Hood River Co.: Eagle Creek, 16.vi.1925 (1♂; USNM); Lane Co.: Willamette N.F., N.F.R.-19, 5.vii.2014, 43°53’00.8”N 22°15’54.5”W, ex. mud seep, R.J. Pivar (1♂, 1♀); Linn Co.: Cascadia S.P., nr. Sweet Home, 9.vii.2014, 44°23’56.1”N 122°28’52.3”W, 261m, ex: along Soda Crk, S.E. Brooks (1♂); Marion Co.: Silver Falls State Park, 12.viii.1989, seepage along Canyon Trail, B.J. Sinclair (1♂, misidentified as paratype of A. sonorensis in Arnaud & Boussy, 1994); Silver Falls S.P., North Falls, 10.vii.2013, 44°53’04”N 122°37’13”W, 454m, seeps, B.J. Sinclair (4♂, 3♀); Multnomah Co.: Wahkeena Falls & Ck., 8.vii.2013, 45°34’31”N 122°07’40”W, 45m, larvae (08.vii.13) and pupae exuviae (reared 9.viii.13), B.J. Sinclair (1♂);

WASHINGTON: Jefferson Co.: Olympic N.P., tribs. of Queets River, along Queets R.

**Distribution (Fig. 2.32)**

A commonly encountered species, it is found along the Cascade Mountain Range from British Columbia south to California, as well as southeastern British Columbia.
Figure 2.31 Ventral view of male genitalia of new specimen of *Androprosopa lindsayorum*.

Figure 2.32 Distribution of *Androprosopa lindsayorum*. 
Androprosopa magnipelvim sp. nov.

Type Material


Recognition

Differs from the closely related A. sierra by the location of the subapical spines on the inner margin of gonostylus.

Description

Wing length: 3.69 mm.

Colouration: Head blackish-brown. Mesonotum dark brown, shiny; pleura brown to dark brown, shiny; scutellum blackish-brown; abdomen dark brown, dull; halter pale yellow; legs pale brown, tarsi darker; terminalia pale brown.

Wing: Lightly infuscate; $R_1(+R_{2+3})$ with macrotrichia along entire length, remaining veins bare; $R_{2+3}$ situated at basal third of $R_1$; bend in $R_{4+5}$ gentle; $R_{4+5}$ and $M_1$ strongly convergent toward wing margin.

Abdomen: Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

Male terminalia (Fig. 2.33): Epandrium quadrate, wider than long; posterior margin strongly indented; apical epandrial processes triangular, rounded; posterolateral epandrial processes produced as flanges, longer than wide, with serrate inner margins in ventral view; angled slightly toward dorsum and sharply
tapered into bird beak-like apex in lateral view. Hypandrium thin. Gonocoxite quadrate, slightly longer than wide. Gonostylus shorter than gonocoxite; base expanded, apical third narrowed and tapered to apex; apex bearing strong terminal claw-like spine with two subapical spine-like anterolateral setae on inner margin. Parameres paired, sinuous, longer than gonostyli; arched medially, converging strongly toward bluntly rounded apex. Gonocoxal plate extending past posterior margin of gonocoxites; distal margin trilobed.

**Additional Material Examined**

Known only from the type series.

**Distribution (Fig. 2.34)**

Known only from the type locality in Great Basin National Park.

**Etymology**

*Androprosopa magnipelvim* after Great Basin National Park where the type series was collected. Magnipelvim is Latin for ‘great basin’.

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*Figure 2.33 Ventral view of male genitalia of holotype of Androprosopa magnipelvim.*
Figure 2.34 Distribution of *Androprosopa magnipelvim*.

*Androprosopa melanderi* (Arnaud & Boussy)


*Androprosopa melanderi* (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**

Recognition

Differing from the closely related *A. brothersi* and *A. contracta* by its light yellow-brown colouration and the hind margin of the epandrium straight bearing one tooth-like projection on the posteroventral corners.

Redescription

*Wing length:* 2.41-2.62 mm.

*Colouration:* Head dull, brown. Mesonotum and pleura light yellowish-brown, scutellum slightly darker; abdomen brown; halter and legs concolourous with thorax, tarsi darker; terminalia brown.

*Wing:* Lightly infuscate; R₁(+R₂+3) with macrotrichia along entire length, remaining veins bare; R₂+₃ situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ convergent toward wing margin, then M₁ slightly divergent just before margin.

*Abdomen:* Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized and slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

*Male terminalia* (Fig. 2.35): Epandrium cylindrical, about as wide as long; posterior margin lacking indentation; posterolateral process absent; apical epandrial processes produced into short, tooth-like projection. Hypandrium narrow, convex. Gonocoxite ovoid, longer than wide. Gonostylus stout; shorter than gonocoxite; base broad, gently tapered towards tip; apex bearing single, strong claw-like spine. Parameres paired, longer than gonostyli; lateral margin smooth; pointed lateral projection at apex. Gonocoxal plate broad, extending past posterior margin of gonocoxites; produced medially into columnar-like keel.
Additional Material Examined

**U.S.A.: CALIFORNIA:** Santa Clara Co.: Uvas Canyon County Park, 8.vii.2014, 37°05’03.9"N 121°47’34.4"W, ex. sweeps along Swanson Ck., J.K. Moulton & R.J. Pivar (7♂); **COLORADO:** Mineral Co.: San Juan N.F., Hwy. 160, 10.vii.2014, 37°26’31.5"N 106°52’37.6W, ex. Falls Ck. near parking lot, R.J. Pivar (2♂).

**Distribution (Fig. 2.36)**

Known from southern California and southeast Colorado.

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Figure 2.35 Ventral view of male genitalia of new specimen of *Androprosopa melanderi*. 
Figure 2.36 Distribution of *Androprosopa melanderi*.

*Androprosopa palouse* (Arnaud & Boussy)


*Androprosopa palouse* (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**

**Holotype:** ♂ mounted on a microscope slide under two cover glasses, labeled: “HOLOTYPE Male/Thaumalea/palouse/Arnaud and Boussy, 1994/USA: IDAHO, Latah Co./4.5 mi. E. Laird Park/larva: IV.19.1970/S.T. Elliott, J.M. Gillespie, F.W. Spray/Code AM” (CAS Entomology Type #17009). **Paratypes:** **U.S.A.: IDAHO:** Latah Co.: 4.5 miles east of Laird Park, larva 19.iv.1970, S.T. Elliott, J.M. Gillespie, F.W. Spray (2♂; CAS); same data as preceding but 3.9 miles east of Laird Park (1♂; CAS); same data but 2 miles east of Laird Park (1♂; CAS).
Recognition

This species is recognized by the male terminalia longer than wide, the hind margin of the epandrium with a very narrow indentation, and the parameres with distal halves parallel and the apex slightly tapered and twisted laterally.

Redescription

*Wing length:* 2.34-2.70 mm.

*Colouration:* Head dark brown to blackish-brown. Mesonotum and pleura dark brown to blackish-brown and somewhat shiny, however some specimens intensely black and others reddish-brown; abdomen blackish-brown, dull; halter pale yellow-brown; legs light brown, tarsi darker; terminalia lighter brown than abdomen.

*Wing:* Infuscate; $R_1 (+R_{2+3})$ with macrotrichia along entire length, remaining veins bare; $R_{2+3}$ situated at basal third of $R_1$; bend in $R_{4+5}$ gentle; $R_{4+5}$ and $M_1$ strongly convergent toward wing margin.

*Abdomen:* Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 with lacking setulae, anterior margin strongly dipped into segment 7.

*Male terminalia* (Fig. 2.37): Epandrium quadrate, wider than long; posterior margin with narrow indentation; apical epandrial processes pointed; posterolateral epandrial processes hook-like, partially arched, longer than wide, with serrate inner margin. Hypandrium thin, narrower than apex of gonostylus. Gonocoxite conical, longer than wide. Gonostylus shorter than gonocoxite; tapered slightly towards apex; apex bearing strong terminal claw-like spine and two smaller subapical spines. Parameres paired, longer than gonostyli; distal halves parallel, with apex tapered and folded laterally. Gonocoxal plate extending past posterior margin of
gonocoxites; distal margin three lobed.

Additional Material Examined


Distribution (Fig. 2.38)

Known from the Idaho panhandle and southeastern British Columbia.

![Figure 2.37 Ventral view of male genitalia of new specimen of *Androprosopa palouse*](image.png)
Figure 2.38 Distribution of *Androprosopa palouse*.

*Androprosopa rainierensis* sp. nov.

**Type Material**

**Holotype:** ♂ pinned with abdomen removed, labeled: "USA: WA: Mt. Rainier N.P./ Narada Falls to Reflection Lake/ tr., 2.vii.2013 46°46′15″N/ 121°44′44″W small stream,/ 1415m, B.J. Sinclair"; “HOLOTYPE: /Androprosopa/rainierensis Pivar" **Allotype:** ♀ “USA: WA: Mt. Rainier N.P./ Narada Falls-Reflection Lake/ 17.viii.2012 46°46′09″N/ 121°44′19″W 1480m/ B.J. Sinclair” **Paratypes: U.S.A.: WASHINGTON:** Mt. Rainier N.P., Comet Falls Trail, 3.vii.2013, 46°47′31″N 121°46′51″W, 1200m, ex. small stream, B.J. Sinclair (1♂); Mt. Rainier N.P., Narada Falls-Reflection Lake, 17.viii.2012, 46°46′09″N 121°44′19″W, 1480m, B.J. Sinclair (1♂); Mt. Rainier N.P., Narada Falls to Reflection Lake tr., 2.vii.2013, 46°46′15″N 121°44′44″W, small stream, 1415m, B.J. Sinclair (3♂).
Recognition

Recognized by its pointed gonostyli lacking terminal setae and the presence of a distinct peg-like seta near the midway point of the gonostylus.

Description

_Wing length_: 2.99-3.12 mm.

_Colouration:_ Head brownish black. Mesonotum and pleura dark brown, shiny; humerus pale brown; scutellum brown with anterolateral corners pale brown; abdomen brownish-black, somewhat shiny; legs light brown, tarsi darker; halter cream coloured with apex of knob and base of stalk brown; terminalia pale yellow.

_Wing:_ Infuscate; R₁(+R₂+3) with macrotrichia along entire length, remaining veins bare; R₂+3 situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ convergent toward wing margin, then diverging just before margin.

_Abdomen:_ Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

_Male terminalia_ (Fig. 2.39): Epandrium cylindrical, slightly longer than wide; posterior margin without indentation; apical epandrial process absent; posterolateral epandrial process absent. Hypandrium thin, slightly convex. Gonocoxite ovoid, slightly longer than wide; lacking finger-like, posterolateral process. Gonostylus shorter than gonocoxite; strongly curved laterally, tapered to point, but lacking apical setae; inner margin bearing single large, peg-like seta distomedially. Parameres paired, longer than gonostyli; broad and blunt toward apex, gently curved toward laterad, slightly thickened near apex. Gonocoxal plate extending to length of gonocoxal plate, including posterolateral process; produced
into medial keel.

**Additional Material Examined**

Known only from the type series.

**Distribution (Fig. 2.40)**

Known only from the southern slopes of Mt. Rainier.

**Etymology**

*Androprosopa rainierensis* is named after the type locality of Mt. Rainier, the only place the species is known from, and for the generosity of the park to provide us with collecting permits. Mt. Rainier National Park has a very high diversity of Thaumaleidae; it is home to 10 species across 2 genera.

![Figure 2.39 Ventral view of male genitalia of holotype of *Androprosopa rainierensis*.](image)
Androprosopa santaclaraensis (Brothers)

Thaumalea santaclaraensis Brothers, 1972: 121.

Thaumalea santaclarenseis Brothers; Arnaud & Boussy, 1994: 53 & 115 (lapsis calami).

Androprosopa santaclaraensis (Brothers); Sinclair 1996: 376.

Type Material

**Holotype:** ♂ is glued to a paper point and its abdomen removed, labeled: “Alum Rock Park/Santa Clara Co., Calif. VII-31-71”; “D.R. Brothers/Acc. No. 8470”; “HOLOTYPE/Thaumalea/santaclaraensis/ Brothers/Det/D.R. Brothers 1971”, abdomen mounted on a microscope slide under one cover glass (CAS Entomology Type #9909). **Allotype:** ♀ pinned with same collection data as holotype, but with Brother’s Accession Number 8265 (CAS). **Paratypes:** U.S.A.: CALIFORNIA: Santa Clara Co.: Alum Rock Park, 13.vi.1971, D.R. Brothers (2♂, 2♀; CAS); same locality,
5.viii.1971 (3♂, 2♀); same locality, 17.viii.1971, D.R. Brothers (5♂; CAS).

**Recognition**

This species is recognized by the broad male terminalia and the distinctly shaped gonostyli.

**Redescription**

*Wing length: 3.01-3.38 mm.*

*Colouration:* Head dark brown. Mesonotum and pleura light brown to brown, shiny; abdomen blackish-brown, somewhat shiny; halter pale brown; legs brown, tarsi darker; terminalia brown.

*Wing:* Lightly infuscate; R₁(+R₂+3) with macrotrichia along entire length, remaining veins bare; R₂+3 situated at basal third of R₁; bend in R₄₊5 gentle; R₄₊5 and M₁ strongly convergent toward wing margin.

*Abdomen:* Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

*Male terminalia* (Fig. 2.41): Epandrium ovoid, wider than long; posterior margin irregular; apical epandrial process strongly produced, hook-like and slightly arched; lacking posterolateral epandrial process. Hypandrium thin, slightly concave. Gonocoxite broadly conical, slightly wider than long. Gonostylus shorter than gonocoxite; with setose basal bulb; few setae after bulb; curved apical process at apex, with subapical, strong process; slightly elbowed at apical third. Parameres paired, longer than gonostyli; converging medially, then diverging at apex; small flange before apex. Gonocoxal plate extending past posterior margin of gonocoxites; distal margin forming distinct mid-lobe and two less visible lateral lobes.
Figure 2.41 Ventral view of male genitalia of new specimen of *Androprosopa santaclaraensis*.

Figure 2.42 Distribution of *Androprosopa santaclaraensis*. 
Additional Material Examined

**U.S.A.: CALIFORNIA:** Uvas Canyon County Park, 8.vii.2014, 37°05’03.9"N 121°47’34.4"W, ex. sweeps along Swanson Ck., J.K. Moulton & R.J. Pivar (2♂); Uvas Canyon County Park, 8.vii.2014, 37°05’03.9"N 121°47’34.4"W, ex. falls @ Uvas Ck., J.K. Moulton & R.J. Pivar (1♀).

**Distribution (Fig. 2.42)**

Known only from the south Coast Ranges of central California.

*Androprosopa schmidiana* (Arnaud & Boussy)


*Androprosopa schmidiana* (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**

**Holotype:** ♂ pinned with abdomen removed, labeled: “U.S.A., Cal./Siskiyou Co./Klamath River/6-VI-1965/F. Schmid”; “CNC 106”; “HOLOTYPE Male/Thaumalea schmidiana/ Arnaud and Boussy/1994,” the abdomen is mounted on a microscope slide under one cover glass (CNC Type #21929). **Allotype:** ♀ with same collection data as holotype (CNC). **Paratypes:** **U.S.A.: CALIFORNIA:** Siskiyou Co.: Klamath River, 6.vi.1965, F. Schmid, (1♂, 7♀; CAS, CNC); **IDAHO:** Cassia Co.: 7.5 miles south of Albion, 22.viii.1972, J.M. Gillespie (2♂; CAS); Idaho Co.: 2.3 miles west of Lowell, larva 5.iv.1970, adult 15.iv.1970, S.T. Elliott, J.M. Gillespie, F.W. Spray (1♂; CAS).

**Recognition**

Distinguished by the inner margin of the parameres parallel and the apical third of the lateral margin with a moderately produced flange, then tapering to a blunt tip.
Redescription

Wing length: 2.73-3.56 mm.

Colouration: Head brownish-black. Mesonotum and pleura brownish-black, some specimens reddish-brown laterally; scutellum brownish-black; abdomen brownish-black to black, dull; halter yellow-brown; legs brown, tarsi darker; terminalia brown.

Wing: Infuscate; R₁(₊R₂₊₃) with macrotrichia along entire length, remaining veins bare; R₂₊₃ situated at basal third of R₁; bend in R₄₊₅ gentle; R₄₊₅ and M₁ strongly convergent toward wing margin.

Abdomen: Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

Male terminalia (Fig. 2.43): Epandrium spherical, wider than long; posterior margin strongly indented; apical epandrial process triangular, rounded; posterolateral epandrial process produced as flattened flange, double tipped, longer than wide, with serrate inner margin. Hypandrium thin, slightly concave. Gonocoxite conical, longer than wide. Gonostylus shorter than gonocoxite; evenly tapered towards apex; apex bearing strong terminal claw-like spine and two smaller subapical, dorsal spines. Parameres paired, longer than gonostyli; expanded medially into moderate lateral flange, then tapering toward apex, ending in blunt point. Gonocoxal plate extending past posterior margin of gonocoxites; distal margin three lobed.

Additional Material Examined

Figure 2.43 Ventral view of male genitalia of holotype of *Androprosopa schmidiana*.

Figure 2.44 Distribution of *Androprosopa schmidiana*.
Distribution (Fig. 2.44)

Recorded from three localities in northern California, and northern and southern Idaho.

*Androprosopa sierra* sp. nov.

**Type Material**

**Holotype:** ♂ “USA: CA: Nevada Co. Big Culvert/ along Sagehen Crk. 6m Malaise/ 39°26’04.4”N 120°16’52.2”W/ 10.iix.-15.x.2012 C.J. Borkent, / J.M. Cumming, S.E. Brooks”; “HOLOTYPE: *Androprosopa/ sierra* Pivar” **Allotype:** ♀ same collection information as holotype. **Paratypes:** Same collection information as holotype (16 ♂, 1 ♀).

**Recognition**

Distinguished from the closely related *A. magnipelvim* by the location of the subapical spines located on outer margin of gonostylus and the gonostyli tapering gently toward apex.

**Description**

*Wing length:* 2.50-2.83 mm.

*Colouration:* Head blackish-brown. Mesonotum and pleura brown to dark brown; scutellum slightly darker brown than thorax; abdomen dark brown, dull; halter pale cream; legs pale yellow, tarsi darker; terminalia pale brown.

*Wing:* Lightly infuscate; R₁(+R₂+₃) with macrotrichia along entire length, remaining veins bare; R₂+₃ situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ strongly convergent toward wing margin.

*Abdomen:* Male abdominal sternites 2-7 rectangular with anterior margin
well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

**Male terminalia (Fig. 2.45):** Epandrium quadrate, wider than long; posterior margin strongly indented; apical epandrial process triangular, rounded; posterolateral epandrial process produced as bifurcated flange, longer than wide, with serrate inner margin in ventral view; angled slightly toward dorsum and sharply tapered into bird beak-like apex in lateral view. Hypandrium thin. Gonocoxite conical, longer than wide. Gonostylus shorter than gonocoxite; apical third narrowed and tapered to apex; apex bearing strong terminal claw-like spine with two subapical spine-like anterolateral seta. Parameres paired, sinuous, longer than gonostyli; arched medially, bluntly rounded at apex. Gonocoxal plate extending past posterior margin of gonocoxites; distal margin trilobed.

**Additional Material Examined**

Known only from the type series.

**Distribution (Fig. 2.46)**

Known only from two localities within the Sierra Nevada mountain range.

**Etymology**

*Androprosopa sierra* is named after the Sierra Nevada mountain range where the type specimen was collected.
Figure 2.45 Ventral view of male genitalia of holotype of *Androprosopa sierra*.

Figure 2.46 Distribution of *Androprosopa sierra*. 
Androprosopa sonorensis (Arnaud & Boussy)


Androprosopa sonorensis (Arnaud & Boussy); Sinclair 1996: 376.

Type Material


Recognition

Recognized by the 3-4 long, claw-like spines on the apex of the gonostyli. Differs from the closely related A. lindsayorum by the following: gonostyli strongly arcuate, gonocoxite with posterolateral process rounded, known from the Pacific Northwest.
Redescription

*Wing length:* 3.69-3.77 mm.

*Colouration:* Head blackish-brown. Mesonotum and pleura light brown to brown, some pleural areas brownish-black; abdomen blackish-brown to black, dull; legs light brown; halter pale brown; terminalia light brown.

*Wing:* Lightly infuscate; R₁(₊R₂₊₃) with macrotrichia along entire length, remaining veins bare; R₂₊₃ situated at basal third of R₁; bend in R₄₊₅ gentle; R₄₊₅ and M₁ convergent toward wing margin, then M₁ slightly divergent just before margin.

*Abdomen:* Male abdominal sternites 2-7 rectangular with basal half well sclerotized, not dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 with setulae, anterior margin strongly dipped into segment 7.

*Male terminalia* (Fig. 2.47): Epandrium in form of truncated cone, slightly longer than wide; posterior margin with slight median indentation; apical epandrial margin produced into small tooth posterolateral epandrial process absent. Hypandrium thin, convex, slightly arched into sternite 8. Gonocoxite cylindrical, longer than wide; with short, rounded posterolateral process. Gonostylus short, sinuous, shorter than gonocoxite; bearing four stout, elongate, claw-like spines on apicolateral surface. Parameres paired, slightly longer than gonostyli; broad, smooth on inner margin, with slight distolateral projection, lateral margin sinuous.

Gonocoxal plate shorter than posterior margin of gonocoxites; broad, truncate.

**Additional Material Examined**

Only the type series is known.

**Distribution (Fig. 2.48)**

Known only from the type locality in Sonora, Mexico.
Figure 2.47 Ventral view of male genitalia of holotype of *Androprosopa sonorensis* (Illustration from Arnaud & Boussy, 1994).

Figure 2.48 Distribution of *Androprosopa sonorensis*. 
Androprosopa uvas sp. nov.

Type Information

Holotype: ♂ "USA: CA: Santa Clara Co. / Uvas Canyon County Park, / 8.vii.2014 N37°05'03.9" / W121°47'34.4" ex. sweeps/ along Swanson Ck./ J.K. Moulton & R.J Pivar"; “HOLOTYPE: Androprosopa uvas Pivar” Paratypes: same collection information as holotype (8♂).

Recognition

Recognizable by the location of the two subapical spines on the dorsal surface of gonostyli.

Description

Wing length: 2.42-2.99 mm.

Colouration: Head dark brown. Mesonotum light brown with black patch posteriorly, shiny; pleura grey, katepisternum pale brown; scutellum blackish brown; abdomen smoky grey to dark brown, dull; halter and legs pale yellow, tarsi darker; terminalia brown.

Wing: Infuscate; R₁(+R₂+3) with macrotrichia along entire length, remaining veins bare; R₂+3 situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ strongly convergent toward wing margin.

Abdomen: Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, sinuous, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin strongly dipped into segment 7.

Male terminalia (Fig. 2.49): Epandrium quadrate, wider than long; posterior margin strongly indented; apical epandrial process triangular, rounded; posterolateral epandrial process produced as bifurcated flanges, longer than wide,
with serrate inner margin in ventral view; angled slightly toward dorsum and sharply tapered into bird beak-like apex in lateral view. Hypandrium thin. Gonocoxite conical, longer than wide. Gonostylus shorter than gonocoxite; apical third narrowed and tapered to apex; apex bearing strong terminal claw-like spine with two subapical spine-like dorsolateral seta. Parameres paired, longer than gonostyli; converging basally, then becoming parallel for apical two-thirds; narrows at apex and bluntly rounded. Gonocoxal plate extending past posterior margin of gonocoxites; distal margin trilobed.

**Additional Material Examined**

Known only from the type series.

**Distribution (Fig. 2.50)**

Known only from the type locality at Uvas Canyon County Park in the Santa Cruz Mountains.

**Etymology**

*Androprosopa uvas* is named after the type locality.

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**Figure 2.49 Ventral view of male genitalia of holotype of *Androprosopa uvas.***
**Androprosopa waha** (Arnaud & Boussy)

*Thaumalea waha* Arnaud & Boussy, 1994: 121.

*Androprosopa waha* (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**

**Holotype:** ♂ pinned on a small pin that is double mounted with right wing and most of abdomen removed, labeled: “Lake Waha, IDA, 9 June 1918/A.L. Melander”; “AL Melander/ Collection/1961” [green and white label]; Arnaud & Boussy/Dissection No./69.IX.26-1”; “HOLOTYPE Male/Thaumalea waha/ Arnaud & Boussy/1994”, the right wing and abdomen are mounted on a microscope slide under two cover glasses with similar label data as above (USNM). **Allotype:** ♀ is cleared and mounted on two microscope slides under two cover glasses and one uncovered preparation, labeled: “U.S.A., Wash./Skagit Co./Marblemount/30-VI-1965/F. Schmid”; Arnaud & Boussy/Dissection No./7-V-1973”; “ALLOTYPE Female/Thaumalea/waha/ Arnaud & Boussy/1994” (CNC). **Paratypes: CANADA:**

Recognition

Distinguished from the closely related *A. zelmae* by the spatula-shaped gonostyli and the apically bifurcate parameres.

Redescription

*Wing length*: 2.97-3.38 mm.

*Colouration*: Head brownish black. Mesonotum and pleura brown to blackish-brown; abdomen brownish-black; legs pale brown, tarsi darker; halter brown at base with knob yellow-brown; terminalia brown.

*Wing*: Lightly infuscate; R₁(₊R₂₊₃) with macrotrichia along entire length, remaining veins bare; R₂₊₃ situated at basal third of R₁; bend in R₄₊₅ gentle; R₄₊₅ and M₁ convergent toward wing margin, then M₁ slightly divergent just before margin.

*Abdomen*: Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 bearing a single medial seta, anterior margin strongly dipped into segment 7.

*Male terminalia* (Fig. 2.51): Epandrium in form of truncated sphere, wider than long; posterior margin broadly indented; apical epandrial process sclerotized, forming two small prongs bent inwardly; posterolateral epandrial processes absent. Hypandrium thin, slightly convex. Gonocoxite broadly conical, slightly wider than long; bearing glabrous, finger-like posterolateral process, three quarters length of
gonostylus. Gonostylus shorter than gonocoxite; thickened basally, constricted abruptly through median third, then gradually expanding to broad, truncated tip; tip very weakly bilobed; strong claw-like spine on inner lobe, directed internally; few setae on gonostylus. Parameres paired, longer than gonostyli; base broad, becoming bifurcate medially into two processes; outer process curved medially, while inner process curved lateroventrally and further bifurcated apically. Gonocoxal plate subequal to length of gonocoxal plate, including posterolateral process; produced into medial keel.

**Additional Material Examined**

**CANADA: BRITISH COLUMBIA:** nr. Kimberley, Meachen Ck. F.R., roadside falls, 17.vii.2015, 49°36.21"N 116°13.45"W, 1027m, B.J. Sinclair (3♂); **U.S.A.:**

**WASHINGTON:** Pierce Co.: Mt. Rainier N.P., Christine Falls, 2.vii.2014, 46°46'51.2"N 121°46’45.5"W, ex. small falls E. of Christine Falls next to road, J.K. Moulton & R.J. Pivar (1♂); Spokane Co.: Mt. Spokane S.P., Deadman Ck., 12.vii.2012, 47°54’20"N 117°06’35"W, 1325m, B.J. Sinclair (1♂).

**Distribution (Fig. 2.52)**

A wide distribution ranging from central California, north through the Cascade Range of Washington and southern British Columbia, and to eastern Idaho.

*Androprosopa zelmae* (Arnaud & Boussy)


*Androprosopa zelmae* (Arnaud & Boussy); Sinclair 1996: 376.

**Type Material**

**Holotype:** ♂ pinned with left wing and abdomen removed, labeled: “Mt Rainier Wn/VanTrump Crk/Sept. 1, 1917/A.L. Melander”; “AL Melander/Collection/1961”; “Arnaud & Boussy Diss. No. 69.X.30-6”; “HOLOTYPE 110
Figure 2.51 Ventral view of male genitalia of new specimen of *Androprosopa waha*.

Figure 2.52 Distribution of *Androprosopa waha*.
Male/Thaumalea/zelmae/Arnaud & Boussy,/1994”, the left wing and abdomen are mounted on a microscope slide under two cover glasses with label data similar to the holotype pinned specimen (USNM).

**Recognition**

Differentiated by the closely related *A. waha* by the gonostyli being overall more uniform in width and parameres bent apically at a right angle with a small process at apex.

**Redescription**

*Wing length*: 3.01 mm.

*Colouration*: Head brownish black. Mesonotum and pleura dark brown; scutellum black; abdomen brownish-black; legs brown, tarsi darker; halter brown at base with knob yellow-brown; terminalia reddish-brown.

*Wing*: Infuscate; R₁(+R₂+3) with macrotrichia along entire length, remaining veins bare; R₂+3 situated at basal third of R₁; bend in R₄+₅ gentle; R₄+₅ and M₁ convergent toward wing margin, then M₁ slightly divergent just before margin.

*Abdomen*: Male abdominal sternites 2-7 rectangular with anterior margin well sclerotized, slightly dipped into preceding segment, bearing microtrichia and numerous setulae; sternite 8 lacking setulae, anterior margin slightly dipped into segment 7.

*Male terminalia* (Fig. 2.53): Epandrium in form of truncated sphere, wider than long; posterior margin broadly indented; apical epandrial process sclerotized, forming two prongs bent inwardly; posterolateral epandrial process absent. Hypandrium thin, slightly concave. Gonocoxite broadly conical, slightly wider than long; bearing glabrous, finger-like posterolateral process half length of gonostylus. Gonostylus nearly subequal to gonocoxite (excluding posterolateral process);
thickened basally, constricted through median third, expanded to widest point, then tapered at apex; stout claw-like spine on small, inner medial lobe at greatest width of gonostylus, directed mediodorsally; few setae on gonostylus. Parameres paired, reaching apex of gonostyli; basal half very broad, strong constriction medially, then bent at right angles laterally, bent towards posterior at tip. Gonocoxal plate extending to length of gonocoxite, including posterolateral process; produced into medial keel.

**Additional Material Examined**

Known only from the holotype male.

**Distribution (Fig. 2.54)**

Known only from Van Trump Creek in Mt. Rainier National Park, Washington.

*Androprosopa zempoala* Sinclair & Huerta

*Androprosopa zempoala* Sinclair & Huerta, 2010: 444.

**Type Material**


**Paratypes**: 2 males, same data as holotype (CNC, CAIM).

**Recognition (Fig. 2.55)**

This species is differentiated from the closely related *A. arnaudi* by the following characters: gonostyli expanded basally and tapered strongly at apex, and the parameres sinuous and the apex arched medially.
Figure 2.53 Ventral view of male genitalia of holotype of *Androprosopa zelmae*.

Figure 2.54 Distribution of *Androprosopa zelmae*.
Description

See Sinclair & Huerta 2010 for a complete description.

Additional Material Examined

Known only from the type material.

Distribution (Fig. 2.56)

Known only from Mexico, between the states of Morelos and Mexico, in Parque Nacional “Lagunas de Zempoala.”

Figure 2.55 Ventral view of male genitalia of paratype of Androprosopa zempoala (Illustration from Sinclair & Huerta, 2010).
Discussion

The Thaumaleidae are small family with roughly 185 described species. Due to their habitat specificity and weak flying abilities, they are infrequently encountered and therefore understudied. The genus *Androprosopa* had been studied fairly well previously in the Nearctic Region (Arnaud & Boussy 1994, Sinclair 1996), yet six new species have been recognized in this study.

All of the new species are found in the western Nearctic Region, particularly in mountain ranges in the southwest portion of the United States. This newfound diversity is likely due to the lack of focused collection of the family historically, as well as underutilization of new identification techniques, such as the use of DNA to help distinguish species. Continued collecting in these regions may yield more new species. Colorado in particular may have a higher diversity of thaumaleids than is represented. Only *A. coloradensis* and *A. c.f. melanderi* are known from southwest Colorado, however, intensive collections throughout the state would likely yield more species due to the extensive available habitat.
The Pacific Northwest is the most diverse area in the Nearctic Region, with 15 of the 34 described Nearctic species of Thaumaleidae. Mt. Rainier National Park is particularly diverse. The park is home to ten species of Thaumaleidae across two genera. Two species (\textit{A. rainierensis} and \textit{A. zelmae}) are endemic to Mt. Rainier. The high altitudes of the mountain, abundance of springs and creeks, and habitat isolation may all be contributing factors to this high diversity.

Further studies and field collection may yet yield new species diversity and will certainly continue to yield range expansions as new areas are collected. Species groups are evident based upon morphology and the following chapter investigates species groups in depth utilizing molecular techniques.
List of References


Vaillant, F. (1959) The Thaumaleidae (Diptera) of the Appalachian Mountains. 


Chapter 3:

Molecular systematics of the Nearctic Androprosopa Mik (Diptera: Thaumaleidae) with a focus on the western species
Abstract

Phylogenetic studies were conducted to determine the relationships between the eastern and western Nearctic *Androprosopa*, and amongst the considerably more diverse western Nearctic species. Fresh, molecular-grade material was obtained for all Nearctic species except the following that eluded capture: *A. arnaudi, A. fusca, A. schmidiana, A. sonorensis, A. uvas, A. zelmae* and *A. zempoala*. Molecular sequences from two nuclear protein-coding genes, Big Zinc Finger (BZF) and Molybdenum Cofactor Sulfurase (MCS), were utilized to test relationships between individual species and among species groups. Analyses using maximum parsimony, maximum likelihood and Bayesian inference methods were implemented. Resulting phylogenies supported monophyly of the western Nearctic species, the presence of strongly supported species groups within the western Nearctic species, but failed to resolve the relationship between the western and eastern Nearctic species to the Palearctic fauna, represented by *A. larvata* and *A. striata*. Six new species groups within the western Nearctic species of *Androprosopa* are proposed herein.

Introduction

The Thaumaleidae, or madicolous midges, are a family of Diptera that is specialized for living in a specific type of aquatic environment. The Thaumaleidae are small (2-5mm long), stocky flies that are typically brown or black, though some may be dark orange or shiny yellow. They are found worldwide on all continents except Antarctica (Vaillant 1977; Sinclair & Saigusa 2002). The family Thaumaleidae currently contains approximately 185 described species, classified within seven genera. As mentioned earlier, they are specialized to a very specific aquatic habitat, which as their common name suggests, is the madicolous habitat (Vaillant 1956; Sinclair & Marshall 1987; Sinclair & Stuckenberg 1995). These habitats are characterized by thin films (2mm or less) of flowing water over various substrates.
(e.g. rock, mud or moss) and are also known as hygropetric zones (Vaillant 1956; Mackie 2004). Examples of such habitats include rock-face seepages (either natural or man-made), cascading streams, splash zones near waterfalls, and boulders in fast moving streams (Sinclair 2000).

Due to the restricted habitat and weak flight dispersal ability of the adults, the Thaumaleidae are a rarely encountered and understudied group. Trapping does not typically yield favourable results: they are not attracted to any coloured trap, nor are they active fliers, therefore traps designed around flight interception prove ineffective. However, success has been achieved (albeit rare) by placing Malaise traps directly above or in front of suitable habitat. New specialized traps may prove useful for collecting as well, such as the madicolous emergent trap developed by Shimabukuro et al. (2015). The best and most efficient method for collecting Thaumaleidae is to sweep riparian vegetation near the madicolous substrate. If sweeping is unsuccessful, inspect the madicolous substrate for adults resting on moss, in cracks and crevices, or on the rock face itself, where they may be aspirated. Larvae may simply be plucked from the substrate using forceps or washed into a white pan.

The Nearctic Region consists of three genera and 29 described species: *Androprosopa* Mik, *Thaumalea* Ruthe and *Trichothaumalea* Edwards (Table 3.1). *Androprosopa* is the most speciose genus in the Nearctic Region.

The earliest taxonomic work on the Nearctic Thaumaleidae dates back to Bezzi’s 1913 paper in which he described the first Nearctic species, *Androprosopa americana* (Bezzi). The other two remaining eastern species are *A. thornburghae* (Vaillant) and *A. vaillantiana* Sinclair. Sinclair (1996) dealt with all the eastern Nearctic Thaumaleidae and provided excellent drawings and keys to the males, pupae and larvae.

The genus is far more diverse in the western half of the Nearctic Region with 22 described species (Dyar & Shannon 1924; Garrett 1925; Schmid 1970; Brothers 1972; Arnaud & Boussy 1994; Sinclair & Huerta 2010). Arnaud & Boussy’s 1994 treatment of the group is the largest to date. They described 17 new species, as well
as provided a diagnostic species key for males to all of the western Nearctic Thaumaleidae. They described females for some species, though they still pose a problem for identification, as they are difficult to associate with males. Gillespie et al. (1994) discussed the biology and taxonomy of larvae and pupae of ten species of Androprosopaa found in Idaho and California. They provided descriptions and drawings of both life stages, however no key was provided and this represents less than half of the western Nearctic fauna. Descriptions of the larvae and pupae of remaining species would be useful not only for identification, but also in the construction of a phylogeny to determine relationships between Nearctic species and Palearctic species.

Due to the absence of a phylogeny, the relationships amongst the Nearctic species of Androprosopaa remain uncertain. The eastern species are characterized by short, blunt apical gonostylar spines, tapering gonostyli and the dense setae on the inner face of the gonocoxites, and may be related to A. ericfisheri (Arnaud & Boussy) (Sinclair 1996). Larval antennal characters may also have phylogenetic use (Sinclair 1996). Also, some species have only been collected on one occasion and are known from only a few specimens (A. fusca (Garrett) & A. zelmae (Arnaud & Boussy)), which make it difficult to assess intraspecific variation. Alternatively, species such as A. gillespieae (Arnaud & Boussy) have a very wide distribution amongst varying habitats, which may indicate a species complex. Despite all of the work done on the Nearctic Thaumaleidae, they remain a very under-collected and understudied group with much still to be learned about diversity and relationships at all levels of classification.

Given that little has been done in regard to exploring the evolutionary relationships within the Thaumaleidae, the purpose of this paper was to create a comprehensive phylogeny of the Nearctic Androprosopaa fauna. This also represents the first attempt to infer phylogenetic relationships within the Thaumaleidae. Molecular sequence data were used to test existing species concepts, as well as to provide a hypothesis on relationships between and among the eastern and western faunas.
Table 3.1 Location and species names for Nearctic *Androprosopa*.

<table>
<thead>
<tr>
<th>Location</th>
<th>Western North America</th>
<th>Eastern North America</th>
</tr>
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<tbody>
<tr>
<td>Genus</td>
<td><em>Androprosopa</em></td>
<td><em>Androprosopa</em></td>
</tr>
<tr>
<td>Species</td>
<td>anolo (Schmid 1994)</td>
<td>americana (Bezzi 1913)</td>
</tr>
<tr>
<td></td>
<td>apache sp. nov.</td>
<td>thornburghae (Vaillant 1959)</td>
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<td></td>
<td>arnouldi sp. nov.</td>
<td>vaillantiana Sinclair 1996</td>
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<tr>
<td></td>
<td>becca (Arnaud &amp; Boussy 1994)</td>
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<tr>
<td></td>
<td>brothersi (Arnaud &amp; Boussy 1994)</td>
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<td>buckae (Arnaud &amp; Boussy 1994)</td>
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<td>chandlerorum (Arnaud &amp; Boussy 1994)</td>
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<td>coloradensis (Arnaud &amp; Boussy 1994)</td>
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<td>confracta (Arnaud &amp; Boussy 1994)</td>
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<td>elnora (Dyar &amp; Shannon 1924)</td>
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<td>ericfisheri (Arnaud &amp; Boussy 1994)</td>
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<td>falciformis (Arnaud &amp; Boussy 1994)</td>
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<td></td>
<td>fusca (Garrett 1925)</td>
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<td></td>
<td>gillespieae (Arnaud &amp; Boussy 1994)</td>
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<td></td>
<td>idahoensis (Arnaud &amp; Boussy 1994)</td>
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<td>lindsayorum (Arnaud &amp; Boussy 1994)</td>
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<td></td>
<td>magnipelvim sp. nov.</td>
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<td>melanderi (Arnaud &amp; Boussy 1994)</td>
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<td>palouse (Arnaud &amp; Boussy 1994)</td>
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<tr>
<td></td>
<td>rainierensis sp. nov.</td>
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<tr>
<td></td>
<td>santaclaraeensis (Brothers 1972)</td>
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<td></td>
<td>schmidiana (Arnaud &amp; Boussy 1994)</td>
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<td>sierra sp. nov.</td>
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<td></td>
<td>sonorensis (Arnaud &amp; Boussy 1994)</td>
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<td>uvas sp. nov.</td>
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<td>waha (Arnaud &amp; Boussy 1994)</td>
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<td></td>
<td>zelmae (Arnaud &amp; Boussy 1994)</td>
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<td></td>
<td>zempoala Sinclair &amp; Huerta 2010</td>
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</table>
Materials and Methods

Taxon Sampling

Field collection over the past five years has yielded molecular grade material for all but seven species (*A. arnaudi, A. fusca, A. schmidiana, A. sonorensis, A. uvas, A. zelmae* and *A. zempoala*) of described Nearctic *Androprosopa*. Upon collection, specimens were placed immediately into 95% ethanol and transferred to a freezer set at -20°C until use. At least one exemplar for each available species was used for molecular study (Table 3.2). When possible or appropriate, specimens for each morphospecies were sequenced from disparate populations to examine intraspecific variation and detect potential cryptic species. Whenever possible, type localities were collected in order to obtain topotype material. Distribution maps were created using SimpleMappr (Shorthouse 2010).

Outgroups were chosen based on relationships established in unpublished data by the author and included two Palearctic species of *Androprosopa* (*A. larvata* Mik and *A. striata* (Okada)), *Trichothaumalea elakalensis* Sinclair, as well as *Afrothaumalea stuckenbergi* Sinclair as the distal outgroup. Ingroup taxa included all available Nearctic *Androprosopa* species.

Genomic Sampling

Gene regions from two nuclear-coding loci were chosen to carry out this study: big zinc finger and molybdenum cofactor sulfurase. These loci were chosen due to their presence as single copies, high levels of sequence divergence, size, and proven ability to resolve relationships among closely related taxa (Senatore *et al.* 2014; Winkler *et al.* 2015).
Table 3.2. Location of adult thaumaleids sequenced for molecular study.

<table>
<thead>
<tr>
<th>Species</th>
<th>Location</th>
<th>Coordinates</th>
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<td><strong>Afrothaumalea</strong></td>
<td><strong>stuckenbergi</strong>*</td>
<td>-32°24'05&quot;</td>
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<td></td>
<td>RSA: Western Cape: Cederberg Wilderness, Duiwelsgat, 693m</td>
<td>19°05'16&quot;</td>
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<tr>
<td><strong>Trichothaumalea</strong></td>
<td><strong>elakalensis</strong>*</td>
<td>39°06'32&quot;</td>
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<td>USA: WV: Blackwater Falls S.P., Elakala Falls</td>
<td>79°29'56&quot;</td>
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<tr>
<td><strong>Androprosoparia</strong></td>
<td><strong>striata</strong>*</td>
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<td>JPN: Kyushu, Kusatsu godoni</td>
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<td><strong>A. larvata</strong></td>
<td>DEU: Hesse: Rhon Biosphere Reserve, N. slope of Heidelstein</td>
<td>50°28'04&quot;</td>
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<tr>
<td></td>
<td></td>
<td>10°00'45&quot;</td>
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<td><strong>A. americana</strong></td>
<td>USA: GA: Towns Co.: Brasstown Bald, seep near waterfall</td>
<td>34°51'36&quot;</td>
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<td></td>
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<td>-83°48'09&quot;</td>
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<td><strong>A. anolo</strong></td>
<td>USA: OR: Marion Co.: Willamette N.F., French Crk. Rd, trib., 660m</td>
<td>44°46'58&quot;</td>
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<td>-122°11'12&quot;</td>
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<td><strong>A. apache</strong></td>
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<td>34°02'28&quot;</td>
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<td>-109°27'33&quot;</td>
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<td><strong>A. becca</strong></td>
<td>CAN: BC: East Kootenay, Hwy. 3/95</td>
<td>49°10'18&quot;</td>
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<td><strong>A. brothersi</strong></td>
<td>USA: CA: Nevada Co.: culvert along Sagehen Crk.</td>
<td>39°26'04&quot;</td>
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<td>-120°16'52&quot;</td>
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<td><strong>A. buckæ</strong></td>
<td>USA: CA: Humboldt Co.: Trinidad State Beach, sea cliff face</td>
<td>41°03'25&quot;</td>
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<td>-124°09'00&quot;</td>
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<td><strong>A. chandlerorum</strong></td>
<td>USA: CA: Nevada Co.: Carpenter Ridge, Cirque lake and stream</td>
<td>39°25'01&quot;</td>
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<td></td>
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<td>-120°18'33&quot;</td>
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<td><strong>A. coloradensis</strong></td>
<td>USA: CO: San Juan Co.: San Juan N.F., Hwy. 550, ex. Coal Crk. waterfalls on W side of road</td>
<td>37°42'29&quot;</td>
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<td>-107°46'17&quot;</td>
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<td><strong>A. confracta</strong></td>
<td>USA: OR: Linn Co.: Santiam S.F., Monument Peak Rd., 820m</td>
<td>44°42'34&quot;</td>
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<td>-122°22'16&quot;</td>
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<td><strong>A. elnora</strong></td>
<td>USA: WA: Spokane Co.: Mt. Spokane SP Deadman Crk., 1325m</td>
<td>47°54'20&quot;</td>
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<td>-117°06'35&quot;</td>
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<td><strong>A. ericfisheri</strong></td>
<td>CAN: BC: Golden, Sm. Trib., Silver Crk.</td>
<td>51°27'55&quot;</td>
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<td></td>
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<td>-117°21'03&quot;</td>
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<tr>
<td><strong>A. falciformis</strong></td>
<td>USA: ID: Latah Co.: Moscow Mt., 1000m, ex. cascading str.</td>
<td>46°47'43&quot;</td>
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<tr>
<td></td>
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<td>-116°54'05&quot;</td>
</tr>
<tr>
<td><strong>A. gillespieae BC</strong></td>
<td>CAN: BC: Hwy 23, 13km N Revelstoke, 600m</td>
<td>51°04'03&quot;</td>
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<tr>
<td></td>
<td></td>
<td>-118°10'31&quot;</td>
</tr>
<tr>
<td><strong>A. gillespieae UT</strong></td>
<td>USA: UT: Utah Co.: Mt. Timpanogos alpine loop Rd., above Sundance, ex. cascading stream next to road</td>
<td>40°23'41&quot;</td>
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<td></td>
<td></td>
<td>-111°34'56&quot;</td>
</tr>
<tr>
<td><strong>A. idahoensis</strong></td>
<td>USA: ID: Nez Perce Co.: Juliaetta Falls</td>
<td>46°31'22&quot;</td>
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<td>-116°44'49&quot;</td>
</tr>
<tr>
<td><strong>A. lindsayorum</strong></td>
<td>USA: OR: Benton Co.: Siuslaw NF, 675m Mary's Peak Rd, Alder Crk Falls</td>
<td>44°28'27&quot;</td>
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<td>-123°31'42&quot;</td>
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Table 3.2 Continued.

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<th>Species</th>
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<td>37°05'03&quot;</td>
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<tr>
<td></td>
<td></td>
<td>-121°47'34&quot;</td>
</tr>
<tr>
<td>A. palouse</td>
<td>CAN: BC: Cranbrook, Gold Creek Rd, ex. small crk. splash zone</td>
<td>49°27'06&quot;</td>
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<td></td>
<td>-115°41'15&quot;</td>
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<tr>
<td>A. rainierensis</td>
<td>USA: WA: Pierce Co.: Mt. Rainier N.P., Narada Falls to Reflection lake tr., small stream, 1415m</td>
<td>46°46'15&quot;</td>
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<td></td>
<td>-121°44'44&quot;</td>
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<tr>
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<td></td>
<td>-121°47'34&quot;</td>
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<td>A. sierra</td>
<td>USA: CA: Nevada Co.: Sagehen Creek Field Station</td>
<td>39°25'54&quot;</td>
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<td>-120°14'26&quot;</td>
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<td>A. thornburghae</td>
<td>USA: GA: Towns Co.: Brasstown Bald, seep near waterfall</td>
<td>34°51'36&quot;</td>
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<td></td>
<td>-83°48'09&quot;</td>
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<tr>
<td>A. vaillantiana</td>
<td>USA: NC: Swain Co.: Great Smoky Mountains N.P., Clingmans Dome, seep at parking lot</td>
<td>35°33'24&quot;</td>
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<td>A. waha</td>
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<td>53F A. cf. zelmae</td>
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* Denotes outgroup taxa.

**Big Zinc Finger (BZF)**

The potential of BZF as a phylogenetic marker was first demonstrated by Senatore et al. (2014), who utilized it to help construct a molecular phylogeny of a black fly species group. Given its success within the closely related family Simuliidae, BZF was an ideal choice for this project. Dipterans are one of several eukaryotic organisms that have single copies of BZF, a rapidly evolving DNA-binding transcriptional regulator (Senatore et al. 2014). Although BZF exceeds 3,000 base pairs, primers used herein focused on the distal two-thirds of the gene, resulting in a roughly 2-kb region containing only a single intron in thaumaleids.

**Molybdenum cofactor sulfuroase (MCS)**

MCS was used for its high degree of phylogenetic informativeness when compared against several other nuclear genes, as illustrated by Winkler et al.
MCS is an enzyme that sulfurates the molybdenum cofactor of xanthine dehydrogenase (XDH) and aldehyde oxidase (AOX1) (Winkler et al. 2015). Primers were designed to amplify and sequence a roughly 2,500 base pair region of the gene. This region contains 7 introns in thaumaleids, although several acquired sequences contain one fewer due to use of an alternate slightly downstream initial forward primer, depending upon which primers ultimately proved successful during amplification.

Gene Amplification

Entire specimens of each taxon were used to extract total DNA using either Thermo Scientific’s GeneJET Genomic DNA Purification Kit #K0722 (ThermoScientific, Waltham, MA) or Omega Bio-tek’s E.Z.N.A.® Insect DNA Kit #D0926-02 (Omega Bio-tek, Inc., Norcross, Georgia) following the manufacturers’ suggested protocols except for reducing the final elution volume. The resulting gDNA was stored at -20°C and the cleared voucher specimen stored in 70% ethanol. Amplifications were performed in GenePro (Bioer Technology Co., Hangzhou, China) thermal cyclers, using 50μL PCR reactions filled with TaKaRa Ex Taq Hotstart DNA polymerase (Takara Bio, Shiga, Japan) kit components per the manufacturer’s suggested protocol, with 1-2μL of template DNA, and 3μl of 20uM custom forward and reverse primers (Table 3.3). Less to completely nondegenerate taxon or clade-specific internal primers were designed in some circumstances in order to obtain sufficient yields of DNA via reamplification when the original PCR primers resulted in poor yields. These are available from the author upon request. The following PCR regime was utilized: Initial 90s denaturing step at 94°C, then 4 cycles of 30s at 94°C, 30s at 56°C and 75s at 72°C, followed by 4 cycles of 30s at 94°C, 25s at 52°C and 75s at 72°C, 9 cycles of 30s at 94°C, 20s at 48°C and 75s at 72°C and finally, 38 cycles of 30s at 94°C, 20s at 45°C and 75s at 72°C. Once all cycling is complete the program ends with a soak at 72°C for 5min., then finishes with a 15°C hold in order to keep the samples cool until removal from the thermo cycler. PCR products were electrophoresed in 1% agarose gels at 115V for 30min.
Table 3.3 Primers\(^a\) used in this study.

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<th>Gene</th>
<th>Primer</th>
<th>F/R</th>
<th>Sequence (5’ → 3’)(^b)</th>
<th>Length</th>
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<td>1.5F</td>
<td>F</td>
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<td>78F</td>
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<td>ATGATHTYGATHGAYCARRSNACNGG</td>
<td>26-mer</td>
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</table>

\(^a\)Sequences for additional, less degenerate, clade-specific PCR and sequencing primers used in this study are available upon request.

\(^b\)R=A/G; Y=C/T; S=C/G; W=A/T; K=G/T; M=A/C; H=A/C/T; D=A/G/T; V=A/C/G; N=A/T/G/C

\(^c\)Primer names published by Senatore et al. 2014
Purified PCR products served as a template for sequencing, which was carried out by using a 1:1 dilution of water and the original PCR reaction primers or by the use of internal primers. Purified templates were sequenced in both directions in 20μL reactions using 20-fold diluted (= 0.4μl) BigDye® v3.1 terminators (Applied Biosystems, Carlsbad, California) utilizing a proprietary 5X sequencing buffer. Sequencing reactions were cleaned using Centrisep columns (Princeton Separations, Adelphia, NJ) and dried in a Centrivap Concentrator (LABCONCO, Kansas City, MO). Dried samples were sent to the University of Tennessee-Knoxville Molecular Biology Resource Facility for sequencing. Sequences from opposing strands were reconciled and verified for accuracy using Sequencher 4.7 (Gene Codes Corp., Ann Arbor, MI). The GT-AG rule was followed to determine exon-intron boundaries (Rogers & Wall 1980) ensuring presence of a resultant continuous open reading frame. BZF sequences contained one intron in the first half, while MCS sequences contained six or seven evenly dispersed introns. All introns were excised in Sequencher prior to alignment and phylogenetic analysis. Sequences of both genes for each species will be deposited in GenBank.

*DNA Alignment and Phylogenetic Analysis*

Final nucleotide data matrices were exported as Nexus-formatted files (Maddison et al. 1997) for subsequent alignment and phylogenetic analysis. Opal 2.1.0 (Wheeler & Kececioglu 2007) as implemented in Mesquite 2.72 (Maddison & Maddison 2011) was used to create an amino acid alignment that guided the creation of a subsequent DNA alignment. PAUP* (Swofford 2001) was used to calculate pairwise sequence divergence. Maximum parsimony, Bayesian and maximum likelihood analyses were performed on the nucleotide alignments. Maximum parsimony analysis was performed using PAUP* using a heuristic search in which 500 random addition sequences were completed using TBR branch rearrangement with MaxTrees set to increase incrementally. Nonparametric bootstrapping (Felsenstein 1985) was conducted using 1000 replicates of a single random addition sequence using the aforementioned parameters.
jModelTest 2 was utilized to determine the optimal evolutionary model for each gene (Guindon & Gascuel 2003; Darriba et al. 2012). The GTR+I+G model was selected for both data sets. CIPRES-XSEDE (Miller et al. 2010) was utilized to implement the best-fit models in Bayesian analyses using MrBayes 3.2.2 (Ronquist & Huelsenbeck 2003). A total of 10,000 trees were created after each Markov chain in the Bayesian search was started from a random tree and set to complete 1 x 10^7 generations, sampling every 1000th one from the chain. Three hot chains and one cold chain were run simultaneously and the first 25% of pre-stationarity trees were discarded as burn-in. Each simulation was run twice. Default settings for the priors were used, and base frequencies were estimated from the data. Tracer 1.6 (Rambaut et al. 2014) was used to parse and combine the log files, determine the point at which the Markov Chain Monte Carlo chain began to sample from the stationarity distribution and to check that effective sample sizes were sufficient for all parameters. In order to reduce the probability of convergence on local optima, multiple starting points for each chain were used. RAxML-HPC2 (Stamatakis 2006; Stamatakis et al. 2008) was used to perform the maximum likelihood analysis, as implemented in CIPRES-XSEDE (Miller et al. 2010). Analyses were conducted using the default evolutionary model (GTRCAT) with 1,000 bootstrap replicates.

Results

Phylogenetic analyses were conducted on each of the genes individually and combined. The BZF data set consists of 30 taxa with 3213 characters. The MCS data set consists of 30 taxa with 2133 characters. When concatenated, the combined data set, consisting of BZF and MCS, has 30 taxa and 5346 characters.

A single tree illustrating the combined BZF+MCS analysis (Fig. 3.1) is presented below, as all of the analyses resulted in nearly congruent topologies. Areas where topologies differ are discussed below, in addition to the analysis of the results for each gene and the combined gene data set. Table 3.4 contains the node support values for the analyses of each gene. Significant bootstrap support values of
≥70% were used for parsimony and likelihood methods, and posterior probability values of ≥95% for Bayesian analysis.

**Molecular Phylogenetic Analysis: Big Zinc Finger (BZF)**

The three analyses for BZF resulted in very similar tree topologies, although some differences did exist between them and Fig. 3.1. Parsimony analysis resulted in a single most parsimonious tree of 4367 steps (CI= 0.602, RI= 0.648, RC= 0.390, HI= 0.398) that was recovered in 950 of the 1000 random additional sequences conducted. The parsimony inference recovered a monophyletic western Nearctic clade with 100% support, but node 2 had weak support (67%) for the placement of the Eastern and Palearctic species. In contrast, likelihood and Bayesian analyses recovered a clade consisting of two western Nearctic species (*A. elnora* & *A. ericfisheri*), along with the three eastern Nearctic and two Palearctic *Androprosopa* *sp.*, though support was weak for these results (likelihood=29%, Bayesian=92%). This clade was the most inconsistent part of the tree, with the placement of *A. elnora* + *A. ericfisheri* uncertain. The eastern species formed a monophyletic group every time with 100% support, with *A. thornburghae* as sister to the *A. americana* + *A. vaillantiana* sister group. *Androprosopa elnora* + *A. ericfisheri* were always recovered as sister species with 100% support. Two large western clades were always recovered (parsimony=96%, likelihood=94%, Bayesian=39%) and are found at nodes 9 and 18. The low Bayesian support value was likely due to the omission of the *A. elnora* group from the western clade. While the two large western clades consistently appeared in resulting phylogenies, relationships within the clades had minor variations. The first large clade at node 9 had *A. chandlerorum* as sister to the remaining species included in that node with each analysis. Parsimony revealed *A. santaclaraensis* as the sister species to the *A. buckae* and *A. gillespieae* groups with maximum support, followed by the *A. buckae* species group (*A. buckae* + *A. idahoensis*). Meanwhile, likelihood (100%) and Bayesian (99%) analyses flipped the position of the *A. buckae* group with *A. santaclaraensis*, but with very weak support (likelihood=51, Bayesian=48). The *A. gillespieae* species group (*A. palouse, A. apache,
Figure 3.1 Hypothesized phylogenetic relationships of Nearctic *Androprosopa* based on maximum parsimony analysis of combined molecular data (BZF+MCS). Values above branches denote node references for Table 2.4.
Table 3.4 Node support for clades\(^1\) inferred from three analyses of each gene.

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<tr>
<th>Analysis(^2)</th>
<th>Gene</th>
<th>BZF</th>
<th>M.P.</th>
<th>M.L.</th>
<th>B.</th>
<th>MCS</th>
<th>M.P.</th>
<th>M.L.</th>
<th>B.</th>
<th>BZF + MCS</th>
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\(^1\)Nodes that resulted in varying topologies from the presented tree were left blank and are discussed in the Results section.

\(^2\)M.P. = Maximum Parsimony (bootstrap value), M.L. = Maximum Likelihood (bootstrap value), B. = Bayesian (posterior probability value).
A. sierra, A. magnipelvim & A. gillespieae) was the terminal species group for western clade #1, and was recovered with strong support through all analyses and mirrors the relationships in the combined data set tree provided. The second large western clade, represented by node 18, was recovered with maximum support through each analysis. The A. confracta species group (A. brothersi, A. cf. melanderi and A. confracta) was consistently recovered with strong support by each analysis. While Fig. 3.1 displays A. cf. melanderi as sister to the A. brothersi + A. confracta group, all three BZF analyses place A. brothersi as the sister to A. confracta + A. cf. melanderi, although none of these arrangements had strong support (the highest being 62 for likelihood). The placement of A. coloradensis at node 21 was consistently recovered with strong support through all analysis. Each analysis resulted in the same topology at node 22, with the A. becca + A. lindsayorum group as sister to the A. anolo species group (A. rainierensis, A. falciformis, A. anolo, A. waha and A. cf. zelmae (53Female)). The topology of the A. anolo clade follows that of Fig. 3.1 for the likelihood analysis, but parsimony had difficulty determining how A. falciformis and A. rainierensis are related to each other, and Bayesian portrays them as sister taxa, but with only 42% confidence.

**Molecular Phylogenetic Analysis: Molybdenum Cofactor Sulfurase (MCS)**

The MCS analyses constructed three nearly congruent trees that closely resemble Figure 3.1. Most deeply rooted nodes resulted in the same clades, with few variances occurring within these clades. Parsimony analysis resulted in a single most parsimonious tree of 4200 steps (CI= 0.541, RI= 0.682, RC= 0.369, HI= 0.459) that was recovered all 1000 of the random additional sequences conducted. The parsimony inference recovered a monophyletic Nearctic clade with 76% node support, with the Palearctic species as sister taxa to that clade, as portrayed in the accompanying tree. However, likelihood (100%) and Bayesian (99%) analyses both support a Palearctic + eastern Nearctic clade (though the eastern species formed a monophyletic group therein). Although the topology differed slightly, the three analyses indicated closer affinities of the eastern Nearctic fauna to the Palearctic
fauna, rather than to the western Nearctic species. All three analyses recovered a monophyletic western Nearctic clade with strong support (parsimony=100, likelihood=96, Bayesian=98). Node 7, consisting of A. ericfisheri and A. elnora as sister species, was strongly supported in all analyses. The two large western clades at node 8 were also recovered with strong support (parsimony=86, likelihood=100, Bayesian=98). At node 9, A. chandlerorum was consistently placed at the base of the first major western clade. Parsimony (100%) and Bayesian (99%) both support A. santaclaraensis as sister to the A. buckae + A. idahoensis group, while likelihood placed the three of them in their own clade with 70% confidence. Regardless of the method of analysis, they were always sister taxa to the A. gillespieae species group. Bayesian analysis very weakly supported A. buckae + A. idahoensis group (node 11) as the sister group to the A. gillespieae group, with a posterior probability of 45. The A. gillespieae group, beginning at node 13, was strongly supported by all analysis. The position of A. palouse and A. apache at nodes 13 and 14 mirrored the combined data set tree. The relationships between the remaining three species differed slightly though, as A. sierra and A. magnipelvim were placed as sister species, and A. gillespieae as their closest relative. The A. contracta group was strongly supported as the sister clade to the remaining species of the second large western clade (parsimony=100, likelihood=100, Bayesian=98). The relationships between the members of the A. contracta group differed for each analysis, though all lacking any confident support. The positions of A. coloradensis and the A. becca + A. lindsayorum sister group were reversed in the three analyses, as compared to the combined data set tree, but with no confidence. The remaining taxa comprising the A. anolo species group at node 24 mirrored the provided tree in all analyses with very strong support.

**Molecular Phylogenetic Analysis: Combined BZF & MCS Data Sets**

All three analyses resulted in nearly identical tree topologies. Parsimony analysis resulted in a single most parsimonious tree of 8572 steps (CI= 0.572, RI= 0.666, RC= 0.381, HI= 0.428) that was recovered all 660 times the random
additional sequences were conducted. The parsimony analysis recovered a monophyletic Nearctic clade of Androprosopa, with A. striata and A. larvata as sister taxa. Likelihood (100%) and Bayesian (99%) methods supported a monophyletic clade consisting of the eastern Nearctic + Palearctic group (with the eastern species forming their own clade), followed by the monophyletic western Nearctic clade. The three eastern Nearctic Androprosopa spp. were always recovered as a clade with maximum support, placing A. americana + A. vaillantiana as sister species. The A. ericfisheri + A. elnora sister group was consistently recovered as sister species to the remaining western Nearctic Androprosopa fauna. Two major clades encompassed the remaining species at nodes 9 and 18. Androprosopa chandlerorum was always placed as sister to the remainder of the first major clade (parsimony=100, likelihood=100, Bayesian=99). Androprosopa santaclaraensis was placed as the sister species (node 10) to the A. buckae species group by parsimony (100%). However, likelihood (100%) and Bayesian (99%) methods included A. santaclaraensis as the sister to the A. buckae + A. idahoensis species group. The A. gillespieae group, beginning at node 13, was recovered with congruent topologies by all analyses with nearly maximum support. The second major western clade, beginning at node 18, was recovered through all three analyses, with nearly identical topology. One main difference between them was that the relationships between members of the A. confracta group were not resolved. None of the analyses provided confident support for the relationships between these species. The placement of the A. becca species group (node 22) also had no significant support (parsimony=49, likelihood=69, Bayesian=83) for its placement as sister to the A. anolo species group. The A. anolo group (node 24) was consistently recovered with congruent topologies between each analysis, all with very strong support for each node therein.

**Discussion**

Over the past 100+ years, entomologists have been contributing to the knowledge of the family Thaumaleidae, primarily through the description of new
species. There have been few papers dealing with phylogenetic relationships, and those that have were primarily a brief mention of potential close affinities between species. This is the case with the Nearctic *Androprosopa*. Arnaud & Boussy (1994) made reference to species they hypothesized may be closely related to one another in the species diagnoses sections of their publication, but they did not investigate relationships at a deeper level. Sinclair (1996) proposed hypotheses about the affinities between certain Nearctic taxa, but again, it had a very narrow scope and encompassed only a few species.

This study was the first to comprehensively treat the Nearctic *Androprosopa* fauna. The goal was to determine the phylogenetic relationships between eastern and western Nearctic *Androprosopa*, and among the species groups that are proposed herein. This phylogeny was created using molecular characters from DNA sequences of two nuclear protein-coding genes, Big Zinc Finger 2 (BZF) and Molybdenum Cofactor Sulfurase (MCS). Morphological characters (primarily genitalic) are used below in order to further support the proposed species groups.

*The Eastern Clade* (*A. americana* group)

The eastern Nearctic species were strongly supported as a monophyletic clade, with *A. americana* + *A. vaillantiana* consistently placed as sister species and *A. thornburghae* as their nearest relative throughout all analyses. This result is in concordance with Sinclair’s hypothesis that the close relationships of the three eastern species are seen in the lack of conical protuberances on the larval head capsule (Sinclair 1992; Sinclair 1996) and the following adult characters: short, blunt, apical gonostylar spines, tapering gonostyli, and dense setae on the inner face of the gonocoxites (Sinclair 1996). Sinclair also noted that due to the adult characters, the eastern species might have close affinities to other Nearctic species, such as *A. ericfisheri*. The molecular data tends to suggest that the *A. elnora* + *A. ericfisheri* species group is the closest western Nearctic relative of the eastern species. Likelihood and Bayesian analyses of BZF, however, place the *A. elnora* group
in a monophyletic clade with the eastern Nearctic and Palearctic species, thus disrupting the monophyly of the western Nearctic species. This configuration has no significant support, making a monophyletic western Nearctic clade a much more plausible hypothesis, especially given the geographical gap between the western and the eastern species. No thaumaleids are known between the 34\textsuperscript{th} and 39\textsuperscript{th} parallels, and that division supports the hypothesis that the western species have closer affinities to one another. Also of note, was the strongly supported recovery of an eastern Nearctic + Palearctic clade with likelihood and Bayesian analyses for MCS and the combined data set. This relationship gives some insight into how the family may have migrated across the supercontinent Laurasia from present day Europe into North America, and warrants further testing with the inclusion of more European taxa.

*The Western Clade*

A monophyletic western clade was consistently recovered with strong support. The western species are characterized by having long, pointed, apical gonostylar claw-like spines, tapering gonostyli and exhibit less dense setae on the inner face of the gonocoxites, contrasting that of the eastern species of *Androprosopa*. Six distinct species were consistently recovered with strong support for each analysis.

*The A. elnora group*

The *A. elnora* species group consists of *A. elnora* + *A. ericfisheri*, and were always recovered as sister species with maximum support. This group was nearly always found to be the sister species group of the western clade (see The Eastern Clade for exceptions). These species are both orange to yellow, contrasting the rest of the Nearctic fauna, which tend toward browns and blacks. Another character shared between both species is the dense setae on the inner face of the gonocoxites, as mentioned by Sinclair (1996). They have been collected in cascading streams and
creeks in the Pacific Northwest, particularly in the Columbia Mountains and Plateau (Fig. 3.2).

![Map showing the known distribution of the A. elnora group.](image)

**Figure 3.2 Known distribution of the A. elnora group.**

*Androprosopa chandlerorum and A. santaclaraensis*

The resulting phylogenies did not reveal any close affinities for *A. chandlerorum* or *A. santaclaraensis*. *Androprosopa chandlerorum* was firmly nested at the base of the first large western clade (node 9) after each analysis. The genitalia does not share any strong likenesses to any other species, aside from being densely setose as in the *A. elnora* group. The position of *A. santaclaraensis* was one of disagreement between the analyses. Parsimony always placed it on its own with no close affinities, while likelihood and Bayesian inferences placed it in a clade with the *A. buckae* group. The latter position never attained strong support. Given the maximum bootstrap support for parsimony analysis and the unique morphology of its genitalia, the most likely position for *A. santaclaraensis* is on its own with no close affinities. Both of these species have been collected from creeks. *Androprosopa*
santaclaraensis has also been collected at the madicolous margins of small waterfalls. *Androprosopa chandlerorum* has only been recorded from one locality in the Sierra Nevada mountain range, while *A. santaclaraensis* is known from two, both within the Coastal Range (Fig. 3.3).

![Figure 3.3 Known distributions of *A. chandlerorum* and *A. santaclaraensis*](image)

**The A. buckae group**

This group consists of sister species *A. buckae* + *A. idahoensis*. It was consistently recovered throughout all analysis with maximum support. The morphology of the genitalia is similar to each other in that the distal margin of the ventral plate is bi-lobed. Arnaud & Boussy (1996) believed that these two species were closely related based upon the morphology of the genitalia. Gillespie et al. (1994) described the larvae and pupae of several species of Nearctic *Androprosopa*, and concluded that *A. buckae* and *A. idahoensis* are closely related based upon the similarities of the pupal abdominal setae. Although this supports the species group,
the pupae of limited species have been described. Investigation into undescribed pupae may uncover other species that share similar setal characters. These species have been collected in the Cascade, California Coastal and Sierra Nevada mountain ranges, and east to the Columbia Plateau (Fig. 3.4). *Androprosopa idahoensis* is most often encountered in madicolous habitats next to waterfalls, while *A. buckae* is a small creek and seep inhabitant.

![Figure 3.4 Known distribution of the A. buckae group.](image)

*The A. gillespieae group*

This is the largest species group within the Nearctic Thaumaleidae. Molecular analysis places the following species within the group: *A. gillespieae, A. palouse, A. apache, A. magnipelvim* and *A. sierra*. While the deepest node of the group itself (node 13) was supported with high confidence through all analyses, some of the relationships between species varied depending on the analysis used. All three MCS analyses produced a sister group of *A. sierra + A. magnipelvim*, while all remaining
analyses place them as closely allied, but not sisters, as in Fig. 3.1. The margin of the genital plate in all members of the *A. gillespieae* group is tri-lobed. This character is also present in four other species that eluded capture, and therefore were not available for molecular testing. These species are likely members of this group as well and they are as follows: *A. arnaudi, A. schmidiana, A. uvas* and *A. zempoala*. This would bring the total number of species in the *A. gillespieae* group to 9. This is a wide-ranging species group, with the most commonly encountered western Nearctic thaumaleid species, *A. gillespieae*. The group is distributed across all western mountain ranges, from southern British Columbia, south to central Mexico and east to the Colorado Rockies (Fig. 3.5). Members of this group have been collected in a wide range of madicolous habitats. Many are only known from creeks, however *A. zempoala* was collected in a seep next to a stream and *A. schmidiana* has been collected at the Klamath River, although the microhabitat was not noted. *Androprosopa gillespieae* may be collected in a variety of madicolous habitats.

![Figure 3.5 Known distribution of the *A. gillespieae* group.](image)
The *A. contracta* group

The *A. contracta* group was always placed as the sister clade to the remaining species of the second large western clade (node 18) with maximum confidence. It consists of three species: *A. brothersi*, *A. contracta* and *A. cf. melanderi*. Although this clade is well supported, relationships between these species are not. None of the analyses provided significant support as to which species are most closely related. These low confidence values may be a result of species that are still yet to be discovered. All species in this group share the characters of the parameres curved laterally at the apex and usually having some degree of serration on the outer margin. In addition, the gonostyli are long and are moderate in thickness. The *A. contracta* group is fairly widespread, yet have few collection events (Fig. 3.6). The nominal species is the most common of the group, but is not known outside of the Cascade Range. Members of this group are most commonly collected from streams; however, seepage collections have been recorded.

![Figure 3.6 Known distribution of the *A. contracta* group.](image)

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The *A. becca* group and *A. coloradensis*

*Androprosopa becca*, *A. lindsayorum* and *A. sonorensis* compose this species group. The molecular data placed these two as sister species in all analyses with maximum support values. Morphologically, they share similar looking parameres, in addition to bearing large, apical, claw-like setae on the gonostyli. *Androprosopa becca* has the longest apical seta of all the Nearctic thaumaleid species. *Androprosopa lindsayorum* is also adorned with long apical setae; however, it possesses a cluster of 3-4 setae per gonostyli, much like the Mexican species, *A. sonorensis*. This species has not been collected since the type series, and thus was not a part of this study. Due to its striking resemblance to *A. lindsayorum*, the two species are highly likely to be sister species, with *A. becca* as the next closest ally. The position of the *A. becca* group in relation to *A. coloradensis* rarely had significant support, as the two clades would switch positions at nodes 21 and 22. *Androprosopa coloradensis* has unique genitalic morphology, with very thin gonostyli and wide parameres, which supports the hypothesis of it not having any close affinities. This group is found mainly in the Pacific Northwest and is fairly common. *Androprosopa lindsayorum* is very common and is mainly found throughout the Cascade Range, whereas *A. becca* is found further east in the Columbia Mountains, Canadian Rockies and the Columbia Plateau (Fig. 3.7). *Androprosopa sonorensis* is unique in that it is only known from the type locality in Mexico. *Androprosopa becca* tends to be collected mainly in seeps; however, collections from creeks are recorded. *Androprosopa lindsayorum* occupies a wide range of madicolous habitats, from roadcut seeps, waterfalls and even seeps where the substrate is made of clay.

*The A. anolo* group

This group was well supported at its deepest node (node 24) in all data analyses. The group consists of the following species: *A. anolo*, *A. rainierensis*, *A. falciformis*, *A. waha* and *A. cf. zelmae*. The latter species is represented in this study by Female #53 as no males were collected to give a positive identification. It is
surmised that this species is *A. cf. zelmae* because it was collected near the type locality and due to its position in the tree as sister to the similar looking *A. waha*. The topology for the group was consistent throughout all analyses, except for the Bayesian inference for BZF, which placed *A. rainierensis* as the sister to *A. falciformis*, but with no confident support. Members of this species group share atypical gonostyli that may bear medial ornamentation, as in *A. rainierensis* and *A. falciformis*, or are flattened and expanded and almost bare of setae, such as *A. waha* and *A. cf. zelmae*. They nearly all have parameres that are strongly recurved in some fashion, except for *A. rainierensis*, which was recovered as the sister species to the remaining members of the group. The species *A. fusca* has not been collected since the type male and is not included in this study. Due to its strongly recurved parameres, it is hypothesized that is also a part of this group, perhaps as a close ally to *A. anolo*. This species group has a Pacific Northwest distribution, mainly throughout the Cascade Range and the Columbia Plateau (Fig. 3.7). They are typically collected in cascading mountain streams and creeks, although *A. anolo* has been collected from roadcut seeps.

![Figure 3.7 Known distributions of the A. becca group and A. coloradensis.](image-url)
**Conclusion**

This study represents the only phylogenetic study of Nearctic *Androprosopa*. Although this study attempted to be as rigorous as possible, gaps still exist. Molecular data is missing due to the inability to obtain DNA-grade material for certain species. While those data will be important to gather in the future, their absence did not adversely affect the overall integrity of the study as male genitalic structures also clearly differentiate species groups. The addition of morphological data into phylogenetic analyses may help solidify some nodes and more confidently place certain species. In particular, larval and pupal characters may be useful. The inclusion of more Palearctic *Androprosopa* species, in order to elucidate the origins of the Nearctic fauna, is necessary. A global, genus-level study would be ideal, but it would prove difficult to acquire the necessary material. A family-level study would also be useful in determining where the family may have originated and how it
radiated to its present distribution. This type of study would also help to decipher how *Androprosopa* and *Thaumalea* are related, as this has been a source of contention. The Thaumaleidae are still a vastly understudied family, especially when it comes to phylogenetic relationships at all taxonomic ranks. Continued work at both the molecular and morphological levels will undoubtedly yield new discoveries about the relationships and diversity of the Thaumaleidae.
List of References


Chapter 4:

A new species of *Austrothaumalea* Tonnoir from Australia

(Diptera: Thaumaleidae)
Abstract

A new species of *Austrothaumalea* is described from Australia: *A. spiculata* sp. nov. Illustrations of the genitalia, as well as distribution maps are provided. Phylogenetic affinities are hypothesized.

INTRODUCTION

The Thaumaleidae are a small family of nematocerous Diptera. They are the most basal lineage of the Chironomoidea and are the sister group to the Simuliidae (Moulton 2000, Wiegmann *et al.* 2011). The larvae are restricted to madicolous habitats, where thin films of water flow vertically over rocks in cascading streams, road-cut seeps, splash zones of waterfalls and cliff-faces (Sinclair, 2008, Sinclair and Huerta, 2010). Adults can be found on or near the larval habitat, and are best collected by sweeping riparian vegetation or by aspirating them from between rocky crevices, on moss or the rock face itself. As the adults are poor fliers, they are infrequently collected in collecting traps (malaise, pans, etc.), and in addition to their habitat specificity, they are a rarely collected and poorly known group.

Thaumaleids are found on all continents, except Antarctica. There are seven genera with roughly 185 described species. In Australia, two genera can be collected: *Austrothaumalea* Tonnoir and *Niphta* Theischinger. The genus *Oterere* McLellan occurs in New Zealand and South America, but has not yet been collected in Australia. There are 3 described species of *Niphta* (Theischinger, 1986) in Australia and as of this paper, 28 *Austrothaumalea* (Sinclair, 2008).

MATERIALS AND METHODS

For best results, thaumaleids should be collected into 95% ethanol. They may later be critical-point-dried or dried using the hexamethyldisilazane (HMDS)
method, as outlined by Brown (1993). The latter method was used for the preparation of these specimens. Adult male genitalia were cleared using a hot, 85% lactic acid bath.

Terms used for adult structures follow those of McAlpine (1981), except wing venation where the interpretations of Sinclair (2015) and Saigusa (2006) are accepted. Homology of the male terminalia follows that of Sinclair (1992).

Distribution maps were created using SimpleMappr (Shorthouse 2010).

Label data for the primary types are cited in full, with labels listed from the top downward and data from each label enclosed in quotation marks. A semicolon represents a change in label. Lines are delimited by a forward slash mark. Label data for other specimens, including secondary types, are abridged and listed alphabetically. The repository for each type is given in parentheses.

SYSTEMATIC ACCOUNT

*Austrothaumalea spiculata* sp. nov.

**Type Material**


*Paratypes:* Same collection information as the holotype (2♂).

**Recognition**

*Austrothaumalea spiculata* is readily distinguished from all other species by its arrowhead shaped paramere.
Description

**Wing length:** 2.7-2.9mm.

**Colouration:** Head dull, dark brown; pronotum dark brown; postpronotum pale brown; mesonotum and pleura brown and somewhat shiny; katepisternum reddish-brown; legs pale yellow, becoming darker on apical tarsal segments; scutellum and mediotergite pale brown, shiny; halter stalk cream coloured, knob dark; abdomen dark brown; terminalia pale brown.

**Wing:** Evenly infuscate, slightly darker spot where R_{4+5} and M_1 meet wing margin; R_{1}(+R_{2+3}) with macrotrichia along entire length, remaining veins bare; R_{2+3} situated towards apex of R_1; bend in R_{4+5} well defined; R_{4+5} and M_1 parallel toward wing margin; CuA with short basal appendage.

**Abdomen:** Abdominal sternite 1 narrow, spectacle-shaped; sternite 2 reduced to slender, median sclerite, with pair of small, posterolateral sclerites, setae restricted to apical fourth and between posterolateral sclerites; sternites 3-6 rectangular, anterior margin well sclerotized, with pair of small, posterolateral sclerites, sternite 3 with setae on posterior two thirds, 4-6 with setae on median third; sternite 7 trapezoidal-shaped, with posterior marginal setae; sternite 8 triangle-shaped, no setae.

**Male terminalia:** Epandrium broadly triangular from ventral aspect; apical third slightly tapered; posterior margin broad and rounded; lacking pointed posterolateral processes. Hypandrium broad, nearly subequal to width of base of gonocoxites; anterior margin slightly concave. Gonocoxite broad, inner margin of basal two-thirds lightly serrate before becoming widest two thirds of way down; apical third strongly tapered. Gonostylus nearly subequal in length to gonocoxite,
curved strongly before mid-length; thickest at mid-point; gradually tapered to blunt tip. Parameres fused, half length of epandrium, rod-like with spearhead-like apex. Gonocoxal plate broad basally; apical margin concave with short, pointed posterolateral process; basally not fused to hypandrium.

**Additional Material Examined**

Only the type series is known.

**Distribution**

Known only from the type locality (Fig. 4.1). Grampians National Park is located in the southwest region of Victoria, roughly 260km west of Melbourne. It consists of sandstone mountain ranges and eight different vegetation communities. Situated in the northern half of the park, Mackenzie Falls is Victoria’s highest waterfall. *Austrothaumalea denticulata* Theischinger is the only other species of Thaumaleid known from the Grampians.

**Etymology**

*Austrothaumalea spiculata* is so named from the Latin, *spica* (point), in reference to the shape of the paramere, which resembles that of a Roman spear.

**Phylogenetic Affinities**

McLellan (1988) and Sinclair (2008) have proposed a total of six tentative species groups for the genus *Austrothaumalea*. *Austrothaumalea spiculata* belongs to the *A. fusca* group, as it is defined by the distinctive truncate gonocoxal plate and its broad base (Sinclair, 2008). Members of this group include *A. bifida* Sinclair, *A. cervulus* Theischinger, *A. fusca* Theischinger, *A. uptoni* Theischinger and possibly *A. apicalis* Edwards and *A. spatulata* Schmid (both from Chile). Further discovery and description of new species will assist in the evaluation of these groups. This would
Figure 4.1 Ventral view of male genitalia of holotype *Austrothaumalea spiculata*.

Figure 4.2 Known distribution of *Austrothaumalea spiculata*. 
be particularly useful with regards to determining relationships between the Neotropical and Australian fauna. *Austrothaumalea spiculata* also has a bilobed fourth tarsomere, which Sinclair (2015) notes has independently arisen in a number of species. These species exhibit a Gondwanan distribution, perhaps indicating that it is the ancestral state and has been lost in other species. The phylogenetic significance of this character remains to be determined and further investigation is required.
List of References


Chapter 5:
General Conclusions
The family Thaumaleidae is a widespread family found nearly worldwide, yet there remains much to be revealed about it. This research has illustrated that, particularly in respects to phylogenetic relationships between genera and species, there are many opportunities for continued research and discovery within the family. Future studies should focus on both diversity and determining phylogenetic relationships within the Thaumaleidae.

As of this thesis, there are approximately 190 described species of Thaumaleidae worldwide, yet that number will undoubtedly grow with continued research on the group. The Holarctic and Australian regions have been fairly well studied, however, as evidenced in this thesis, new species are still being uncovered. The Neotropics and Afrotropical regions are both vastly understudied and future studies should focus on these areas and will likely yield many more undescribed species. Sustained collection in the Nearctic Region will also continue to give new distribution information and diversity, particularly in the southwest and Colorado. Continued collection of the family will also allow for the acquisition of fresh molecular grade material to be used in future molecular studies to infer phylogenetic relationships.

As mentioned in Chapter 3, this thesis is the first study to rigorously test relationships between species of Thaumaleidae. Although this paper focused on only one region and genus, the results were positive and informative. It has also given some insight into how the Nearctic fauna is related to Palearctic fauna. The eastern Nearctic fauna appears to be more closely related to the Palearctic fauna, though further investigation is required. Obtaining more European and Asian material would help to increase the Palearctic data and allow for a more robust study. The uncertainty of the relationships between the Nearctic and Palearctic fauna also raises questions pertaining to generic relationships as a whole.

An investigation into the generic relationships within the Thaumaleidae would give insight into many unknown aspects of the family: What are the relationships between the Gondwanan genera? And the Northern Hemisphere fauna? How are the Gondwanan and Northern Hemisphere genera related? Does
each genus form a monophyletic clade? Where did the family originate and what were its global dispersal patterns? These questions can be answered by the continued collection of thaumaleid specimens from around the world.
Vita

Robert Pivar was born in Burlington, Ontario, Canada. He earned his BSc in Environmental Biology from the University of Guelph in 2010. Rob always had an interest in insects growing up, but it was during his time at Guelph that he developed a passion for insect systematics. After taking numerous entomology courses with Dr. Stephen Marshall and spending time with the graduate students in his lab, Rob knew he wanted to be involved in insect systematics. He found the order Diptera (true flies) particularly intriguing due to their high diversity and unique life histories. After his undergraduate studies, Rob continued to work in the University of Guelph Insect Collection conducting arthropod surveys and helping to curate the collection. After three years of various entomology related jobs and exploring tropical regions in search of insects, Rob’s chance to study flies had arrived. He moved to Knoxville, TN to join the Insect Systematics lab where Dr. J.K. Moulton gave him the opportunity to study a little known family of flies, Thaumaleidae. Rob plans to continue his graduate studies in Dr. Moulton’s lab and pursue his PhD.