

STUDIES OF PARASITIC WASPS (BRACONIDAE) IN GRAND TETON NATIONAL PARK



SCOTT R. SHAW
DEPARTMENT OF RENEWABLE RESOURCES
UNIVERSITY OF WYOMING ♦ LARAMIE,

♦ ABSTRACT

A survey of braconid wasps in GTNP and south YNP recognizes 71 genera and at least 150 species. Of these, 100 are new distribution records and at least nine are new (undescribed) species. The species richness of Braconidae in GYE (150 species) is substantially greater than the maximum species richness of all herbaceous plants, shrubs, trees, birds and mammals in lodgepole pine communities of YNP (112 species). This total also substantially exceeds the number of braconid species recorded in fire-disturbed habitats of south YNP (109 species).

♦ INTRODUCTION

Braconid wasps (Hymenoptera: Braconidae) are one of the key groups of beneficial organisms that naturally regulate other insect populations (Shaw & Huddleston 1991). Prior to our YNP studies done in 1990 (Lockwood, Shaw & Struttman 1996), there had been no systematic surveys to assess what braconid species were present in the Greater Yellowstone Ecosystem (GYE). No studies have been done to assess how GYE braconid faunas change over time. This study is targeted towards providing a survey of which braconid species are present, and better understanding their roles in the GYE. Since braconid wasps affect the population dynamics of many plant-feeding insects, this research relates to the larger NPS goal of examining rangeland restoration after the 1988 fires.

♦ METHODS.

Sampling of parasitic wasps was conducted in Grand Teton National Park (GTNP) from 28 July to 15 August 2002. Four Townes-style Malaise (flight intercept) traps were placed in forested areas near the AMK research station. Trap jars were changed daily, samples sorted, and all Braconidae specimens were preserved in 95% ethanol. Subsequently, most of these samples were chemically-dried, point-mounted on pins, and labeled for taxonomic analysis. Other sampling methods included yellow pan traps, black light, and by-hand collecting with nets and aspirators. Because of the difficulty of placing and maintaining Malaise traps in remote areas, sampling in south Yellowstone National Park (YNP) was restricted to by-hand collecting with nets and aspirators from 30 July to 9 August.

♦ RESULTS

Thus far, 1,021 braconid specimens have been dry-mounted for study. This represents the bulk of the Malaise trap material, but some smaller samples are still stored in alcohol. From these samples 19 subfamilies of Braconidae are represented: Doryctinae, Braconinae, Rhyssalinae, Hormiinae, Rogadinae, Opiinae, Alysiinae, Homolobinae, Macrocentrinae, Meteorinae, Neoneurinae, Blacinae, Helconinae, Orgilinae, Agathidinae, Aphidiinae, Adeliinae, Cheloninae, and Microgastrinae. Six of these subfamilies (Rhyssalinae, Hormiinae, Homolobinae,

Neoneurinae, Agathidinae, and Adeliinae) are recorded from GTNP for the first time. Only one subfamily expected to occur was not sampled, the Ichneutinae. For each of these groups, representative genera and (if possible) species were determined using the identification manual provided by Wharton et al. (1997) and other sources (cited below). A full listing of species is not feasible because of the lack of modern taxonomic treatments for many groups. Results for each subfamily group follow below.

Subfamily Doryctinae

Doryctine species are ectoparasites of wood-boring beetle larvae, especially attacking the beetle families Bostrichidae, Buprestidae, Cerambycidae, Lyctidae, and Scolytidae. Consequently, they are normally found in association with dead or damaged trees, or firewood. Only five doryctine specimens were sampled, representing three genera and species (all new records for GTNP): *Dendrosoter scaber* Muesebeck, *Onsira imperator* (Haliday), and *Spathius* species near *sequoiae* (Ashmead). *Dendrosoter scaber* was previously known from California, Oregon, and Montana (Marsh 1979) but not Wyoming. It is recorded as a parasite of bark beetles in *Pseudotsuga taxifolia* and *Pinus monophylla* (Muesebeck 1938). *Onsira imperator* is widely distributed in Europe and North America but it has not been previously recorded in GTNP (Marsh 1966). *Spathius sequoiae* is widely distributed in western North America, and is known to parasitize several bark beetle species in a variety of conifers (Matthews 1970).

Subfamily Braconinae

Most braconine species are ectoparasites of wood-boring beetle larvae or Lepidoptera larvae in plant tissue. Four braconine genera and ten species were found in GTNP during this study: *Atanycolus pilosiventris* Shenefelt, *Bracon* species near *montowesi* Viereck, *Bracon nigradorsum* Ashmead, *Bracon* species near *nigradorsum* Ashmead, *Bracon nitidulus* Dalla Torre, *Bracon nuperus* Cresson, *Bracon palliventris* (Provancher), *Bracon tychei* (Muesebeck), *Coeloides sympyitis* Mason, and *Cyanopterus laevis* (Provancher). Most of these species are widely distributed across the northern United States and Canada but none had been previously recorded from GTNP. Species of *Atanycolus* are parasitic on the wood-boring larvae of Cerambycidae and Buprestidae (Shenefelt 1943). *Bracon* species parasitize a wide variety of small Coleoptera and Lepidoptera larvae feeding in plant tissues (Muesebeck 1925; Marsh 1979). *Coeloides*

species are important parasites of bark beetles (Scolytidae) in western forests (Mason 1978). *Coeloides rufovariegatus* (Provancher) has been previously recorded from GTNP and *Coeloides vancouverensis* (D.T.) has been found in YNP and the Shoshone National Forest (Mason 1978) but neither species was found in this study.

Subfamily Rhyssalinae

These minute wasps are gregarious ectoparasitoids of microlepidoptera and Coleoptera larvae concealed in plant tissue (Muesebeck 1935). A single female specimen of *Oncophanes* species near *californicus* (Ashmead) was collected in GTNP on August 9, 2002. This is the first record for this subfamily in GTNP. A single female specimen of the same species was collected in YNP on September 7, 1990. *Oncophanes californicus* was previously known only from California, Oregon, and Washington and its host is unknown (Marsh 1979). A closely related species in the eastern United States is a parasite of leaf-mining sawflies in birch (Muesebeck 1935; Marsh 1979).

Subfamily Hormiinae

These minute and poorly studied wasps are gregarious ectoparasites of concealed microlepidopterous larvae including Gelechiidae, Pyralidae, and Tortricidae (Marsh 1979). During this study 36 specimens of a *Hormius* species were sampled. The genus *Hormius* has never been revised for North America, so no identification keys are available. The GTNP species may be *Hormius americanus* Ashmead, which was previously recorded from Colorado (Marsh 1979). None has previously been reported from GTNP.

Subfamily Rogadinae

Rogadines are divided into two tribes, the Rhysipolini and the Rogadini. Rhysipolines are solitary ectoparasites of microlepidopterous leaf-miners of the families Momphidae and Gracillariidae (Spencer & Whitfield 1999). *Rhysipolis decorator* (Haliday) and *Rhysipolis platygaster* Spencer were previously recorded from YNP and another species, *Rhysipolis stenodes* Spencer, from GTNP by Spencer and Whitfield (1999). In this study, *Rhysipolis platygaster* is reported from GTNP for the first time.

Species of the tribe Rogadini are mostly solitary endoparasites of macrolepidoptera larvae, especially attacking the Noctuoidea, Geometroidea, and Arctioidea (Shaw, Marsh & Fortier 1997; Marsh

& Shaw 2001). Four rogaedine species were sampled in this study: *Aleiodes* near *perplexus* (Gahan), *Aleiodes* near *scrutator* (Say), and two male specimens each representing a new species of the *Aleiodes coxalis* species-group.

Subfamily Opiinae

Opiines are solitary endoparasites of dipterous larvae with pupation occurring in the fly puparium (Marsh 1979; Fischer 1977). Two genera and eight species were found in this study: *Diachasma* probably *muleibre* (Muesebeck), *Opius blantonii* Fischer, *Opius cinctus* Provancher, *Opius dimidiatus* (Ashmead), *Opius hartleyi* Fischer, *Opius hollisterensis* Fischer, *Opius kinleyensis* Fischer, and *Opius rudis* Wesmael. With the exception of *Opius dimidiatus* (Ashmead), all are new records for GTNP. *Diachasma muleibre* (Muesebeck) was known previously from Washington, Oregon, and California as a parasite of *Rhagoletis* fruit flies (Marsh 1979). *Opius dimidiatus* (Ashmead) is widespread across North America and is recorded as a parasite of *Agromyza*, *Cerodontha*, *Liriomyza*, *Phytobia*, and *Phytomyza* species (Marsh 1979). *Opius rudis* Wesmael is recorded as a parasite of *Agromyza* species (Marsh 1979). *Opius kinleyensis* Fischer and *Opius hartleyi* Fischer were previously known only from Alaska.

Subfamily Alysiinae

The Alysiinae are all internal parasites of the larvae of cyclorrhaphous Diptera, completing their development in the fly puparium (Marsh 1979). These wasps are easily distinguished by their unusual twisted and out-turned mandibles, which is regarded as an adaptation for escaping from the fly puparium. Alysiine wasps are classified into two tribes: Dacnusiini and Alysiini. Members of the Dacnusiini are mostly solitary endoparasites of leaf-mining fly larvae of the family Agromyzidae, and there are often very host-specific (Griffiths 1964). Members of the tribe Alysiini, on the other hand, have a much broader host range and attack at least 25 different families of flies (Wharton 1984).

In this study, four genera and at least five species of tribe Dacnusiini were found in GTNP: *Chorebus*, *Dacnusa*, *Epimicta griffithsi* Wharton, and *Exotela* (2 species). *Epimicta griffithsi* was previously known only from Texas (Wharton 1994) and Kansas (Bob Kula, personal communication). Identification of most dacnusiine species was not possible because of the lack of revisionary studies for this group. Since no North American species of

Exotela have been described, these two are presumed to be new species.

In this study, seven genera and at least 12 species of tribe Alysiini were found in GTNP: *Alysia* (3 species), *Anisocyrta*, *Aphaereta*, *Aspilota* (2 species), *Dapsilarthra*, *Dinotrema* (2 species), and *Phaenocarpa* species (2 species). *Alysia* species have been revised by Wharton (1980, 1986, 1988). *Alysia* species are mostly parasites of fly larvae in carrion or mushrooms (Wharton 1986). *Alysia micans* (Viereck) was reported from GTNP and YNP by Wharton (1988). *Alysia brevissima* Wharton and *Alysia brachycera* Thomson are reported from GTNP for the first time. *Alysia brachycera* is a widespread Holarctic species but *Alysia brevissima* was formerly known only from Alaska, Yukon Territory, and Northwest Territories. *Anisocyrta nearctica* van Achterberg is recorded from GTNP and Wyoming for the first time. The species has been previously recorded from Colorado, British Columbia, Yukon Territory, and Alaska as a parasite of fly larvae in mushrooms (van Achterberg 1986). Species of *Aspilota* and *Dinotrema* are mostly parasites of phorid fly larvae in decaying organic matter, or less commonly platypezid fly larvae in mushrooms (van Achterberg 1988).

Subfamily Ichneutinae

Ichneutine braconids are solitary internal parasites of sawfly larvae (Hymenoptera). Although two species are known to occur in YNP, no ichneutine species were found in GTNP during this study. This is probably because adults of this group are active much earlier in the season.

Subfamily Homolobinae

Homolobine wasps are solitary internal parasites of Noctuidae and Geometridae caterpillars. The subfamily is recorded from GTNP for the first time. One specimen of *Homolobus* (*Apatia*) *truncator* (Say) was sampled by Malaise on 5 August. *H. truncator* is recorded as a parasite of *Agrotis*, *Feltia*, *Spodoptera* and other cutworm-like larvae. The subfamily was revised by van Achterberg (1979).

Subfamily Macrocentrinae

Macrocentrines are solitary or gregarious endoparasites of concealed-feeding Lepidoptera larvae. Some gregarious species are known to be polyembryonic, with 8-10 individuals developing from a single egg. Three species of *Macrocentrus*

were found in GTNP during this study. *M. incompletus* Muesebeck is recorded from GTNP for the first time. One female specimen of *Macrocentrus* species near *clypeatus* Muesebeck shows unusual variation, and may be a new species. The North American species of *Macrocentrus* were revised by Muesebeck (1932). A modern revision of the genus is currently in progress by Ken Ahlstrom. According to Ahlstrom the single male specimen from GTNP is a new species near *Macrocentrus innuitorum* Walley.

Subfamily Meteorinae

Meteorine braconids are mostly solitary (a few are gregarious) internal parasites of Lepidoptera or (less commonly) Coleoptera larvae. The most frequently attacked hosts are caterpillars of Noctuidae, Geometridae, Tortricidae, and Arctiidae (Huddleston 1980). The hosts of *Meteorus* species attacking beetles are mostly species living in wood, tree bark, and bracket fungi, especially Cerambycidae, Tenebrionidae, Scolytidae, Cryptophagidae, Melandryidae, and Ciidae (Huddleston 1983). Most *Meteorus* species produce very distinctive cocoons suspended by a long single thread of silk (Zitani and Shaw 2003). The most recent revision for North American species is that of Muesebeck (1923) and the group is very much in need of modern studies. Four meteorine species were found in this study and all are new records for GTNP: *Zele reticulatus* (Muesebeck), *Meteorus* species near *angustipennis* Muesebeck, *Meteorus* species near *dimidiatus* Cresson, *Meteorus* species near *rubens* (Nees). *Z. reticulatus* is a parasite of geometrid caterpillars of the genus *Semiothisa* (Marsh 1979). Two specimens of *M. near angustipennis* were found indoors in the Lawrence House. Although they might have been attracted to lights, they were females and they appeared to be searching the walls. This raises the possibility that this, or other beetle-associated braconid species, might be used as indicator species for beetle activity in structural wood of historic buildings of the park system.

Subfamily Euphorinae

Euphorine braconids are mostly solitary (a few are gregarious) internal parasites of various adult and nymphal insects, including beetles, bark lice (Psocidae), worker bees, and worker ants (Shaw 1985; Shaw & Huddleston 1991). The following genera and species are recorded from GTNP for the first time: *Centistes* (*Syrrhizus*) *agilis* (Cresson), *Centistes* (*Ancylocentris*) *laevis* (Cresson), *Falcosyntretus muesebecki* Papp & Shaw, *Myiocephalus boops* Wesmael, and *Peristenus*

species. *Euphoriella pacifica* Muesebeck and *Microctonus* species are newly recorded from YNP (based on material from the 1990 study). A key to New World species of *Centistes* was provided by Shaw (1995). *Centistes agilis* is recorded as a parasite of anthicid beetles of the genus *Notoxus*. *C. laevis* is recorded as a parasite of carabid ground beetles of the genus *Amara*. *Euphoriella* was revised by Loan and New (1971). They are parasites of nymphal Psocidae. *Falcosyntretus* was revised by Papp and Shaw (2000). The host of *Falcosyntretus muesebecki* is not known, but other syntretines parasitize adult ichneumonid wasps or adult bumblebees. *Microctonus* is a large genus parasitizing various beetles. The genus is in need of revision, and species-level identifications are difficult without host-associated material. *Myiocephalus boops* is a holarctic species that has previously been found in south YNP. Its host is not known but it has been associated with adult *Formica* ants (Shaw 1985). *Peristenus* is a large genus that parasitizes nymphs of mirid plant bugs (Shaw 1985).

Subfamily Neoneurinae

Neoneurine braconids are thought to be internal parasites in the abdomen of adult worker ants, but information on their biology and behavior is sparse (Shaw 1992, 1993; Poinar & Miller 2002). Three neoneurine species are recorded from GTNP for the first time: *Elasmosoma vigilans* Cockerell, *Neoneurus mantis* Shaw and *Neoneurus* species near *masneri* Shaw. These were from Malaise trap samples, but on 12 August two additional individuals of *Neoneurus* were found in a spider web. The genus *Elasmosoma* was revised by Huddleston (1976). The North America species of *Neoneurus* were revised by Shaw (1992).

A new species of *Elasmosoma* near *pergandei* was discovered in south YNP on 30 July near the South Gate Ranger Station and in areas just south of the park entrance. These wasps were observed to be active from 30 July to 9 August. They were observed hovering near nests of *Formica obscuripes* mound-building ants between 9am and noon on sunny days. They were less active on cooler days and during cloudy weather. Samples were obtained by aspirator. A manuscript describing and naming this new species is in preparation.

Subfamily Blacinae

These minute and poorly studied wasps are thought to be internal parasites of beetle larvae in damp decaying vegetation. Males of some species

form mating swarms. One species, *Blacus* (*Blacus*) *caduceus* van Achterberg, is recorded from the GYE for the first time. The Blacinae were revised by van Achterberg (1988b).

Subfamily Helconinae

Helconine braconids are mostly solitary internal parasites of beetle larvae under bark or in plant tissue (Shaw & Huddleston 1991). Six helconine genera and species are recorded for the first time from the GYE: *Aliolus* new species, *Allodorus* species probably *crassigaster* (Provancher), *Diospilus* species, *Eubazus* species, *Triaspis pissodis* Viereck, and *Wroughtonia* species probably *frigida* (Cresson). Most helconine genera are in need of modern revisions.

Subfamily Agathidinae

Agathidines are solitary endoparasites of concealed-feeding Lepidoptera larvae. Most species attack caterpillars feeding in concealment in leaf rolls, silk webs, flower heads, or plant stems, such as Coleophoridae, Pyralidae, Tortricidae, and Gelechiidae (Muesebeck 1927). Although diverse and widely distributed, the subfamily Agathidinae has not been previously recorded from GTNP. Only five agathidine specimens were sampled, representing two genera and three species (all new records for GTNP): *Agathis tibiator* (Provancher), *Bassus gibbosus* Say, and *Bassus nigripes* (Cresson). All three species are widely distributed across the northern U.S. and Canada.

Subfamily Orgilinae

Orgilines are solitary internal parasites of caterpillars feeding in concealed sites, especially Pyralidae, Tortricidae, Coleophoridae, Gelechiidae, Oecophoridae, and Gracillariidae (Muesebeck 1970; Marsh 1979). Seven orgiline species were found from the GYE during this study: *Orgilus* species near *conflictanae* Muesebeck, *Orgilus grapholithae* Muesebeck, *Orgilus* species near *medicaginis* Muesebeck, *Orgilus politus* Muesebeck, *Orgilus rostratus* Muesebeck, *Orgilus strigosus* Muesebeck, and *Orgilus* species near *utahensis* Muesebeck. *O. rostratus* was previously recorded from GTNP but the others are all new distribution records. Orgilines comprised 14% of all braconid specimens sampled by Malaise trap, making them one of the most abundant braconid subfamilies (second only to the Microgastrinae). The genus *Orgilus* was revised by Muesebeck (1970). The most abundant orgiline species in this study, *O. grapholithae*, is recorded as

a parasite of the tortricid moth *Grapholitha conversana* Walsingham in Oregon.

Subfamily Aphidiinae

These minute wasps are solitary internal parasites of aphids. Most species pupate inside the mummified body of the host aphid (Shaw & Huddleston 1991). Eight aphidiine genera and species were recorded from the GYE during this study: *Acanthocaudus* species probably *schlingeri* (Muesebeck), *Aphidius* species, *Binodoxys* species, *Diaeretiella* species, *Ephedrus* species, *Euaphidius* species, *Monoclonus* species, and *Praon unicum* Smith. Four of these are new distribution records for GTNP. The North American aphidiines were studied by Smith (1944) but most genera are in need of modern studies. Johnson (1987) revised the North American *Praon* species. *Praon unicum* has been recorded as a parasite of at least 13 aphid species, including common aphids on willows.

Subfamily Adeliinae

Adeliines are inconspicuous wasps that are rarely encountered because of their minute size. They are thought to be solitary internal parasites of leaf-mining larvae of nepticulid moths, including species that are leaf-miners in poplars and willows (Marsh 1979). One species, *Adelius coloradensis* Muesebeck, is recorded from GTNP for the first time. A key for North American *Adelius* species was provided by Muesebeck (1922).

Subfamily Cheloninae

Chelonine wasps are solitary internal egg-larval parasites of various Lepidoptera (Shaw & Huddleston 1991). The chelonine females lays an egg directly into the host egg, but development of the parasite is delayed until the host caterpillar is fully developed and ready to pupate. Most chelonines attack host caterpillars that feed in concealment, such as Tortricidae, Pyralidae, and Gelechioidea (Shaw & Huddleston 1991). This study documents two genera and at least eleven chelonine species, all new records for the GYE: *Ascogaster* species near *borealis* Shaw, *Chelonus* (*Archichelonus*) *aculeatus* Ashmead, *Chelonus* (*Chelonus*) *muesebecki* McComb, *Chelonus* (*Chelonus*) (several species), *Chelonus* (*Microchelonus*) *alius* McComb, *Chelonus* (*Microchelonus*) near *caulicola* McComb, *Chelonus* (*Microchelonus*) near *disjunctus* McComb, *Chelonus* (*Microchelonus*) species near *eucosmae* McComb, *Chelonus* (*Microchelonus*) *marshi* McComb, *Chelonus* (*Microchelonus*) near *medicaginis*

McComb, and *Chelonus* (*Microchelonus*) *phthorimaeae* McComb. The genus *Ascogaster* was revised by Shaw (1983). *Ascogaster borealis* is recorded as a parasite of the spruce needle miner, *Endothenia albolineana*. The genus *Chelonus* is highly diverse and badly in need of taxonomic study. The large-bodied species of the subgenus *Chelonus* are common and conspicuous, yet the subgenus has never been revised and no keys for species are available (Marsh 1979). The smaller species of the genus *Microchelonus* were revised by McComb (1968) but identification of species remains difficult. McComb's lengthy key includes 111 species, but the key treats only females and is not illustrated. Interpretation of variation is often difficult. *Chelonus* (*Microchelonus*) *leptogaster* McComb has been previously recorded near the South Gate of YNP (McComb 1968).

Subfamily Microgastrinae

The subfamily Microgastrinae is regarded as the single most important group of parasitoids of Lepidoptera in the world, both in economic terms and in numbers of species (Whitfield 1995). Microgastrines are solitary or gregarious internal parasites of various caterpillars. Due to their high diversity and frequent occurrence of gregarious parasitism, microgastrines are very abundant in forest habitats and are normally the most commonly encountered braconid subfamily. This was also true in this study, where microgastrine species comprised more than 54% of all Braconidae sampled. Despite their abundance and economic importance, many microgastrines remain very difficult to identify. There are few modern taxonomic revisions for most groups, and most males cannot be identified to species level unless they are associated with host-reared series of females. The following microgastrine genera and species are recorded from the GYE during this study: *Apanteles aristoteliae* Viereck, *Apanteles* species near *crassicornis* (Provancher), *Apanteles ensiger* (Say), *Apanteles* near *femurnigrum* Provancher, *Apanteles fumiferanae* Viereck, *Apanteles* species near *stigmatophorae*, *Cotesia* species near *anisotae* (Muesebeck), *Cotesia* species near *carduicola* (Packard), *Cotesia* species near *clisiocampae* (Ashmead), *Cotesia* species near *enypiae* (Mason), *Cotesia gillettei* Baker, *Cotesia glomerata* (Linnaeus), *Cotesia griffini* (Viereck), *Cotesia xyliana* (Say), *Cotesia yakutatensis* (Ashmead), *Dolichogenidea* near *miantonomoi* Viereck, *Diolcogaster fascetosa* (Weed), *Glyptapanteles* near *compressiventris* (Muesebeck), *Microgaster femoralamericanus* Shenefelt, *Microgaster* species near *peroneae* Walley,

Microplitis alaskensis Ashmead, *Microplitis autographae* Muesebeck, *Microplitis laticinctus* Muesebeck, *Microplitis* new species 1, *Microplitis* new species 2, *Microplitis* species 3, *Microplitis* species 4 (near *laticinctus*), *Microplitis* species 5, *Microplitis* species 6, *Pholetesor bedelliae* (Viereck), and *Sathon neomexicanus* (Muesebeck). *Apanteles aristoteliae* and *A. fumiferanae* both have broad host ranges but are both recorded as parasites of the spruce budworm, *Choristoneura fumiferanae* (Marsh 1979). *Cotesia gillettei* is recorded as a parasite of *Archips argyrospilus*, a common leaf-roller on many broad leaf trees including trembling aspen (Marsh 1979). The most recent revision for *Apanteles* is that of Muesebeck (1920). The genus *Apanteles* (as formerly defined) was reclassified by Mason (1981) and many common species were re-assigned to other genera including *Cotesia* and *Glyptapanteles*. The annotated checklist provided by Whitfield (1995) is highly useful for checking generic and species combinations in this group. The genus *Sathon* was revised by Williams (1988).

◆ DISCUSSION

This survey of braconid wasps in GTNP and south YNP recognizes 71 genera and at least 150 species. Of these, 100 are new distribution records and at least nine are new (undescribed) species. The species richness of Braconidae in GYE (150 species) is substantially greater than the maximum species richness of all herbaceous plants, shrubs, trees, birds and mammals in lodgepole pine communities of YNP (112 species according to Taylor 1973). This total also substantially exceeds the number of braconid species recorded in fire-disturbed habitats of south YNP (109 species recorded by Lockwood, Shaw & Struttman 1996).

The high number of new distribution records (100) is probably a reflection not of scarcity of these species, but rather the scarcity of previous studies, the difficulties of sampling microscopic insects, and the lack of studies in GYE because of permit restrictions. No checklist of Braconidae species has previously been published for the GYE. A checklist of species based on this study is provided below. Most of the new distribution records are for species that are widely distributed in the northwestern United States, Canada, or Alaska. Some species recorded were previously known from Alaska (*Opius kinleyensis*, *Opius hartleyi*, *Alysia brevissima*). Several circumpolar (Holarctic) species are also present (*Onsira imperator*, *Aleiodes unipunctator*, *Alysia brachycera*, *Homolobus truncator*, *Meteorus*

rubens, *Myiocephalus boops*, *Cotesia glomerata*). The community of braconid species appears to be dominated by boreal elements, many of which probably dispersed into the GYE from the north, along the corridor of the Rocky Mountains.

Although the high species richness of Braconidae is perhaps not unexpected, it is still rather remarkable that so many previously unrecorded species could be sampled during such a short time frame (28 July to 15 August), mostly at one sampling site (AMK ranch), mostly by one sampling method (Malaise trap), and during a severe drought season. It should be kept in mind that sampling done earlier in the season, in plant communities other than mature lodgepole pine, at other locations, and using a variety of other sampling methods would likely yield many other braconid species not recorded here. Host-rearing studies are very much needed to establish host ranges for braconid species in the GYE and to obtain conspecific series to examine variation. Given these considerations, it seems reasonable to suppose that the total richness of Braconidae species in the GYE is probably much greater than the 150 species recorded here, and might easily exceed 200 species.

It is also interesting to observe that the discovery of new insect species reflects not so much the rarity of these organisms, but rather the lack of previous sampling and revisionary research for GYE forest Braconidae. For example, although *Microplitis* was one of the most abundant and easily sampled genera in Malaise samples, the most common *Microplitis* species in these samples were undescribed species (Jim Whitfield, personal communication). A new species of *Elasmosoma* was discovered literally within minutes of entering YNP, and was found to be rather common for several days.

★ ACKNOWLEDGMENTS

Jim Whitfield (University of Illinois) provided species identifications for *Microplitis* and *Pholetesor*. Kenneth Ahlstrom (North Carolina Department of Agriculture) provided species identifications for *Macrocentrus*. Robert Kula (University of Kansas) provided the identification for *Epimicta griffithsi*. Christie Hendrix (YNP) and Nicki Tippets (GTNP) assisted with providing park collecting permits. Rick Mossman (YNP ranger) pointed out the location of ant colonies in south YNP, crucial to the discovery of *Elasmosoma*. This research was funded by a 2002 grant from the UW-NPS research station and Macintyre-Stennis project number WYO-362-02. My son, Michael Shaw,

provided critical assistance with setting and maintaining Malaise traps and other field assistance.

★ LITERATURE CITED

- Achterberg, C. van. 1979. A revision of the subfamily Zelinae auct. (Hymenoptera, Braconidae). *Tidschrift voor Entomologie* 122:241-479.
- Achterberg, C. van. 1986. The Holarctic genus *Anisocyta* Foerster (Hymenoptera: Braconidae: Alysini). *Zoologische Mededelingen* 60:285-297.
- Achterberg, C. van. 1988. The genera of the *Aspilota*-group and some descriptions of fungicolous Alysini from the Netherlands (Hymenoptera: Braconidae: Alysini). *Zoologische Verhandelingen* 247:3-88.
- Achterberg, C. van. 1988b. Revision of the subfamily Blacinae Foerster (Hymenoptera, Braconidae). *Zoologische Verhandelingen* 249:1-324.
- Fischer, M. 1977. Hymenoptera: Braconidae (Opiinae II – Amerika). *Das Tierreich* 96:1-1001. (in German)
- Griffiths, G.C.D. 1964. The Alysini (Hym. Braconidae) parasites of the Agromyzidae (Diptera). I. General questions of taxonomy, biology, and evolution. *Beiträge zur Entomologie* 14:823-914.
- Huddleston, T. 1976. A revision of *Elasmosoma* Ruthe (Hymenoptera, Braconidae) with two new species from Mongolia. *Annales Historico-Naturales Musei Nationalis Hungarici* 68:215-225.
- Huddleston, T. 1980. A revision of the western Palearctic species of the genus *Meteorus* (Hymenoptera: Braconidae). *Bulletin of the British Museum (Natural History)* 41:1-58.
- Huddleston, T. 1983. *Meteorus* (Hymenoptera: Braconidae) of Australia and New Guinea. *Systematic Entomology* 8:393-420.
- Johnson, J.W. 1987. A revision of the species of *Praon* in North America north of Mexico (Hymenoptera: Aphidiidae). *The Canadian Entomologist* 119:999-1025.

- Loan, C.C. and T.R. New. 1971. An account of the North American species of *Euphoriella* Ashmead with descriptions of seven new species (Hymenoptera: Braconidae, Euphorinae). Proceedings of the Entomological Society of Ontario 102:92-108.
- Lockwood, J.A., S.R. Shaw, and J.M. Struttman. 1996. Biodiversity of wasp species (Insecta: Hymenoptera) in burned and unburned habitats of Yellowstone National Park, Wyoming, USA. Journal of Hymenoptera Research 5:1-15.
- Marsh, P.M. 1966. The Nearctic Doryctinae, II. The genus *Doryctodes* Hellén (Hymenoptera: Braconidae).
- Marsh, P.M. 1979. Family Braconidae, pp. 144-313, In: Catalog of Hymenoptera in America north of Mexico, Krombein et al. (eds.), Smithsonian Institution Press, Washington D.C.
- Marsh, P.M. and S.R. Shaw. 2001. Revision of North American *Aleiodes* (Part 6): the *gasterator* and *unipunctator* species-groups. Proceedings of the Entomological Society of Washington 103:291-307.
- Mason, W.R.M. 1978. A synopsis of the Nearctic Braconini, with revisions of Nearctic species of *Coeloides* and *Myosoma* (Hymenoptera: Braconidae). Canadian Entomologist 110:721-768.
- Mason, W.R.M. 1981. The polyphyletic nature of *Apanteles* Foerster (Hymenoptera: Braconidae): a phylogeny and reclassification of Microgastrinae. Memoirs of the Entomological Society of Canada 115:1-147.
- Matthews, R.W. 1970. A revision of the genus *Spathius* in America North of Mexico (Hymenoptera, Braconidae). Contributions of the American Entomological Institute 4:1-86.
- McComb, C.W. 1968. A revision of the *Chelonus* subgenus *Microchelonus* in North America north of Mexico (Hymenoptera: Braconidae). University of Maryland Agricultural Experiment Station Bulletin A-149, 1-148.
- Muesebeck, C.F.W. 1920. A revision of the North American species of ichneumon-flies belonging to the genus *Apanteles*. Proceedings of the United States National Museum 58:483-576.
- Muesebeck, C.F.W. 1922. A revision of the North American ichneumon-flies belonging to the subfamilies Neoneurinae and Microgastrinae. Proceedings of the United States National Museum 61:1-76.
- Muesebeck, C.F.W. 1923. A revision of the North American species of ichneumon-flies belonging to the genus *Meteorus* Haliday. Proceedings of the United States National Museum 63:1-44.
- Muesebeck, C.F.W. 1925. A revision of the parasitic wasps of the genus *Microbracon* occurring in America North of Mexico. Proceedings of the United States National Museum 67:1-85.
- Muesebeck, C.F.W. 1927. A revision of the parasitic wasps of the subfamily Braconinae occurring in America North of Mexico. Proceedings of the United States National Museum 69:1-73.
- Muesebeck, C.F.W. 1932. Revision of the Nearctic ichneumon-flies belonging to the genus *Macrocentrus*. Proceedings of the United States National Museum 80:1-55.
- Muesebeck, C.F.W. 1935. On the genus *Oncophanes* Foerster, with descriptions of two related genera (Hymenoptera: Braconidae). Annals of the Entomological Society of America 28:241-250.
- Muesebeck, C.F.W. 1938. The genus *Dendrosoter* Wesmael in the United States (Hymenoptera: Braconidae). Proceedings of the Entomological Society of Washington 40:281-287.
- Muesebeck, C.F.W. 1970. The nearctic species of *Orgilus* Haliday (Hymenoptera: Braconidae). Smithsonian Contributions to Zoology 30:1-104.

- Papp, J. and S.R. Shaw. 2000. A study of the genus *Falcosyntretus* Tobias from the New World with five new species and a key to known species (Hymenoptera: Braconidae: Euphorinae). Proceedings of the Entomological Society of Washington 102:634-642.
- Poinar, G. Jr. and J.C. Miller. 2002. First fossil record of endoparasitism of adult ants (Formicidae: Hymenoptera) by Braconidae (Hymenoptera). Annals of the Entomological Society of America 95:41-43.
- Shaw, M.R. and T. Huddleston. 1991. Classification and biology of braconid wasps (Hymenoptera: Braconidae). Royal Entomological Society of London, Handbooks for the Identification of British Insects 7:1-126.
- Shaw, S.R. 1983. A taxonomic study of nearctic *Ascogaster* and a description of a new genus *Leptodrepana* (Hymenoptera: Braconidae). Entomography 2:1-54.
- Shaw, S.R. 1985. A phylogenetic study of the subfamilies Meteorinae and Euphorinae (Braconidae). Entomography 3:277-370.
- Shaw, S.R. 1988. Euphorine phylogeny: the evolution of diversity in host-utilization by parasitoid wasps. Ecological Entomology 13:323-335.
- Shaw, S.R. 1992. Seven new North American species of *Neoneurus* (Hymenoptera: Braconidae). Proceedings of the Entomological Society of Washington 94:26-47.
- Shaw, S.R. 1993. Observations on the ovipositional behavior of *Neoneurus mantis*, and ant-parasitoid from Wyoming. Journal of Insect Behavior 6:649-658.
- Shaw, S.R. 1995. A new species of *Centistes* from Brazil (Hymenoptera: Braconidae: Euphorinae) parasitizing adults of *Diabrotica* (Coleoptera: Chrysomelidae), with a key to New World species. Proceedings of the Entomological Society of Washington 97:153-160.
- Shaw, S.R., P.M. Marsh, and J.C. Fortier. 1997. Revision of North American *Aleiodes* (Part 1): the *pulchripes* species-group in the New World. Journal of Hymenoptera Research 6:10-35.
- Shenefelt, R.D. 1943. The genus *Atanycolus* in America North of Mexico. Research Studies of the State College of Washington 11:51-163.
- Smith, C.F. 1944. The Aphidiinae of North America (Braconidae: Hymenoptera). Ohio State University Contributions in Zoology and Entomology 6:1-154.
- Spencer, L. and J.B. Whitfield. 1999. Revision of the Nearctic species of *Rhysipolis* Förster (Hymenoptera: Braconidae). Transactions of the American Entomological Society 125:295-324.
- Taylor, D.L. 1973. Some ecological implications of forest fire control in Yellowstone National Park, Wyoming. Ecology 54:1394-1396.
- Wharton, R.A. 1980. Review of the Nearctic Alysini (Hymenoptera, Braconidae) with discussion of the generic relationships within the tribe. University of California Publications in Entomology 88:1-112.
- Wharton, R.A. 1984. Biology of the Alysini (Hymenoptera: Braconidae), parasitoids of cyclorrhaphous Diptera. Texas Agricultural Experiment Station Technical Monograph 11:1-39.
- Wharton, R.A. 1986. The braconid genus *Alysia* (Hymenoptera: a description of the subgenera and a revision of the subgenus *Alysia*. Systematic Entomology 11:453-504.
- Wharton, R.A. 1988. The braconid genus *Alysia* (Hymenoptera): a revision of the subgenus *Anarcha*. Contributions of the American Entomological Institute 25:1-69.
- Wharton, R.A. 1994. New genera, species, and records of New World Alysini (Hymenoptera: Braconidae). Proceedings of the Entomological Society of Washington 96:630-664.

- Wharton, R., P. Marsh, and M. Sharkey. 1997. Manual of the New World genera of the family Braconidae (Hymenoptera). Special Publication of the International Society of Hymenopterists, Number 1, 439 pp.
- Whitfield, J.B. 1995. Annotated checklist of Microgastrinae of North America north of Mexico (Hymenoptera: Braconidae). Journal of the Kansas Entomological Society 68:245-262.
- Williams, D.J.M. 1988. Classification, phylogeny and zoogeographic studies of species of *Sathon* Mason (Hymenoptera: Braconidae). Quaestiones Entomologicae 24:529-639.
- Zitani, N.M. and S.R. Shaw. 2003. From meteors to death stars: variations on a silk thread (Hymenoptera: Braconidae: Meteorinae). American Entomologist 48:228-235.

CHECKLIST OF BRACONIDAE FOR THE GYE

Subfamily Doryctinae

Doryctes fartus (Provancher) GTNP
Doryctes species near *fartus* (Provancher) YNP
Doryctes species YNP
Dendrosoter scaber Muesebeck GTNP (new record)
Heterospilus species YNP
Ontsira imperator (Haliday) GTNP (new record)
Spathius canadensis Ashmead YNP
Spathius species near *sequoiae* Ashmead GTNP (new record)

Subfamily Braconinae

Atanycolus pilosiventris Shenefelt GTNP (new record)
Bracon species near *montowesi* Viereck (new record)
Bracon nigridorsum Ashmead (new record)
Bracon species near *nigridorsum* Ashmead (new record)
Bracon nitidulus Dalla Torre (new record)
Bracon nuperus Cresson (new record)
Bracon palliventris (Provancher) (new record)
Bracon tychei (Muesebeck) GTNP (new record)
Coeloides rufovariegatus (Provancher) GTNP (Mason 1978)
Coeloides sympitys Mason YNP, GTNP (new record)
Coeloides vancouverensis (Dalla Torre) YNP
Cyanopterus laevis (Provancher) YNP, GTNP (new record)

Subfamily Rhyssalinae (new record)

Oncophanes species near *californicus* (Ashmead) YNP, GTNP (new record)

Subfamily Hormiinae (new record)

Hormius species possibly *americanus* Ashmead YNP, GTNP (new record)

Subfamily Rogadinae

Tribe Rhysipolini
Rhysipolis decorator (Haliday) YNP (Spencer and Whitfield 1999)
Rhysipolis platygaster Spencer YNP (Spencer and Whitfield 1999), GTNP (new record)
Rhysipolis stenodes Spencer GTNP (Spencer and Whitfield 1999)
Tribe Rogadini
Aleiodes near *perplexus* (Gahan) GTNP, YNP
Aleiodes near *scrutator* (Say) GTNP, YNP
Aleiodes unipunctator (Thunberg)
= *Aleiodes harrimani* (Ashmead) (new synonym) GTNP (Marsh & Shaw 2001)
Aleiodes coxalis species-group new species 1 GTNP

Aleiodes coxalis species-group new species 2 GTNP

Subfamily Opiinae

Diachasma probably *muleibre* (Muesebeck) GTNP (new record)
Opius blantonii Fischer GTNP (new record)
Opius cinctus Provancher GTNP (new record)
Opius dimidiatus (Ashmead) GTNP
Opius hartleyi Fischer GTNP (new record)
Opius hollisterensis Fischer GTNP (new record)
Opius kinleyensis Fischer GTNP (new record)
Opius rudis Wesmael GTNP (new record)

Subfamily Alysiinae

Tribe Dacnusiini

Chorebus species GTNP
Dacnusa species GTNP
Epimicta griffithsi Wharton GTNP (new record)
Exotela new species 1 GTNP
Exotela new species 2 GTNP
Tribe Alysiini
Alysia brachycera Thomson GTNP (new record)
Alysia brevissima Wharton GTNP (new record)
Alysia lucia Haliday YNP
Alysia micans (Viereck) GTNP (Wharton 1988)
Anisocyrta nearctica van Achterberg GTNP (new record)

Aphaereta species GTNP
Aspilota species 1 GTNP
Aspilota species 2 GTNP
Dapsilarthra species GTNP
Dinotrema species 1 GTNP
Dinotrema species 2 GTNP
Idiasta species YNP
Phaenocarpa species 1 GTNP
Phaenocarpa species 2 GTNP

Subfamily Ichneutinae

Ichneutes bicolor (Cresson) YNP (new record)
Proterops californicus Cresson YNP (new record)

Subfamily Homolobinae

Homolobus (Apatia) truncator (Say) GTNP (new record)

Subfamily Macrocentrinae

Macrocentrus species near *clypeatus* Muesebeck (new record)
Macrocentrus incompletus Muesebeck (new record)
Macrocentrus new species near *innuitorum* Walley (male only)

Subfamily Meteorinae

Zelet reticulatus (Muesebeck) GTNP (new record)
Meteor species near *angustipennis* Muesebeck GTNP (possible new species) (new record)

Meteorus species near *dimidiatus* Cresson GTNP (new record)

Meteorus species near *rubens* (Nees) GTNP (new record)

Subfamily Euphorinae

Centistes (*Syrrhizus*) *agilus* (Cresson) GTNP (new record)

Centistes (*Ancylocentris*) *laevis* (Cresson) GTNP (new record)

Euphoriella pacifica Muesebeck YNP (new record)

Falcosyntretus muesebecki Papp & Shaw GTNP (new record)

Microctonus species YNP

Myiocephalus boops Wesmael YNP, GTNP (new record)

Peristenus species GTNP (new record)

Subfamily Neoneurinae (new record)

Elasmosoma vigilans Cockerell GTNP (new record)

Elasmosoma new species near *pergandei* YNP (new record)

Neoneurus mantis Shaw GTNP (new record)

Neoneurus species near *masneri* Shaw GTNP (new record)

Subfamily Blacinae (new record)

Blacus (*Blacus*) *caduceus* van Achterberg YNP, GTNP (new record)

Subfamily Helconinae

Aliolus new species YNP, GTNP (new record)

Allodorus species probably *crassigaster* (Provancher) YNP (new record)

Diospilus species GTNP (new record)

Eubazus species YNP

Triaspis pissodis Viereck YNP, GTNP (new record)

Wroughtonia species probably *frigida* (Cresson)

Subfamily Agathidinae

Agathis tibiator (Provancher) (new record)

Bassus gibbosus Say (new record)

Bassus nigripes (Cresson) (new record)

Subfamily Orgilinae

Orgilus species near *conflictanae* Muesebeck YNP, GTNP (new record)

Orgilus grapholithae Muesebeck GTNP (new record)

Orgilus species near *medicaginis* Muesebeck YNP (new record)

Orgilus politus Muesebeck GTNP (new record)

Orgilus rostratus Muesebeck GTNP (Muesebeck 1970)

Orgilus strigosus Muesebeck YNP (new record)

Orgilus species near *utahensis* Muesebeck YNP (new record)

Subfamily Aphidiinae

Acanthocaudus species probably *schlingeri* (Muesebeck) GTNP (new record)

Aphidius species GTNP

Binodoxys species GTNP (new record)

Diaeretiella species YNP

Ephedrus species YNP, GTNP (new record)

Euaphidius species YNP

Monoctonus species YNP

Praon unicum Smith GTNP (new record)

Praon species YNP, GTNP

Subfamily Adeliinae (new record)

Adelius coloradensis Muesebeck GTNP (new record)

Subfamily Cheloninae

Ascogaster species near *borealis* Shaw GTNP (new record)

Chelonus (*Archichelonus*) *aculeatus* Ashmead YNP (new record)

Chelonus (*Chelonus*) *muesebecki* McComb YNP, GTNP (new record)

Chelonus (*Chelonus*) species YNP, GTNP (several species)

Chelonus (*Microchelonus*) *alius* McComb GTNP (new record)

Chelonus (*Microchelonus*) near *caulicola* McComb GTNP (new record)

Chelonus (*Microchelonus*) near *disjunctus* McComb GTNP (new record)

Chelonus (*Microchelonus*) species near *eucosmae* McComb GTNP (possible new species)

Chelonus (*Microchelonus*) *leptogaster* McComb YNP (McComb 1968)

Chelonus (*Microchelonus*) *marshi* McComb GTNP (new record)

Chelonus (*Microchelonus*) near *medicaginis* McComb GTNP (new record)

Chelonus (*Microchelonus*) *phthorimaeae* McComb GTNP (new record)

Chelonus (*Microchelonus*) species YNP, GTNP (several species)

Subfamily Microgastrinae

Apanteles aristoteliae Viereck GTNP (new record)

Apanteles species near *crassicornis* (Provancher) GTNP (new record)

Apanteles ensiger (Say) GTNP (new record)

Apanteles near *femurnigrum* Provancher GTNP (new record)

Apanteles fumiferanae Viereck GTNP (new record)

Apanteles species near *stigmatophorae* GTNP (new record)

Apanteles species GTNP, YNP

Cotesia species near *anisotae* (Muesebeck) GTNP (new record)

Cotesia species near *carduicola* (Packard) GTNP (new record)
Cotesia species near *clisiocampae* (Ashmead) GTNP (new record)
Cotesia species near *enypiae* (Mason) GTNP (new record)
Cotesia gillettei Baker GTNP
Cotesia glomerata (Linnaeus) GTNP (new record)
Cotesia griffini (Viereck) GTNP (new record)
Cotesia xylina (Say) GTNP (new record)
Cotesia yakutatensis (Ashmead) GTNP (new record)
Cotesia species GTNP, YNP
Dolichogenidea near *miantonomoi* Viereck GTNP (new record)
Diolcogaster fascetosa (Weed) GTNP, YNP
Glyptapanteles near *compressiventris* (Muesebeck) GTNP (new record)
Glyptapanteles species GTNP, YNP
Microgaster femoralamericanus Shenefelt YNP, GTNP (new record)
Microgaster species near *peroneae* Walley GTNP (new record)
Microplitis alaskensis Ashmead GTNP (new record)
Microplitis autographae Muesebeck GTNP (new record)
Microplitis laticinctus Muesebeck GTNP, YNP (new record)
Microplitis new species 1 GTNP
Microplitis new species 2 GTNP, YNP
Microplitis species 3 GTNP
Microplitis species 4 (near *laticinctus*) GTNP
Microplitis species 5 GTNP
Microplitis species 6 (dwarf males) YNP
Microplitis species YNP, GTNP
Pholetesor bedelliae (Viereck) GTNP (new record)
Sathon neomexicanus (Muesebeck) GTNP, YNP