Progress in the study of sharpshooter leafhoppers (Hemiptera: Auchenorrhyncha: Cicadellidae) over 150 years: monographs, museums and individuals

Michael R. Wilson & James A. Turner

The progress in taxonomic knowledge of the sharpshooter leafhoppers (Hemiptera: Cicadellidae: Cicadellinae) over the past 150 years is described. The availability of taxonomic monographs of the group has allowed an attempt to make digital images of the world fauna and to progress towards a web-based taxonomy.

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Introduction
The leafhoppers comprise by far the largest family within the Hemiptera, with approximately 19,500 described species in over 40 subfamilies (Oman et al. 1990) of which the subfamily Cicadellinae comprises around 2,400 species in around 330 genera. The name “sharpshooter” for this group of xylem-feeding leafhoppers has increasingly been used especially in the USA. They are among the largest and most brightly coloured of the leafhoppers. Some species are important vectors of the xylem-limited bacterium Xylella fastidiosa, which affects both citrus trees in Brazil as well as grapevines in southern USA.

The Cicadellinae, as currently defined, was revised by David Young (1915–1991) in three remarkable volumes (Young 1968a, 1977a, 1986a). The publication of these works has enabled the evaluation and description of additional genera and species, primarily by researchers in Brazil and China. The availability of these taxonomic monographs and subsequent publications has made the Cicadellinae a relatively well-known group. In 2004 a project was started, funded by UK-based Leverhulme Trust, which has enabled a compilation of digital images of Cicadellinae. This paper is a brief review of the project in the context of the history of taxonomic work on this group of leafhoppers over the past 150 years.

Abbreviations for Institutions discussed in text
BMNH The Natural History Museum, London, UK
HNHM Hungarian Museum of Natural History, Budapest, Hungary
MMBC Brno, Czech Republic
MNHN Muséum National d’Histoire Naturelle, Paris, France
NCSU North Carolina State University Insect Collection, Raleigh, North Carolina, USA
NHRS Naturhistoriska riksmuseet, Stockholm, Sweden
NMW Naturhistorisches Museum Wien, Vienna, Austria
USNM National Museum of Natural History, [formerly, United States National Museum], Washington, DC, USA
ZMHB Museum für Naturkunde der Humboldt-Universität, Berlin, Germany

Taxonomic history

A short history of cicadelline study
Linnaeus (1758a) described four cicadelline species in the genus Cicada, which included many other Auchenorrhyncha species, such as treehoppers,
spittlebugs, planthoppers, and true cicadas. A first attempt to better define the genus *Cicada* was made by Fabricius (1794a), who transferred some Linnaean species of other Auchenorrhyncha and even some leafhoppers (such as *Jassus*) to other genera. Following this Germar (1833a) defined the genus *Tettigonia* Geoffroy (posteriorly emended to *Tettigonia* by Olivier, 1789a, but rejected by the International Commission of Zoological Nomenclature, see Hemming 1954, and currently used as synonymous to *Cicadella* Latreille, ICZN 1963a) using characters that will mostly define the subfamily *Cicadellinae* for following authors, such as the tumid frons and the ocelli positioned on the middle of the crown. Since Linnaeus (1758) about 2,790 species have been described in the tribes Cicadellini and Proconiini by around 60 authors. Of the described species, around 2,290 are currently accepted as valid.

Signoret (1853b,c, 1854a,b, 1855a,b,c,d) was the first to attempt to monograph the group as it was then understood. He published re-descriptions of a number of species (including those of Walker, with whom he was a contemporary) and described a large number of species, accompanied by colour illustrations (e.g. see Fig. 2). Although Signoret (1853) recognized that there were twelve generic names available, including *Dilobopterus* Signoret, 1850, which he erected himself, he treated all species in the large genus *Tettigonia*. He regretfully decided to abandon the previously established genera because he understood their diagnostic characters as part of a continuum, impossible to objectively break down, event though he did assemble *Tettigonia* species in five groups. Stål (1869) attempted to separate genera and described other new genera in the subfamily. His arrangement was mostly followed by Fowler in a series of papers (1894–1909) in the “*Biologia Centrali Americana*”. This volume was also accompanied by high quality colour illustrations. Fowler treated a number of genera that would all fall into the tribe Proconiini as presently defined. His remaining species were placed in *Tettigonia* and he covered 160 species (in what would be the tribe Cicadellini). Fowler (1899: 235) also states that: “It is possible that the genus may at some future time be divided, but it seems impossible to do this satisfactorily in the present stage of our knowledge”. As with most authors at this period, Fowler was relying on external characteristics, as did also Distant (1908, 1918) who also described many species from the Oriental region.

Melichar (1924a, 1925a, 1926a, 1932a, 1951a) made a substantial contribution in his monograph-published after his death in 1924. He divided the
Fig. 2. Reproduction of one of the Plates from the Signoret monograph. – 1, *Erythrogonia colorata* (Germar, 1821); 2, *Tettigonia* divisa Signoret, 1853; 3, *Tettisama quinquemaculata* (Germar, 1821); 4, *Erythrogonia areolata* (Signoret, 1853); 5, *Erythrogonia jucunda* (Walker, 1851); 6, *Erythrogonia quadriguttata* (Fabricius, 1787); 7, *Erythrogonia sexguttata* (Fabricius, 1803); 8, *Erythrogonia quadrapiagiata* (Walker, 1851); 9, *Trachyonionia germanii* (Signoret, 1853); 10, *Cardioscarta quadrifasciata* (Linnaeus, 1758); 11, *Agrosoma pulchella* (Guerin-Meneville, 1829); 12, *Agrosoma proxima* (Signoret, 1853); 13, *Agrosoma cruciata* (Signoret, 1853); 14, *Stehlikiana crassa* (Walker, 1851) = *walkeri* Signoret, 1853; 15, *Graphocephala multicolor* (Signoret, 1853); 16, *Tettigoniella cosmopolita* (Signoret, 1853).
subfamily into two sections: the Proconiaria with 54 genera and the Cicadellaria with 101 genera, which correspond more or less with the Cicadellini and Proconiini as treated subsequently by Young. The main problem with using Melichar’s classification is that the work is entirely without illustrations. While further species were described by other workers following Melichar, it was not until Young commenced his work in around 1952 that real progress was made, although the availability of the Metcalf’ catalogue to the “Tettigellinae” (1964) would have made progress easier. In the introduction to his monograph on Proconiini (Young 1968a) he states that the need for a generic revision became clear while working for the US Department of Agriculture. Cicadellinae specimens sent for identification could rarely be identified to genus on the basis of existing literature. Young followed previous authors (e.g., Oman 1949) by utilising characters of the male genitalia to delimiting genera (in addition to using female terminalia as specific diagnostic characters in 1977a and 1986a) and a move to the University of North Carolina provided more research time than available before. His monographic revisions of the group (Young 1968a, 1977a, 1986a) occupied him for the rest of his career, and has given a remarkable legacy from which all modern work has started. While Young’s intention was to provide a generic framework, he described many new species and also made synonyms based on his studies in European museums. He did not, however, provide a modern phylogenetic analysis of the relationships of the genera, and only gave schematic relationships among genera and groups of genera. The availability of the monographs has allowed a new generation of specialists, especially in Brazil and China, to describe many new species. Recently some re-analysis of generic and species relationships using phylogenetic analysis both morphological and molecular data and has been carried out in the tribe Proconiini (Takiya 2007). A new catalogue to the Cicadellinae has been produced (McKamey 2007) which will make the group further accessible.

Who described the species
As discussed above, around 60 individuals have described species in the Cicadellinae since Linnaeus (1758). The accumulation of species is shown (for valid species) in Fig. 1. But around 65% of the total currently valid species (2,300 species) have been described by just six individuals (indicated on the Figure). It is worth presenting their work in more detail.

Signoret, Victor Antoine (1816–1889) (Fig. 3)
Victor Signoret was born in Paris, France April 6 1816 and died in Paris on April 3 1889. Signoret was a qualified pharmacist and medical doctor and practised in Paris. He started his natural history studies with Coleoptera, but moved his interests to Hemiptera and published around 130 scientific papers mostly on Hemiptera. He was a founder of scale insect taxonomy and made slide preparations of specimens in order to study their morphology (Ben-Dov & Matile-Ferrero 1995). These authors also indicated that notebooks from his later studies were stored in the MNHN. These show Signoret to be a superb artist and his pencil sketches of Heteroptera (especially Cydnidae) and leafhoppers are quite remarkable. Among the major achievements of his studies on Auchenorrhyncha is the “Revue iconographique des Tettigonides”, published in the “Annales de la Société Entomologique de France” in parts between 1853–1855. The final part contains an index to species. Signoret reviewed the known sharpshooter species and described 246 species (of which 211 are presently considered valid). The highlight of the work
is the 19 beautifully illustrated colour plates of the dorsal view of 310 species (e.g. Fig. 2). It is interesting that, as noted by Young (1968a), the colour of the plates varies between different copies. All species were treated in the genus *Tettigonia* and Signoret indicated in the text the collection from which the specimens originated.

Upon his death in 1889, his collection of around 30,000 specimens was sold to the NMW. There were 3000 species of Auchenorrhyncha represented by 8,300 specimens and among these were many of the specimens used in the preparation of the monograph. The NMW collection was studied by Young in 1962–63 and he designated lectotypes for most species (Young & Beier, 1963a). Significant numbers of Signoret specimens are also found in the ZMHB.

**Walker, Francis (1808–1874)** (Fig. 4)

Francis Walker was born in Southgate, England on July 1 1809 and died at Wanstead, England October 5 1874. Walker was employed by the BMNH as a curator between 1844 and 1873. He described almost 20,000 new insect species, but, unfortunately, he was, sometimes a careless taxonomist, often describing the same species more than once under different specific names. The British Museum paid him one shilling for each new species and one pound for each new genus. He is best known for his catalogues of Orthoptera, Neuroptera, Homoptera, Diptera, Lepidoptera and Hymenoptera. Upon his death one (anonymous) obituary read: “More than twenty years too late for his scientific reputation, and after having done an amount of injury to entomology almost inconceivable in its immensity, Francis Walker has passed from among us.” Walker described 222 Cicadellinae species of which 138 are considered valid. Despite his generally poor taxonomic reputation, Carvalho & Webb (2005) describe in detail the labelling of Walker specimens, which has generally led to confident selection of type specimens of the species he described.

**Distant, William Lucas (1845–1922)** (Fig. 5)

William Distant was born in London on 12 November 1845 and died in London on 4 February 1922. He had a keen interest in natural history from an early age and he developed an interest in the taxonomy of the Coleoptera, Lepidoptera and Hymenoptera.
In his later life he concentrated almost completely on the Hemiptera and especially the Cicadidae. He was appointed as a part-time assistant at the BMNH, London in April 1899, where he worked on the arrangement of the Hemiptera for two or three days a week until ill health made it impossible for him to continue. He published the results of his studies at the Museum in a series of papers “Rhynchostral Notes” in the “Annals and Magazine of Natural History”. He also contributed to Volume 1 of the Homoptera of the *Biologia Centrali-Americana* and the Hemiptera volumes of the Fauna of British India. Distant published several hundred titles and many of them were divided into parts. His bibliography was compiled by Dolling (1991).

Distant described 147 cicadelline species (79 Old World and 68 New World) of which 104 species are currently accepted. The majority of the type material is deposited in the BMNH, London.

**Fowler, William W. (1849–1923)** (Figs 6, 9)

William Fowler was born in Gloucester, England in January 1849 and died in Reading on June 3, 1923. Canon Fowler’s father was a Vicar and after taking his degree at Oxford William Fowler was ordained a priest and eventually appointed as Canon in Lincoln Cathedral. He was drawn in his leisure time to the study of insects and especially Coleoptera and wrote “The Coleoptera of the British Islands” which appeared in five volumes between 1887 and 1891. Despite its age this book is still highly sought after for the study of Coleoptera in Britain. His interests were not confined to British entomology and he wrote the Hemiptera-Homoptera sections of the “*Biologia Centrali-Americana*”, which appeared between 1894–1909. This work also contains some beautiful coloured plates (e.g. Fig. 9) (which are available online at http://www.sil.si.edu/digitalcollections/bca/). He described 139 (113 valid) Cicadellinae species and the majority of these are housed in London, but some others are in Vienna (Wilson 2008). Young (1965c) selected and designated lectotypes of Fowler’s species in the course of preparation of his monographs.

**Melichar, Leopold (1856–1924)** (Fig. 7)

Leopold Melichar was born in Brno, Moravia, Czech Republic on December 5, 1856 and died in
Brno on September 2 1924. For most of his career Melichar was a medical doctor in Vienna. In 1912 he retired to Brno to allow more time to be spent on entomology. After his death his insect collection was passed to the MMBC where it is currently housed. Melichar was the first since Victor Signoret to attempt a monographic treatment of the Cicadellinae, but no part was published during his life. As well as his own collection, he also examined specimens from other European museums, especially from HNHM. His manuscript was sent to Dr Géza Horváth for publication in the Annales Musei Nationales Hungarici where four parts appeared between 1924 and 1932. However, in 1951, following questions about the completion of the series and the remaining manuscript, Dr Vilmos Székessy published a further part in Melichar’s name (Melichar 1951a). In these monographs, seventy-seven new cicadelline genera and approximately 200 taxa in the species-group were described. These species-group taxa include many “varieties”, which were correctly interpreted as available names of subspecific rank by Young. Unfortunately, the work was entirely without illustrations, characters were based solely on external morphology, and the majority of his new genera, although validly published according to the nomenclatural rules of the International Commission of Zoological Nomenclature (ICZN 1999), lacked formal descriptions and type designations. China (1927d) dealt with preoccupied generic names from Melichar (1926a) and later (in 1938d) designated type species for several of Melichar’s genera based on the remaining unpublished manuscript.

During his European study visit in 1962–63 David Young spent some weeks in Brno and fully examined the Melichar collection and subsequently designated lectotypes for Melichar species deposited in the MMBC (Young & Lauterer 1966a). Further Melichar lectotype designations were made by Lauterer & Schroder (1970). Young also worked extensively on the specimens and the Cicadellinae collection is now fully re-curated by Pavel Lauterer and is the best represented after Raleigh, London and Washington. A visit to HNHM, Budapest in 2006 enabled MRW to study the cicadelline collection and inventory the Melichar species in that museum (Wilson & Takiya 2007).

Young, David Allan (1915–1991) (Fig. 8)

David Young was born May 26 1915, Wilkinsburg, Pennsylvania, USA and died June 8 1991, Kentucky. He studied entomology at Cornell University and received his M.S. in 1942. Following war service, he took an instructorship in the Department of Biology at the University of Louisville until 1948, after which he entered the University of Kansas to study for his Ph.D., awarded in 1950, under the direction of R. H. Beamer. From 1950 to 1957 he worked at the USNM employed by the US Department of Agriculture. In 1957, Young accepted a position as an associate professor at North Carolina State University, where he continued his systematic research on leafhoppers (begun with Beamer) and administered the NCSU Insect Collection. Young (1957) published a synopsis of the U.S. species of Homalodisca (Proconiini) and, after his promotion to Professor in 1961, spent the academic year in Europe (1962–1963) visiting a number of European museums where the large majority of species, which had been described by European workers were deposited. This visit enabled Young to study most of the types of Cicadellinae described by European workers and the taxonomic and nomenclatorial research became the basis of the three monographs he produced on the group (Young 1968a, 1977a & 1986a).
of this was available to Young during his year-long visit. Young published a series of papers designating lectotypes based on these studies: Stockholm, Sweden (mostly Stål species) (Young 1963a); Berlin, Germany (Young 1964a); Eberswalde, Germany (Breddin species) (Young 1965a); London, U.K. (Walker, Distant and Fowler species) (Young 1965c); Copenhagen, Denmark and Kiel, Germany (Fabricius species) (Young 1965d); Dresden, Germany (Jacobi species) (Young & Lauterer, 1964a); Brno, Czech Republic (Melichar species) (Young & Lauterer 1966a); Warsaw, Poland (Schmidt species) (Young & Nast 1963a); Budapest, Hungary (Young & Soós 1964a); Paris, France (Young 1974). The political situation in parts of Europe made it difficult or impossible to visit certain museums. There were a number of cicadelline species (around 150 species) that Young either failed to place in a genus (especially unique female types) or failed to locate during his studies. He listed these at the end of each of the monographs (Young 1977a, 1986a) as genera and species of uncertain position.

The format of Young’s monographs was established in the 1968 study of the tribe Proconini. In general lectotype designations had been made prior to publication, but frequently, taxonomic notes on these were given in the monographs. Unfortunately, for reason of time constraints, Young did not list museums where he examined specimens of previously described species, or provide detailed descriptions, but did usually figure the characters of the male genitalia (often of a lectotype or topotype). Full details and descriptions were only provided for new species. A list of species with synonyms and country records is given for each genus. Effectively each genus discussed is a partial revision and in some cases it is now clear that further work is necessary to provide a full revision. Among all three monographs, Young described 738 species (734 currently valid) among 169 genera.

Interactions between workers
The major workers have all followed and built on each other’s work in the 150 years since the publication of the first part of Signoret’s monograph. He had synthesised the earlier accounts in the group, but few other workers were specialised in leafhoppers. There is evidence that Signoret had been in contact with Walker and indeed examined some of his specimens during a visit to London. Both Signoret and Walker had died before Melichar commenced his monographic treatment. Fowler and Distant were contemporaries, but cryptic remarks in the introduction to the *Biologia Centrali-Americana* suggest little collaboration. There is little evidence that there was any contact between these authors and Melichar. After Melichar’s death in 1924, there was a gap of almost 35 years before David Young started his work on these insects. Signoret, Melichar, and Young all intended a monographic treatment but Young described many more species than the other workers combined. This was mostly, of course, because he was the first to use the male genitalia structures in the Cicadellinae in any detail. He was also able to both examine most of the type material and accumulate large collections for study. Signoret and Melichar were both medical doctors but their remarkable entomological outputs would impress many “professionals”. Walker was, of course, a generalist who described species in many groups. Distant and Fowler worked on other groups as well as Hemiptera. Young was the only one of the 6 who concentrated almost exclusively on the Cicadellinae and was a professional taxonomist (and one who trained others by supervising undergraduate and graduate studies).

Where are the species deposited?
The accumulation of specimens in any one museum is a result of geography, history, staff, and collectors. Despite the majority of species being found in the tropics of almost all of the world, Cicadellinae species described until the 1950’s had been by European workers. Much of this material had been deposited in major museums in central and northern Europe. During the study visit made by David Young in 1962–63 much of this was examined, lectotypes were designated, and he also loaned large numbers of unidentified specimens. As discussed above, Young did not give the details of the museums from where he studied specimens of the existing species. During the current imaging project (see below) we have accumulated information on over 30 institutions, which house significant collections in this group. On completion of his monographs the specimens were returned to their original museums, but several representatives were retained for deposition in the NCSU collection, Raleigh. As a result, Raleigh has the largest number of species represented, followed closely by the BMNH, London and the USNM, Washington, D. C. Each of these institutions has around 50% of the world fauna represented. The BMNH is notable for both the number of Cicadellinae species and of historic types (Walker, Distant, and Fowler).

Other large museums have between 350 (NMW, HNHM) and 560 (NHRS) species but are very important because of the number of historic types present. The Bishop Museum, Honolulu has 75% of
the species known from New Guinea (110 species: almost all endemic), although representatives are found in London (36%) and in Raleigh (51%). Table 2 gives information on the numbers of cicadelline species described by the 6 main authors and their presence in each of the 5 main collections. Perhaps not surprisingly the majority of species are found in the “home” Institute (or place where the collection is deposited) of the author. This effect is especially seen in Fowler and Distant species, which are overwhelmingly represented in the BMNH, London. This may also be an effect of their working on a regional fauna. It is less obvious among Signoret species, perhaps because he was an early pioneer whose species are likely to be among the more commonly encountered and also because he described on a world basis. The NCSU, Raleigh also has the largest percentage of species described by David Young, although compared to other authors, Young species are represented in a lower percentage (see Table 2). Young did retain some representatives in NCSU when he described species, but he also studied specimens from many other institutions. Additionally, Young described many species based on a single specimen and he did deposit all his primary types in the USNM.

Interestingly only around 20 cicadelline species are found in all of the ten largest collections. Even the top seven contain only 86 species, but this number rises to 170 in the largest five institutions, and to 281 in the top four. The overlap in the three largest institutions for this group is, however, considerable, and 468 species are found in all of these, and between NCSU and BMNH, 694 species are found in common. Naturally, in common with most insects, the majority of cicadelline species are known only from the type material, with 282 species found only in the largest five collections (with BMNH having 120 of these). Most institutions have numerous species unique to them.

The current project
The current project to image Cicadellinae species on a world basis arose by having seen a large collection of unidentified sharpshooters in Quito, Ecuador. Many of these could be identified to genus and to species if access to a good collection and the monographs by Young, were possible. Neither of these were available in Ecuador. Another approach was to accumulate images of species that might be placed on a website or in a modern monographic treatment, which would nevertheless be based on the work of David Young and subsequent studies. It was this approach that resulted in a successful application for funding by The Leverhulme Trust in 2004. The intention was to take images that would provide a web-accessible information source, as well as volumes of images that would reflect the three monographs by Young.

Methods
Each photograph was made using JVC KY70 3CCD camera on a Leica microscope MZ8 and Synoptics Automontage software. This software allows for a number of images (we usually used around 20) each at a slightly different focus to be “montaged” to provide an image with an enhanced depth of field. Images were saved both as TIFF files and as JPG (for use in the database). Each TIFF image was around 4MB in size. A special chamber (designed by James Turner, who made almost all of the images) was used diffusing the lighting in order to reduce shadows and highlights created by intense fibre optic light.

Whenever possible, specimens were selected that had been card pointed so that no pin had been used. Where pins had been used for mounting they were “removed” using Adobe Photoshop, as were the legs, so that each specimen was consistent. Minor damage to specimens was also “repaired” using Photoshop. However, there would be no doubt as to which specimen has been illustrated, because information as to the museum where the specimen is stored is given with the image. All images were managed in the relational database FilemakerPro v.8.5, comprising taxonomic, image and depository databases. Images are given a unique reference number, which has been attached to the imaged specimen as a label. Museums from which imaged specimens have been loaned will be provided with a spreadsheet with this information and copies of the images.

Choice of specimens
Some have assumed that during this project type material would be imaged as a priority. But many historic type specimens are in relatively poor condition and unsuitable to provide good quality images. Given that David Young examined many of these type specimens the selection of specimens to photograph was initially based on the quality of available specimens identified by him in the course of his work. Following the publication of the monographs other specialists have identified some species. Many species, assumed to be those that are more common and widespread, are to be found in a number of museums and there was plenty of choice of suitable specimens. Many species are known from only small numbers of specimens in the type series located in a limited range of museums. In practice, each museum visited or contacted during the course of this
Fig. 9. Reproduction of a plate from Fowler, Biologia Centrali-Americana.
Fig. 10. Selection of images from current project. – 1, *Agrosoma proxima* (Signoret, 1853); 2, *Agrosoma pulchella* (Guérin-Méneville, 1829); 3, *Cardiosculta quadrifasciata* (Linnaeus); 4, *Erythrogonia areolata* (Signoret, 1853); 5, *Erythrogonia colorata* (Germar, 1821); 6, *Erythrogonia jucunda* (Walker, 1851); 7, *Erythrogonia quadriplagiata* Walker, 1851; 8, *Tettisama quinquemaculata* (Germar, 1821); 9, *Graphocephala multicolor* (Signoret); 10, *Stehlikiana crassa* (Walker, 1851); 11, *Tettigoniella cosmopolita* (Signoret, 1853); 12, *’Tettigonia’ divisa* Signoret, 1853; 13, *Oncometopia (Similitopia) alpha* (Fowler, 1899); 14, *Phera lacerta* Fowler, 1899; 15, *Oncometopia undata* (Fabricius, 1794).
work enabled a new range of species to be added to the database. Also, Young described 745 species so the specimens he utilised in the description of each species may be regarded as authoritative.

Time constraints did not allow us to take more than the dorsal view of each species. However, for the Proconiini a lateral view was also taken because the lateral view head shape is often diagnostic. A view of the face would also have been very useful for species recognition in some genera. A number of specimens were imaged if sexual dimorphism, colour, or pattern variation was noted during study.

**Project Outcomes**

During the two years of the Leverhulme project around 5,000 images have been taken and 90% of the world Cicadellinae fauna represented at species level (e.g Fig. 10). Over 95% of genera have been imaged. A website has been completed, based on the FileMakerPro database. Three volumes of images will be produced as an illustrated checklist (based on McKamey 2007), with the first being a volume on Old World Cicadellini (2007 in prep.). In this volume, for ease of use, the species have been divided into sections relating to geographical regions in the Old World. There is little overlap between species. The section “Species of uncertain position” reflects Young’s list at the end of his 1977 and 1986 monographs. One unexpected and satisfying outcome of the project and especially of having been able to visit a number of important European museums, was being able to locate types of around 30 species that Young failed to see during his studies.

**The Future**

Since the compilation of Young’s monographs, there has been a rapid acceleration of taxonomic work being published on the group, especially by workers in Brazil and China. Most of these works involve descriptions of new species and small revisions. A morphological character and molecular analysis on the tribe Proconiini has been carried out (Takiya 2007), from which the morphological part has generated an online interactive key to the genera and taxonomic database including geographical, host-plant, images, and literature data (http://ctap.inhs.uiuc.edu/takiya). It is anticipated that the availability of Young’s monographs, the new taxonomic catalogue (McKamey 2007), and online accessible interactive identification tools, such as interactive keys and images resulting from this project, will enhance the rate of further revisionary work in this group.

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**Table 1. Number of species in five largest Cicadellinae collections.**

<table>
<thead>
<tr>
<th>Institute</th>
<th>Total No. species (%)</th>
<th>No. &amp; % Old World species</th>
<th>No. &amp; % New World species</th>
<th>No of ‘uniques’</th>
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<tbody>
<tr>
<td>NCSU, Raleigh</td>
<td>1121 (49)</td>
<td>228 (36)</td>
<td>893 (54)</td>
<td>18</td>
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<tr>
<td>BMNH, London</td>
<td>1030 (45)</td>
<td>286 (44)</td>
<td>744 (45)</td>
<td>120</td>
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<td>USNM, Washington</td>
<td>954 (42)</td>
<td>149 (23)</td>
<td>805 (49)</td>
<td>55</td>
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<td>MMBC, Brno</td>
<td>715 (32)</td>
<td>126 (20)</td>
<td>589 (35)</td>
<td>43</td>
</tr>
<tr>
<td>NHRS, Stockholm</td>
<td>563 (28)</td>
<td>99 (15)</td>
<td>464 (28)</td>
<td>30</td>
</tr>
</tbody>
</table>

**Table 2. Number of species (and % of total) from each of main authors in the five largest Cicadellinae collections.**

<table>
<thead>
<tr>
<th>Author</th>
<th>NCSU, Raleigh</th>
<th>BMNH, London</th>
<th>USNM, Washington</th>
<th>MMBC, Brno</th>
<th>NHRS, Stockholm</th>
<th>NMW, Vienna</th>
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<td>Signoret</td>
<td>115 (55)</td>
<td>109 (52)</td>
<td>93 (44)</td>
<td>97 (46)</td>
<td>103 (49)</td>
<td>146 (70)</td>
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<tr>
<td>Walker</td>
<td>74 (54)</td>
<td>123 (90)</td>
<td>52 (38)</td>
<td>58 (42)</td>
<td>57 (41)</td>
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<tr>
<td>Fowler</td>
<td>72 (64)</td>
<td>107 (95)</td>
<td>58 (51)</td>
<td>35 (31)</td>
<td>21 (19)</td>
<td>-</td>
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<tr>
<td>Distant</td>
<td>51 (49)</td>
<td>100 (96)</td>
<td>30 (29)</td>
<td>41 (39)</td>
<td>31 (30)</td>
<td>-</td>
</tr>
<tr>
<td>Melichar</td>
<td>64 (39)</td>
<td>39 (24)</td>
<td>62 (38)</td>
<td>131 (79)</td>
<td>39 (24)</td>
<td>55 (33)</td>
</tr>
<tr>
<td>Young</td>
<td>425 (57)</td>
<td>261 (35)</td>
<td>383 (51)</td>
<td>141 (19)</td>
<td>148 (20)</td>
<td>-</td>
</tr>
</tbody>
</table>
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References

Citation of references follows that given by Metcalf (1964: Bibliography of the Cicadelloidea) and in McKamey 2007.


Agriculture Research Service 730 pp.
Olivier G.A., 1789a Hémiptères, section 1. – Encyclopédie méthodique histoire naturelle insectes. 4: 1–331.
Stål, C., 1869. Hemiptera Fabriciana 2 – Svenska Vetensk Akad Handl. 8(1) 231–300.

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