MORPHOLOGY AND EVOLUTIONARY CHANGE OF MANDIBLES OF SELECT SPECIES WITHIN THE GENUS *THRAULODES* (LEPTOPHLEBIIDAE: EPHEMEROPTERA)

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Morphology and Evolutionary Change of Mandibles of Select Species within the genus *Thraulodes (Leptophlebiidae:* Ephemeroptera)

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Within the order Ephemeroptera, the relationship between morphology and food and niche specialization is poorly studied. In particular, mandibular morphology has not been well documented. Due to the absence of this data, the function of the mandibles has not yet been completely understood. These species have been found across North and Central America, and therefore inhabit many different niches. The purpose, or advantage, specific differentiations in morphology between the mandibular structures of this order to different niches is unknown. The purpose of this study is to gain a better understanding of how changes in the morphology of mandibles has resulted in feeding and niche specialization. If successful, function can be carefully inferred from the morphology data found.

CHAPTER I

INTRODUCTION

The most complete accounting of the taxonomy and morphology of the genus *Thraulodes* in North America has been previously studied by a small number of researchers. However, only very limited data has been published concerning the detailed morphology of mandibles in this genus, and no studies have been published discussing the details of feeding. However, some studies have been published concerning the feeding behavior of other species in the order Ephemeroptera.

McShaffrey and McCafferty (1986) studied the feeding behavior of *Stenacron interpuctatum*- (Ephemeroptera: Heptageniidae). They concluded that this species was an opportunistic gatherer based on the morphological structures of the mouthparts. *Siphlonisca aerodromia* is yet another studied species whose feeding habits have been well documented (Gibbs, 1986). McShaffrey and McCafferty compared *Rhithrogena pellucida* (Ephemeroptera: Heptageniidae) feeding behaviors and functional morphology to *Stenacron interpunctatum* but their study was limited due to the fact that there were few species compared and it had a more general focus of the overall mouthparts- not the mandibles alone. However, upon their comparisons, they found that stereotypic feeding behavior of larvae consists of cycles of the labial palps and specific stages of the entire mandibular apparatus (McShaffrey, 1988). The setale structures of the legs have also been documented to be an important part of fine particle-suspension feeding in the genus *Isonychia* (Ephemeroptera :Isonychiidae) (Wallace, 1979). Extensive research was done on the predatory mayfly, *Dolania americana*, specifically its feeding habits (Tsui, 1979). Predacious

mayflies are not common, therefore that study was important in proving the knowledge of predacious feeding within the Ephemeroptera.

There are three goals of this research project. First, to gain a better understanding of the morphological structure of mandibles within the genus *Thraulodes*. Second, relate morphology to feeding niche and behaviors. And third, to propose possible explanations for the evolution of the mandibles within the species studied.

CHAPTER II

METHODS

Extensive planning for the following procedures occurred. Completion of learning the correct terminology and anatomy of the mouthparts of the mayflies was an important factor in order to label the diagrams of the different species. Education of the use of a compound microscope had to occur. Faculty advisor, Dr. Baumgardner, alongside other researchers, had prepared slides of the individual species' mouthparts for past research and these were put into use throughout this experiment. The five species were first examined through files on the computer. The exact names of the species chosen to examine were *Thraulodes lunatus*, *Thraulodes zonalis*, *Thraulodes specious*, *Thraulodes gonzalesi*, and lastly, *Thraulodes brunneus*. Particular structures of the species of genus *Thraulodes* were located on the diagrams. The prostica, incisors, molar regions, denticles, and setae were labeled. Careful notes of significant details and differences between the different species mouthparts were recorded. These labeled parts were closely compared and inferences were made about their evolutionary change. The noteworthy differences, similarities, and significant details between the five different species were then looked at more closely and literature was found about those particular structures and their specific functions.

The following are photos of the species from a dorsal viewpoint of four of the species (Fig. 1).

Figure 1. Dorsal viewpoint of species. Thraulodes brunneus, Thraulodes gonzalesi, Thraulodes specious, and Thraulodes zonalis respectively.

CHAPTER III

RESULTS

The results of this experiment are still being examined. However, there did prove to be some major differences and similarities between species of the genus, *Thraulodes*. The details determined by examining morphology are important in order to infer the evolutionary change of the mandibles. The following contains terminology abbreviations contained in the following table, Table 1. Beneath Table 1 is a labeled mandible of *Thraulodes brunneus* (Fig. 2).

Table 1. Terminology. Definition of terms used during labeling.

omh	Outer mandible hairs
oi	Outer incisors
ii	Inner incisors
pr	Prostheca
mr	Molar region

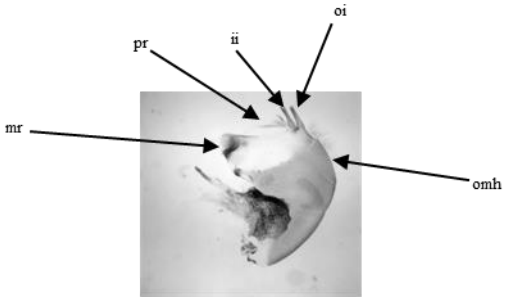

Fig. 2. *Thraulodes brunneus.* Labeled left mandible.

Thraulodes lunatus (Fig. 3): Left Mandible: omh>100 hairs, extending approximately to midline of mandible; oi=2 denticles; ii=2 denticles; pr consists of clump of elongate setae projecting medically with a few, short setae projecting anteriorly. Right Mandible: omh>100 hairs; oi=3 denticles; ii=3 denticles; pr consists of clump of elongate setae projecting medially.

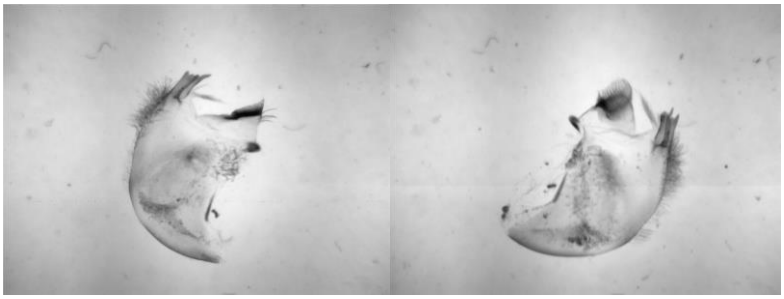

Fig. 3. A comparison of the right and left mandible, respectively, of *Thraulodes lunatus*.

Thraulodes zonalis, (Fig. 4): Left Mandible: omh <50 hairs; oi=3 denticles; ii=3 denticles; pr consists of clump of elongate setae projecting medially past later margin of molar region, and with a fan of smaller setae between main cluster of setae and ii; Right Mandible: omh<50 hairs in small clump; oi=3 denticles; ii=2 denticles; pr consists of clump of elongate setae projecting medially.

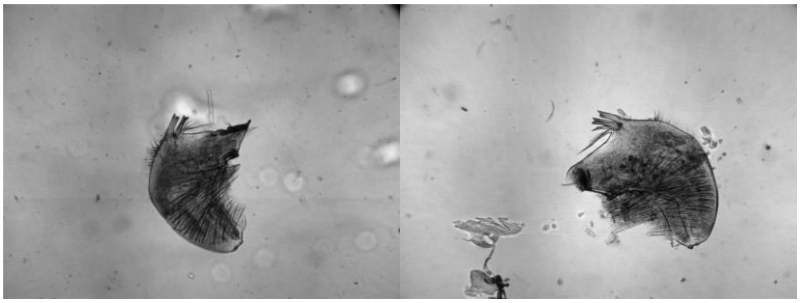

Fig.4.The respective right and left mandibles of *Thraulodes zonalis.*

Thraulodes specious (Fig. 5): Left Mandible: omh <100 hairs; oi=3 denticles; ii=2 denticles; pr consists of clump of elongate setae projecting medially well past later margin of molar region, and with a few, short setae projecting from clump of main setae. Right Mandible: omh>100 hairs in small clump; oi=2 denticles; ii=3 denticles; pr consists of clump of elongate setae projecting medially with a fan of small setae projecting in a fan-like pattern.

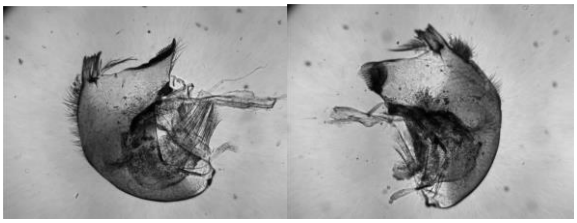

Fig. 5. The respective right and left mandibles of *Thraulodes specious.*

Thraulodes gonzalesi (Fig. 6): Left Mandible: omh>100 hairs; oi=2 denticles; ii=2 denticles; pr consists of clump of elongate setae projecting medically with a few, short setae projecting anteriorly. Right Mandible: omh>100 hairs; oi=2 denticles; ii=2 denticles; pr consists of clump of elongate setae projecting medially.

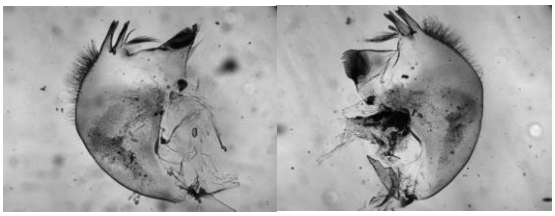

Fig. 6. The respective right and left mandibles of *Thraulodes gonzalesi.*

Thraulodes brunneus (Fig. 7): Left Mandible: omh>100 hairs; oi=3 denticles; ii=3 denticles; pr consists of clump of elongate setae projecting medically with a few, short setae projecting

anteriorly. Right Mandible: omh>100 hairs; oi=3 denticles; ii=2 denticles; pr consists of multiple setae of various lengths projecting medially and anteriorly.

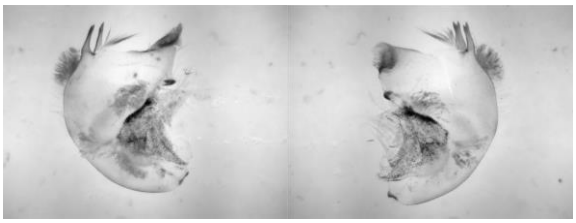

Fig. 7. The respective right and left mandibles of *Thraulodes brunneus.*

Although the differences between these structural components were minute, fluctuations in structure usually signify that the structure is not immensely essential to the species, especially for survival. However, the asymmetry of the right and left molar regions of each species did remain stagnant. The right mandible always had a triangular and sharp molar region, while the left side had a more rectangular and comb-like shape. Table 2 below displays the composed data from all of the left mandibles of each species, and Table 3 displays the right mandible data.

Table 2. Left Mandible Data. The prominent features of mandibles on the left side labeled in this data are organized into the chart above.

Left Mandibles	**pr**	**omh**	**ii**	**oi**
Thraulodes lunatus	pr consists of clump of elongate setae projecting medically with a few, short setae projecting anteriorly	omh>100 hairs, extending approximately to midline of mandible	ii=2 denticles	oi=2 denticles
Thraulodes zonalis	pr consists of clump of elongate setae projecting medially past later margin of molar region, and with a fan of smaller setae between main cluster of setae and ii	omh <50 hairs	ii=3 denticles	oi=3 denticles
Thraulodes specious	pr consists of clump of elongate setae projecting medially well past later margin of molar region, and with a few, short setae projecting from clump of main setae.	omh <100 hairs	ii=2 denticles	oi=3 denticles
Thraulodes gonzaesi	pr consists of clump of elongate setae projecting medically with a few, short setae projecting anteriorly	omh>100 hairs	ii=2 denticles	oi=2 denticles
Thraulodes brunneus	pr consists of clump of elongate setae projecting medically with a few, short setae projecting anteriorly	omh>100 hairs	ii=3 denticles	oi=3 denticles

Table 3. Right Mandible Data. The prominent features of mandibles on the right side organized into the chart above.

Right Mandibles	**pr**	**omh**	**ii**	**oi**
Thraulodes lunatus	pr consists of clump of elongate setae projecting medially	omh>100 hairs	ii=3 denticles	oi=3 denticles;
Thraulodes zonalis	pr consists of clump of elongate setae projecting medially.	omh<50 hairs in small clump;	ii=2 denticles	oi=3 denticles;
Thraulodes specious	pr consists of clump of elongate setae projecting medially with a fan of small setae projecting in a fan-like pattern.	omh>100 hairs in small clump;	ii=3 denticles	oi=2 denticles
Thraulodes gonzalesi	pr consists of clump of elongate setae projecting medially.	omh>100 hairs	ii=2 denticles	oi=2 denticles
Thraulodes brunneus	pr consists of multiple setae of various lengths projecting medially and anteriorly	omh>100 hairs	ii=2 denticles	oi=3 denticles

CHAPTER IV

CONCLUSION

In conclusion, mandibular structure is highly conserved, with very little variation among species. The order of the evolution of mouthparts is unknown for each species, but each species does in fact have minute differences mandibular characteristics evidently suited to best fit their niches. This initial study shows that there are small differences in the mandibular structure of the species studied, but exactly how those differences relate to niche specialization remains unknown. However, one of the main points of observation that was significant were the asymmetrical shapes produced by the between the right and left mandibles of each species, individually. The left mandible always seemed to possess a comb and rectangular- like shape and the right mandible always had a more triangular and sharp shape, which leads one to believe that each mandible has a specific function of the molar region best suited to their right and left sides. This asymmetrical feature is also found in shrimp. Future studies aimed at answering some of the structural morphology questions could focus upon the diet of the various species and laboratory studies of the function of living species using video recordings. The movements of the right and left sides could be the primary focus during recordings in order to figure out their different roles in feeding.

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