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A tentative revision of the genus Cylloceria Schiødte, 1838 (Hymenoptera; Ichneumonidae)

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A tentative revision of the genus *Cylloceria* Schiødte, 1838 (Hymenoptera; Ichneumonidae)

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In memory of Erika Lindgren

Photo: *C. impolita* (Dasch 1992) London Natural History Museum. The scale bar is 2.5 mm long in total

Abstract

The Hymenoptera family Ichneumonidae is yet to be fully known and understood, we still expect that there are new species to be discovered in this family. *Cylloceria*, a genus within Ichneumonidae, is a genus with a lot of species names both synonymous and currently in use. How sure can we be that those species actually are different enough to be considered true species? In this study a part of the determined collection at the NHM in London was examined morphologically with focus on four known species (*C. borealis* (Roman, 1925), *C.caligata* (Gravenhorst, 1829), *C. melancholica* (Gravenhorst, 1820) and *C.sylvestris* (Gravenhorst 1829)) and one assumed to be a new species, to see if specimens of the five focus species are most similar within the species or if they are closer to specimens determined to other species. The other species present at the NHM of London (*C. alvaradoi* (Gauld

1991), *C. arizonica* (Dasch 1992), *C. aquilonia* (Dasch 1992), *C. barbouraki* (Gauld 1991), *C. imperspicua* (Rossem 1987), *C. impolita* (Dasch 1992), *C. striatula* (Dasch 1992), *C. trishae* (Gauld 1991) and *C. ugaldevi* (Gauld 1991)) were used as outgroups which made it possible to see if the five species keeps together in their species. In total 31 specimens of 15 species were examined using morphological characters.

The data of collection sites and collection times of the specimens investigated morphologically enabled me to conclude approximately when and where both the five focus species and the genus *Cylloceria* are flying during the year. The five focus species flies from around May to September where only the species *C. melancholica* might have two generations. *Cylloceria* as a whole were found to have one generation from in April to July and one second flight period in November to January in South Mexico and Costa Rica, specimens collected north of there had only one generation in May to September.

A cluster analysis was made based on eight of the morphological characters, the ones that were categorical excluding the ambiguous and constant characters. None of the five focus species formed species unique clusters but grouped with specimens from other species in the tree, although *C. borealis* was much more separated according to species than the rest. The result of the morphological analysis shows that there are much more to be done to get a clear definition of the five focus species including whether or not the possibly new species actually is a new species. I would believe that a future study with a genetic analysis in combination with morphological characters to know definitely which specimens that belongs to the same species, followed by a study of type specimens so that the found species gets the correct species name could make the uncertainties in the genera (*Cylloceria*) almost disappear. If the morphological characters analysed are later used to find out which characters that should be used in future morphological species determination then all current questions regarding the genus taxonomy will be solved.

Introduction

A large part of the animals on our planet is still believed to be unknown, there are still many species left to be discovered (Mora et. al 2011). Estimations on how many species of insects there are diverge a lot, from around three to five million to more than 30 million (Gaston 1991: May 1992). The parasitic wasp family Ichneumonidae is a big family (Barahoei et. al. 2012), a family estimated to include 60,464 species of which 4,023 were known from the Western Palearctic in 1969 (Townes 1969). Quickle (2012) wanted to conclude weather the general body size within the family increases towards the equator, he came to the conclusion that it is impossible to say because the relatively big species near the equator might be the only ones discovered from there in contrast to the more thoroughly investigated Europe. So there are things left to be learnt about Ichneumonidae. New discoveries in the family Ichneumonidae are made within both Europe and Asia regarding new species, new hosts and new ranges for species (Fritzén 2014: Karlsson & Magnusson 2011: Lotfalizadeh et. al. 2009).

One of the genera in the Ichneumonidae family is the genus *Cylloceria*, it is a genus with many species names (about 27 valid ones) and several that are synonymous (synonymous species names are names that are considered to regard species that have another species name

that is currently in use, each species name ever used is also linked to a species description); 24 synonymous (ITIS & species 2000, 2015). *Cylloceria* was first described as a new genus in 1838 by Schiødte, the second time as *Chalinocerus* in 1852 by Ratzeburg (NHM London 2015; Musebeck et al. 1951) and a final time as *Asphragis* in 1869 by Förster (NHM London 2015). The genus is recognized by that the first flagellomere is very long compared to the rest of the flagellomeres (Humala 2002). The male antenna has tyloids (depressions) on the third and fourth flagellomere (Dash 1992). The females have a small notch close to the tip of their ovipositor (Gauld 1991). Neither males nor females have yellow or white clypeus in contrast to another genus *Allomacrus*; Forster 1869 in the same subfamily (Dash 1992).

Townes (1971) had trouble placing the genus *Cylloceria* in a subfamily when he created a taxonomic guide down to genera within the family Ichneumonidae, the genus didn't seem to fit anywhere. So it ended up in the subfamily Microleptinae which Townes anticipated would have to be adjusted in the future. *Cylloceria* was in later moved into the subfamily Cylloceriinae based on their larvae structures by Wahl (1986) in Humala (2012). The genus *Cylloceria* is still in the subfamily Cylloceriinae (SLU 2015).

There are a lot of species names in *Cylloceria* (ITIS & species 2000 2015: Yu 2015) (See appendix table 1), which are living in many parts of the world (Gahari et al. 2010; Gauld 1991; Humala 2002; Humala 2012; Humala & Reshchikov 2014). When three keys over the genus were compared (Rossem 1987, Dash 1992 and Humala 2002) they together contained 20 different species names but only 2 of the species names (*C. borealis* (Roman 1925) and *C. melancholica* (Gravenhorst 1820)) occurred in all of them. Together Rossem (1987) and Humala (2002) have eight species in common perhaps as a result of having almost the same geographical area in focus.

Almost all synonymous species names within the genus *Cylloceria* belongs to the species *C. melancholica*; 22 names (ITIS & species 2000 2015). *Cylloceria caligata* (Gravenhorst, 1829) is one of those synonymous according to both IT IS & species 2000 (2015) and Dasch (1992), the NHM in London on the other hand has more than 20 determined specimens of it and both Humala (2002) and Rossem (1987) consider it to be a valid species. Could there be other species hidden among the synonymous names, species that actually should be valid? A clarification regarding how species within the *Cylloceria* can be separated would be useful. Calle et al. (2002) used a cluster analysis based on morphological characters which created a dendrogram which helped to understand the relationship between five species of the genus Anopheles (mosquitos known to spread malaria), a similar method involving a dendrogram could also be usable for specimens within *Cylloceria.*

The first of the two aims of this study is to help clarify the different species (using The National History Museum in London's collection of *Cylloceria*) focusing on five species of *Cylloceria* which are known to Europe; (*Cylloceria borealis* (Roman 1925), *Cylloceria caligata* (Gravenhorst 1829), *Cylloceria melancholica* (Gravenhorst 1820), *Cylloceria sylvestris* (Gravenhorst, 1829) and one group of unidentified specimens in the collection. A group of specimens that didn't fit into any species description of valid species although they were similar enough to arise the Senior Curator (Dr. Broad) beliefs that they belong to the

same species, maybe a new species (from here on referred to as *C. new?*). Those five focus species (included *C. new?*) will be examined using four specimens (two males and two females) each except *C. caligata* where some of the specimens have different in colouration therefore five specimens of *C. caligata* will be examined to include one of the odd colouration. One specimen of all the other species in the collection will be examined to create context in which it will be possible to interpret the five focus species. The clarification will be done using a cluster analysis based on morphological characters, similar to Calle et al. (2002), Nielsen et al. (1995), Sakamoto (1984) and the same analysis method as Enaberue1 et al. (2014) applied to genetic data.

There is not much knowledge when it comes to the ecology of *Cylloceria*. I could only find that Larvae of Tipulidae are the only credible recorded hosts for *Cylloceria* (Humala 2002 and that "at moderate latitudes, members of this genus apparently produce 1 generation and usually fly in July" (Humala 2002). The process of reaching the first aim requires specimens and specimens of insects in a museum collection are often tagged with a time and location of capture, this data can be used to get a better understanding about when and where different species are flying. The second aim is to use capturing data from the museum specimens used for the first aim in order to find out when time of flight is for the five focus species groups and also for the genus as a whole.

Materials and methods

The terminology used regarding body parts of the specimens follows the definitions of the Hymenoptera Anatomy Consortium (2015), simplified explanations can also be found in appendix, table 2.

In total 31 specimens in the collection were examined one specimen of all species in the collection were examined the five focus species was examined using four specimens (two males and two females) except *C. caligata* were five specimens were used. Because the species *C. caligata* should have orange or red coxa (Humala 2002: Rossem 1987) although a few specimens determined to *C. caligata* in the collection have dark coxa therefore one of the specimens with dark coxa was included to see how similar it is to the rest. Only specimens with land of origin and approximate collection time were chosen for examination, no type specimens were available.

All species in the collection were investigated using at least one specimen during the period between the 25th of March and the 24th of April 2015. Species with determined representatives in the collection at the time were:
C. alvaradoi (Gauld 1991), *C. arizonica* (Dasch 1992), *C. aquilonia* (Dasch 1992), *C. barbouraki* (Gauld 1991), *C. borealis* (Roman 1925), *C. caligata* (Gravenhorst 1829), *C. imperspicua* (Rossem 1987), *C. impolita* (Dasch 1992), *C. melancholica* (Gravenhorst 1820), *C. striatula* (Dasch 1992), *C. sylvestris* (Gravenhorst 1829)., *C. trishae* (Gauld 1991), *C. ugaldevi* (Gauld 1991).

I used characters from the keys of Rossem (1987), Gauld (1991), Dasch (1992) and Humala (2002) to investigate on each specimen. In the end all but a few characters, added by Dr. Broad and me, came from those keys. The checklist grew to include more than 60 characters which all were applied on the 31 specimens, the appearance of each body part referred to by the characters were noted in a spreadsheet. During the process each new specimen examined got an individual number starting at 1 and reaching up to 31 as more and more specimens were examined (see appendix table 3 for a list of all examined specimens and their origin). These numbers will also end up in the tree as a mean of identification. The *C. caligata* with dark coxa became number 20.

Those characters that differed amongst the specimens and the ones that didn't risk being misunderstood and interpreted differently from one specimen to the next were meant to be used in the analysis-program. The program of choice was Mesquite (Madison & Madison 2015) in which it turned out to be hard to include categorical and continuous data in the same analysis. Therefore eight remaining categorical characters (appendix table 4) were used to construct a tree (a dendrogram) via a cluster analysis. Some characters seemed to be more important than others according to the keys, but it was only two gender specific characters that stood out and both of them were used to separate *C. borealis* from other species. I made those characters into one character (by giving them the same number no matter if they had the female character for the species or the male one) for the cluster analysis to avoid that different genders ending up on different places in the tree. I chose not to value any character higher than others to avoid that a character graded as more important would reduce the importance of an unknown but equally important character.

Settings for the cluster analysis were chosen in an effort to be the simplest possible so that the choices wouldn't affect the structure of the tree. These settings were: That the distance used in the cluster analysis should be based on the matrix of the eight characters and the 31 specimens investigated. The distance should be calculated from the differences in characters and not on some sort of constructed tree. Single linkage became the method of clustering, this means that the most similar members of two groups is the only difference between the groups that program sees. I also chose to let the program do 100 repetitions amongst which the best tree would be found.

Finally the five focus species and *Cylloceria* as a whole was investigated for the possibility of several generations in one year in relation to area of occurrence.

Results

Morphological relationships

None of the five focus species (including *C. new?)* ended up in a totally separated branch with all examined specimens as seen in the dendrogram (Figure 1). The species closest to it is *C. borealis* which have three of four specimens in a separate clade, specimen number 2 *C. borealis* on the other hand is most similar to *C. barbouraki*.

Three out of for specimens of *C. new?* ends up in a group were both *C. aquilonia* and *C. imperspicua* is closer to the males of the species than the third specimen of *C. new?* is. The last member of the suspected new species seems totally isolated, it is closest to the stem with no closer connection to any other specimen.

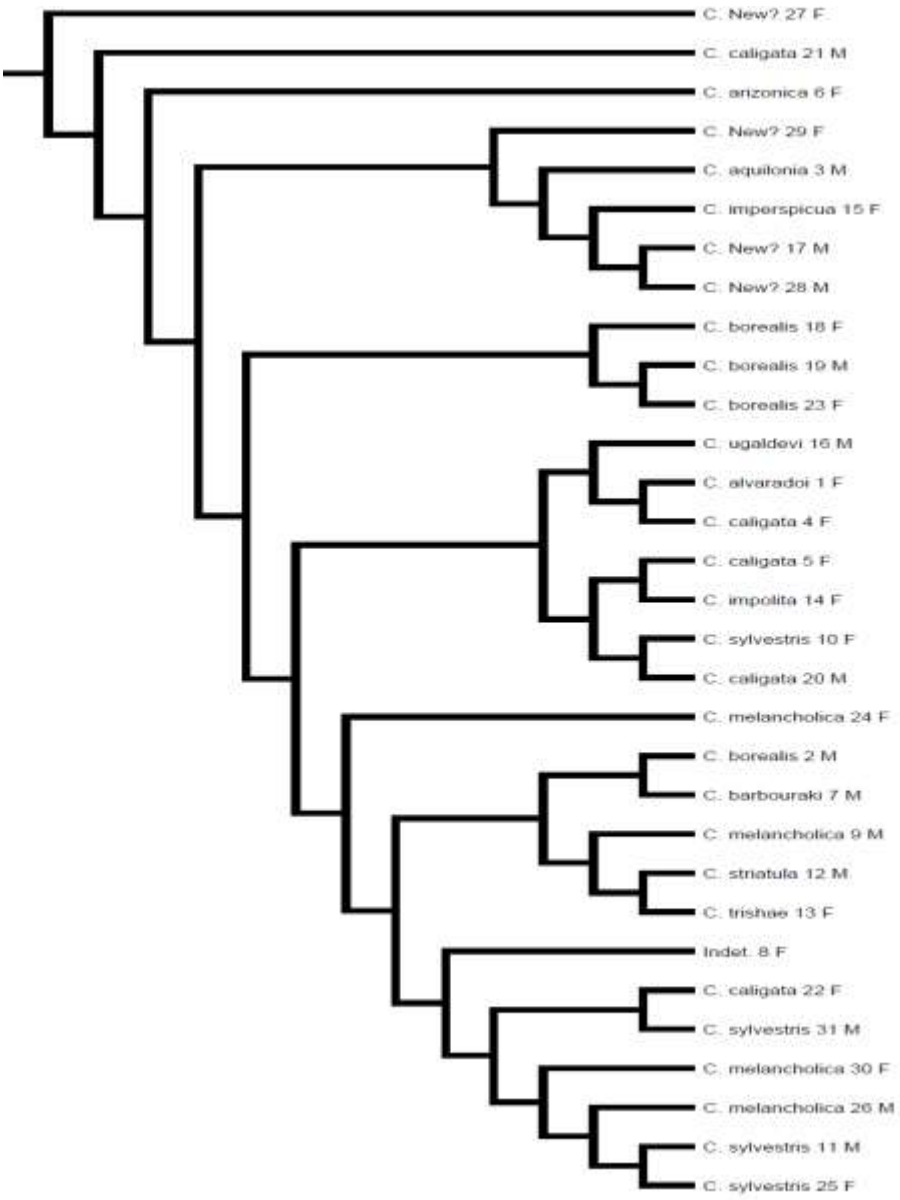

Figure 1: Phylogenetic tree based on eight morphological characters (appendix table 4). The numbers corresponds to the order they were examined starting from 1, they are also used to avoid that 2 specimens has the same name. The letters M and F marks the gender (Male and Female).

Two of the specimens of *C. sylvestris* ended up most similar to each other (male and female). The two other specimens ended up separated in the tree, both were closest to two specimens of *C. caligata*. *C. caligata* is the species that seems to occur most random in the tree, they are all over it. Although three of them gathers together in the same clade a clade that also includes *C. ugaldevi*, *C. alvaradoi*, *C. impolita* and *C. sylvestris* number 10.

The members of *C. melancholica* have one group of two individuals that are closer to one another than the rest, that group also includes the closest individuals of *C. sylvestris*. The rest of them are scattered over half the tree.

In summary my eight characters do not separate the species fully and the best separated species is *C.borealis* none of the others ended up in a similar clade.

Time of flight and distribution

The genus *Cylloceria* was caught from the end of May to the beginning of August in North Western Europe (Finland, Sweden, Netherlands, Switzerland, Austria, England) and one specimen from England was caught in September. *Cylloceria* from the northern parts of Canada and northern USA were collected during July and the beginning of August. Specimens from more southern parts of the world (the south part of USA, Mexico and Costa Rica) shows a similar pattern of flight in April – July but this pattern also includes an additional time of occurrence some were between November and January (Table 5 appendix).

When the flight time for the five focus species (*C. borealis*, *C. caligata*, *C. melancholica*, *C. new?* and *C. sylvestris*) was investigated for several generations during one year, most of them had date of capture some time in every month between the first and the last date of capture (see appendix table 6.). Only *C. melancholica* had a gap of more than a month between captures, a gap of 67 days. *C. melancholica* is the only one of the species (*C. caligata*, *C. sylvestris*, *C. melancholica* and *C. new?*) that possibly has two generations. All 4 specimens of *C. borealis* were caught within a two day period in July.

Discussion

Morphological relationships

Most of the specimens of *C. borealis* ends up in a separate clade which indicates that borealis is a well-defined group even when the character used to separate them from other species isn't valued higher than other characters.

The aim to help clarify the species within *Cylloceria* proved to be difficult. More and different analyses likely based on both genetics and morphological characters are needed to reach the goal of a future without unidentifiable specimens within *Cylloceria*.

My experience both regarding how the different characters varies and how to see structures on dried specimens increased during the examination of the 31 specimens which means that specimens in the beginning might have been judged slightly different compared to the final ones.

The small spatial and temporal difference between the specimens of *C.borealis*, all specimens were caught on the same place within a 2 day period, could also contribute to their similarity. It makes it more probable that they are from the same population and might therefore not be as different as specimens from different populations. Further research should be made using specimens of borealis from different locations and times.

The only specimen of *C. borealis* that didn't end up in the same clade was specimen number 2 instead it turned out to be most similar to *C. barbouraki*. There is no comparison of them within the same key because the key where Gauld (1991) first described the species does not include the species *C. borealis* and none of the other keys used (Dasch 1992: Humala 2002 and Rossem 1987) contains *C. barbouraki*. Different persons tend to view the specimens a bit differently and therefore also describe them differently, although there are two species specific characters (a tooth like edge of one of the male tyloids or a female clava) which are frequently used in keys to distinguish *C.borealis* from other species of C*ylloceria* and neither of those were mentioned in the species description of *C. barbouraki* (Gauld 1991). It's therefore possible that my inexperience in seeing structures during the examination of specimen number 2 (*C. borealis*) made it more similar to the according to the species description rather smooth structured *C. barbouraki* than it actually was. It also seems improbable that *C. barbouraki* and *C. borealis* individual number 2 is be the same species considering the spatial difference between Costa Rica (collection site for *C. barbouraki*) and Southern Finland (collection site for all studied *C. borealis*). If we also consider the height (3 000 m) at which the *C. barbouraki* specimen were captured then the habitats/niches might not be that different after all at least regarding the temperature. In general most of *C. borealis* keep together in the tree, this suggests that *C. borealis* actually is a well-defined species. It is interesting to note that the only male in the separated *C. borealis* clade is closest to one of the 2 females in the tree not the other female. So gender specific differences, except the one countered by making two characters into one, amongst the characters that we used are either none existent in the case of *C. borealis* or not significant enough to give a separation due to gender in the tree. On the contrary *C. new?* is the only species that might have gender specific differences which affects the characters used in this study because the males cluster so close to each other while the most similar female was less similar to the males than *aquilonia* and *C. imperspicua*. There are several characters which differ between the 2 males and the 2 females including the colouration of metasoma. Characters that separate the two females are less obvious and the big distinction between them in the tree might be a result of how some of the characters with only a nuance difference were grouped into different categories, possibly creating a bigger difference than there actually should be. A future analysis able to use both continuous and categorical data should be able to use such characters without that risk.

C. melancholica seems to be scattered all over the tree with the most similar ones equally similar to *C. sylvestris*, so maybe C. melancholica is a group of many species as the grand list of synonymous species names suggests. Type specimen- and DNA studies might show that only parts of the group fits as *C. melancholica*, maybe some of the synonyms actually deserve to be valid species.

C. caligata is also spread over the tree, there could be that the effort to try to cover all different types of *C.caligata* actually proved to work or maybe some of them aren't actually *C. caligata*. All of them, except specimen 21 and 22, are a part of the same clade. One explanation to this is that *C. caligata* 21 has brown coxa instead of orange, which the species is supposed to have, so it could be that it actually should belong to a different species.

Specimen 22 on the other hand does not appear to differ much from the others except on the structure of pronotum where it has wrinkles, so does specimen 21 but on different places, in contrast to the 3 more collected specimens which has some punctuations at most. Maybe the texture of pronotum actually is a useful character for *C.caligata*.

C.sylvestris is more gathered than both *C. melancholica* and *C. caligata* because 2 of the 4 specimens are closest to each other. But also here 2 specimens are far from together with the rest, both of them are ranked closest to different specimens of *C. caligata*. Which is interesting considering that it's not the *C. caligata* species with brown coxa and none of *C. sylvestris* has orange coxa so maybe another difference between the 2 species is missing in the analysis or maybe the colour of coxa will prove unimportant in future DNA-studies combined with character analysis and the od specimens of both *C.sylvestris* and *C. caligata* actually is a separate species.

It is possible that the difference between how well separated specimens of *C. borealis* was compared to the other species is an effect of the few number of characters used. The 2 species specific characters for *C. borealis* happened to be 2 of the easiest categorical characters to understand and see, there was no insecurity about how the specimens should be interpreted in relation to those 2 characters. Some of the other characters were sometimes more of a judgement call therefore clear and obvious species specific characters might be more efficient at separating their specific species from the rest compared to more inconclusive characters. There is also a risk that some of the species specific characters were lost when only categorical characters were analysed. This could explain why most of the species, except *C. borealis*, were so mixed with specimens from other species.

Time of flight and distribution

Cylloceria seems to be flying once a year from the end of May to the beginning of August and possibly a bit into September in North Western Europe. North Western Europe could be the same as Humala (2002) was referring to as "moderate latitudes" in that case the time of flight can evidently be much longer than just in July. There is a possibility that the time of flight is temperature dependent, the time they need to develop might differ as it does for several other species of parasitic wasps (Bahar, Soroka and Dosdall 2012 : Hance et al. 2007). Therefore might vary between years and also through time as a result of the global warming

The data of occurrence is not precise enough to conclude if they fly in different bursts during the summer months in Europe or if they have just one very long adult phase over all those months. But the data is detailed enough to conclude that *Cylloceria* flies at least one time in Europe and North America to North East USA during May-September and that they probably have two times of flight in more southern countries (Southern USA, Mexico and Costa Rica) one around April – July and one in November- January when at least some adults fly in November. The rain-season in Costa Rica and South Mexico ends around November (FrommerMedia 2015: Go visit Costa Rica 2015) so maybe that's why they start to fly then when there are moisture enough but not a constant rainfall.
A bigger data set with more exact dates of capture and more individuals from each species could provide information about when each species fly and where.

Everything points towards one generation for *C. caligata*, *C. sylvestris* and *C. new?*. *C. melancholica* is the only species that might have two generations. Maybe this difference in time of capture is just a result of chance. The chance that the specimen that was caught during that empty period is in the collection but just wasn't picked or that such a specimen exists somewhere but hasn't made it to the collection.
It could also be a result of their big difference in the year they were caught. Changes in weather could affect when individuals of *C. melancholica* becomes mature as the difference in climate between two locations in Japan affects the life cycle of the Ichneumonidae *Zatypota albicoxa* (Takasuka and Tanaka 2013). Much could have happened in 74 years, that's the difference between the 2nd youngest specimen and the youngest one.

Future studies in search for good species characters would be easier if access to a group of specimens already determined to species through DNA-analysis or aided by it. The specimens could then be studied morphologically, where many characters would be examined, and finally several analyses could be conducted to conclude which characters which results in clades that agrees with their species identity. A future DNA-study of the specimens of the genus *Cylloceria* in the Natural History Museum of London might prove difficult as older specimens generate shorter sequences (Strutzenberger et al. 2012) how the specimens were killed could also affect the DNA samples (Dillon et al. 1996).

Conclusion

If you are not used to see and find structures on dry specimens it might take some specimens before the judgement of those characters can be considered comparable to later assessed specimens.

C. borealis seems to be more easily defined both in keys and according to the dendrogram than the other species investigated here. It's probably a well-defined species, in no need of dividing.

There are many speculations to be drawn from this study but the genus of *Cylloceria* really needs more morphological research because it can actually make things clearer as it did in the study by Ohl and Spahn (2009) who used 76 characters in their analysis instead of eight to explain the relations within the wasp family Ampulicidae.

I would believe that a future study with a genetic analysis in combination with morphological characters to know definitely which specimens that belongs to the same species, followed by a study of type specimens so that the found species gets the correct species name could make the uncertainties in the genera (*Cylloceria*) almost disappear similar to what Novkovic´ et al. (2011) did excluding their hybridisation tests. If the morphological characters analysed are later used to find out which characters that should be used in future morphological species determination then all current questions regarding the genus taxonomy will be solved.

All and all the whole *Cylloceria* seems to have one grownup generation during the summer months (May-September) in the more northern parts of the world and one additional one in

more southern parts (South Mexico and Costa Rica) of the world in the winter months (November- January).

All species with more than one examined specimen have a flight period during the summer months (May - September) the only one of those with possibly 2 generations during this time is *C. melancholica*.

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References

Bahar Md. H., Soroka J. J., and Dosdall L. M. 2012. *Constant Versus Fluctuating Temperatures in the Interactions between Plutella xylostella (Lepidoptera: Plutellidae) and Its Larval Parasitoid Diadegma insulare (Hymenoptera: Ichneumonidae).* Environmental Entomology, 41(6):1653-1661. 2012. (Accessed 26th August 2015)

Barahoei H., Rakhshani E. and Riedel M. 2012. *A checklist of Ichneumonidae (Hymenoptera: Ichneumonoidea) from Iran.* Iranian Journal of Animal Biosystematics Vol.8, No.2, 83-132 (Accessed: 19th August 2015) [Available at: http://ijab.um.ac.ir/index.php/biosys/article/view/25582/4388]

Calle D. A. L., Quiñones M. L., Erazo H. F., Jaramillo N. O. 2002. *Morphometric Discrimination of Females of Five Species of Anopheles of the Subgenus Nyssorhynchus from Southern and Northwest Colombia.* Mem. Inst. Oswaldo Cruz vol.97 no.8 Rio de Janeiro Dec. 2002 (Accessed 25th August 2015)

Dasch, C. 1992. *The Ichneumon-flies of America north of Mexico: Part 12. Subfamilies Microleptinae, Helictinae, Cylloceriinae and Oxytorinae (Hymenoptera: Ichneumonidae).*Memoirs of the American Entomological Institute, 52: 1–470.

Dillon N., Austin A. D. and Bartowsky E., 1996. *Comparison of preservation techniques for DNA extraction from hymenopterous insects.* Insect molecular biology (1996) 5(1), 21-24 (Accessed 14th July 2015)

Enaberue1 L. O., Obisesan I.O., Okolo E.C., Akinwale R.O., Aisueni N. O. and Ataga C. D. 2014. *Genetic Diversity of Shea Butter Tree (Vitellaria paradoxa C.F. Gaernt) in the Guinea Savanna of Nigeria Based on Morphological Markers.* American-Eurasian J. Agric. & Environ. Sci., 14 (7): 615-623

Fritzén N. R. 2014. *Two new species of the Polysphincta genus-group (Hymenoptera: Ichneumonidae: Pimplinae) reared from their spider (Araneae) hosts in Europe*. Zootaxa 3894 (1): 117–130 (Accessed: 6th March 2015)

FrommerMedia 2015. *When to go.* [Available at: www.frommers.com/destinations/mexico] (Accessed 26th August 2015)

Gahari H., Jussila R., Kolarov J., Sedivy J., 2010. *A contribution to the Ichneumon wasps (Hymenoptera: Ichneumonidae) from the forests of northern Iran.* Munis Entomology & Zoology vol. 5 no. 1 2010. (Accessed 17th August 2015)

Gaston, K. J., 1991. *The Magnitude of Global Insect Species Richness.* Conservation Biology Volume 5, No. 3. (accessed 30th June 2015) (Available through: http://izt.ciens.ucv.ve/ecologia/Archivos/ECOLOGIA_DE%20_POBLACIONES_Hasta%202004/ECOL_POBLAC_Hasta%202004_(A-G)/Gaston%201991.pdf)

Gibson J. P., 2015. *Mesquite tutorial* (Available at: http://www.ou.edu/gibsonlab/Tree_Thinking → tree thinking modules & lab exercises → Mesquite users guide) [Accessed 29th June 2015]

Go visit Costa Rica. 2015. *Costa Rica Weather*.[Available at: www.GoVisitCostaRica.com] (Accessed 26th August 2015)

Hance T., van Baaren J., Vernon P. and Boivin G. 2007. *Impact of Extreme Temperatures on Parasitoids in a Climate Change Perspective*. The Annual Review of Entomology 2007. 52:107–26 (Accessed 26th August 2015)

Humala, A.E. 2002. *A Review of Parasitic Wasps of the Genera Cylloceria Schiodte, 1838 and Allomacrus Förster, 1868 (Hymenoptera, Ichneumonidae) of the Fauna of Russia.* Entomological Review, Vol. 82, No. 3 (Accessed 6 th February 2015)

Humala, A.E. 2012. *Contribution to the knowledge of the genus Cylloceria (Hymenoptera: Ichneumonidae: Cylloceriinae) in Central America with description of a new species from Mexico*. Zoosystematica Rossica, 21(1): 163-168 (Accesssed 24th January 2015)

Humala, A.E., Reshchikov, A. 2014. *Ichneumonidae (Hymenoptera) species new to the fauna of Norway*. Biodiversity Data Journal 2: e1047. doi: 10.3897/BDJ.2.e1047

Hymenoptera Anatomy Consortium. Accessed on Tue Aug 18 01:05:54 -0500 2015. Available at http://glossary.hymao.org.

ITIS & Species 2000. 2015. *Catalogue of life 2015.* Search "Cylloceria" [Available at: http://www.catalogueoflife.org/annual-checklist/2015] (Accessed 6th July 2015).

Karlsson D. and Magnusson P. 2011. *Brachycyrtinae (Hymenoptera: Ichneumonidae), ny underfamilj brokparasitsteklar för Sverige*. Entomologisk Tidskrift 132(1): 51-54. Uppsala, Sweden 2011. ISSN 0013-886x. (Accessed: 7th March 2015)

Lotfalizadeh H., Ezzati-Tabrizi R. and Masnadi-Yazdinejad A. 2009. *Diplolepis fructuum (Rübsaamen) (Hym.: Cynipidae) a new host for Exeristes roborator (Fabricius) (Hym.: Ichneumonidae) in Iran*. Vol. 3, No.2, Pp.: 171-173 (Accessed 19th August 2015) [Available at: ReaserchGate]

Maddison, W. P. and D.R. Maddison. 2015. *Mesquite: a modular system for evolutionary analysis.* Version 3.03 http://mesquiteproject.org .

May R. M., 1992 *How many species inhabit the earth?* Scientific American October 1992 (18- 24) (Accessed 25th August 2015)

Mora C., Tittensor D. P., Adl S., Simpson A. G. B., Worm B. 2011. *How Many Species Are There on Earth and in the Ocean?* Plos Biology 9(8): e1001127. (Accessed the 4th June 2015).

Musebeck C. F. W., Krombein K.V., Townes H. K. (Eds.), 1951. *Monograph no. 2, U. S. Dept. of Agricultur.* Washington, U.S. Govt. Print. Off., 1951. (Accessed 7th July 2015) [Available at: http://catalog.hathitrust.org/Record/001500514/Home]

National History Museum: London. 2015. *Cylloceria* (Accessed the 3rd June 3, 2015) [Available at: http://www.nhm.ac.uk/research-curation/scientific-resources/biodiversity/uk-biodiversity/uk-species/species/cylloceria.html]

Nielsen P., Fritze D. and Priest F. G., 1995. *Phenetic diversity of alkaliphilic Bacillus strains: proposal for nine new species.* Microbiology (1995), 141, 1745-1761 (Accessed 25th August 2015)

Novkovic´ B., Mitsui H., Suwito A and Kimura M. T. 2011. *Taxonomy and phylogeny of Leptopilina species (Hymenoptera: Cynipoidea: Figitidae) attacking frugivorous drosophilid flies in Japan, with description of three new speciesens.* Entomological Science (2011) 14, 333–346 (Accessed 26th August 2015).

Ohl M. and Spahn P. 2009. A cladistics analysis of the cockroach wasps based on morphological data (Hymenoptera: Ampulicidae). Cladistics 26 (2010) 49-61. (Accessed 26th August)

Rossem G. van .1987. *A Revision of Western Palaearctic Oxytorine Genera. Part VI. Genera: Hemiphanes; Oxytorus; Apoclima; Cylloceria (new revision); Proclitus; Pantisarthrus; Plectiscidea; Gnathochorisis; Eusterin (new revision); Helictes; Phosphoriana (nomen novum); Proeliator and Megastylus (Hymenoptera, Ichneumonidae).* Tijdschrift voor Entomologie, 130: 49–108. (Accessed 27th February 2015)

Sakamoto K., 1984. *Interrelationships of the family Pleuronectidae (Pisces: Pleuronectiformes).* Memoirs of the faculty of Fisheries Hokkaido University, 31(1-2): 95-215

SLU /Dyntaxa. 2015. Taxonomisk databas - search “Cylloceria”. [Available at: www.dyntaxa.se] (Accessed: 17 July 2015)

Strutzenberger P., Brehm G., Fiedler K., 2012. *DNA Barcode Sequencing from Old Type Specimens as a Tool in Taxonomy: A Case Study in the Diverse Genus Eois (Lepidoptera: Geometridae)*. PLoS ONE 7(11): e49710. doi:10.1371/journal.pone.0049710 (Accessed 14th July 2015)

Takasuka K. and Tanaka K. 2013. *Seasonal Life Cycle of Zatypota albicoxa (Hymenoptera: Ichneumonidae), an Ectoparasitoid of Parasteatoda tepidariorum (Araneae: Theridiidae), in Southwestern Japan*. Pacific Science (2013), vol. 67, no. 1:105 – 111 (Accessed 26th August 2015)

Townes H**. 1969.** *The Genera of Ichneumonidae. Part 1.* Memoirs of the American Entomological Institute, no. 11

Townes H**. 1971.** *The Genera of Ichneumonidae. Part 4.* Memoirs of the American Entomological Institute, 17: 1-372.

Quickle D. L. J., 2012, *We Know Too Little about Parasitoid Wasp Distributions to Draw Any Conclusions about Latitudinal Trends in Species Richness, Body Size and Biology*. PLoS ONE 7(2): e32101. [Available at: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0032101] (Accessed 8 July 2015)

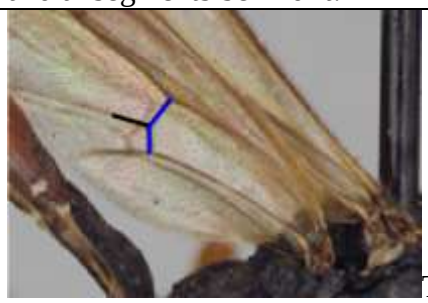
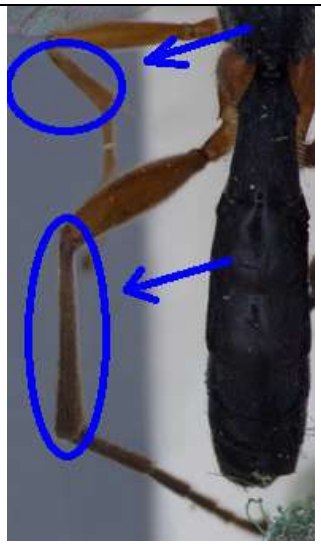
Yu D. S.,2015. *Hymenoptera – Ichneumonoidea including Megalyroidea & Stephanoidea.* Search "Cylloceria". [Available at: http://www.ichneumonoidea.name/ → Global index] (Accessed 7th July 2015).

Appendix

Table 1: Species in the genera *Cylloceria*, synonymous species names and known occurrence of these species (ITIS & Species 2000, 2015: Yu, 2015).

Species	Occurence	Synonyms
Cylloceria aino (Uchida, 1928)	China, Japan, Russia (near Japan)	
Cylloceria alpigena (Strobl, 1902)	Austria, France, Poland	
Cylloceria alvaradoi (Gauld, 1991)	Costa Rica	
Cylloceria aquilonia (Dash, 1992)	Canada, USA (Alaska).	
Cylloceria arizonica (Dash, 1992)	Mexico, USA; Arizona & New Mexico	
Cylloceria barbouraki (Gauld, 1991)	Costa Rica	
Cylloceria borealis (Roman, 1925)	Canada, USA; Alaska & Colorado, Finland, Lithuania, Norway, Romania, Russia, Sweden	*Cylloceria nodosa* (Walley, 1941) *Lampronota borealis* (Roman, 1925)
Cylloceria brachycera (Humala, 2002)	Russia; Russia-Chita Oblast	
Cylloceria calva (Dash, 1992)	Canada; Canada-Northwest Territories	
Cylloceria fusciventris (Hellen, 1940)	Finland, Norway, Poland, Russia	
Cylloceria imperspicua (Rossem, 1987)	Poland, Sweden	
Cylloceria impolita (Dash, 1992)	Canada-Ontario, North eastern USA.	
Cylloceria invicta (Rossem, 1987)	Kazakhstan, Russia	
Cylloceria melancholica (Gravenhorst 1820)	Austria, Azerbaijan, Belarus, Belgium, Bulgaria, Canada; Canada-Alberta, North eastern China, Czech Republic, Czechoslovakia, Denmark, Estonia, France, Finland, Georgia, Germany, Hungary, Iran, Ireland, Italy, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Mongolia, Netherlands, Norway, Poland, Romania, Russia, Serbia & Montenegro, Spain, Sweden, Switzerland, Turkey, USA, Ukraine, United Kingdom, Yugoslavia	*Cylloceria aciculata* (Cameron 1905), *Cylloceria affinis* (Zetterstedt, 1838), *Cylloceria altior* (Heinrich, 1953), *Cylloceria atra* (Ruthe, 1855), *Cylloceria caligata* (Gravenhorst, 1829), *Cylloceria crenicornis* (Curtis, 1832), *Cylloceria defectiva* (Gravenhorst, 1829), *Cylloceria denticornis* (Haliday, 1838), *Cylloceria errans* (Dalla Torre, 1901), *Cylloceria fracticornis* (Haliday, 1838), *Cylloceria fuscolina* (Davis, 1898), *Cylloceria longicornis* (Ratzeburg, 1852), *Cylloceria lugubris* (Cresson, 1879), *Cylloceria manca* (Ruthe, 1855), *Cylloceria marginator* (Schiodte, 1838), *Cylloceria marginatrix* (Schulz, 1906), *Cylloceria nigra* (Gravenhorst, 1829), *Cylloceria nuntiator* (Zetterstedt, 1838), *Cylloceria occidentalis* (Cresson, 1870), *Cylloceria rugulosa* (Haupt, 1917), *Cylloceria sexcarinata* (Davis, 1895), *Cylloceria sexlineata* (Say, 1829)
Cylloceria mexicana (Kasparyan & Ruiz-Cancino, 2003)	Mexico	
Cylloceria occupator (Gravenhorst, 1829)	Austria, Belgium, Finland, France, Germany, Poland, Romania	*Cylloceria langei* (Lange, 1898), *Cylloceria occupatrix* (Shulz, 1906)
Cylloceria orientalis (Humala, 2002)	Russia; Russia-Primor'ye Kray; Russia-Sakhalin Oblast	
Cylloceria rubrica (Dash, 1992)	USA: Arizona	
Cylloceria simplicornis (Strobl, 1901)	Austria	
Cylloceria striatula (Dash, 1992)	Canada, USA.	
Cylloceria sylvestris (Gravenhorst, 1829)	Finland, Kazakhstan, Latvia, Lithuania, Norway, Poland, Russia, Sweden, United Kingdom	*Cylloceria striolata* (Hellen, 1915)
Cylloceria tenuicornis (Humala 2002)	Finland, Russia	
Cylloceria tincochacae (Viereck 1913)	Peru	
Cylloceria tipulivora (Chao 1994)	China-Guizhou	
Cylloceria trishae (Gauld 1991)	Costa Rica	
Cylloceria ugaldevi (Gauld 1991)	Costa Rica	
Cylloceria ussuriensis (Humala 2002)	Eastern China, Eastern Russia (near Japan)	

Table 2: Lexicon of morphological terms. If the word regarding the morphology of the genus *Cylloceria* isn't explained here for some reason, go to the Hymenoptera Anatomy Ontology Portal.

Clava	The thicker last or 2nd last segment/-s on the antenna.
Clypeus	An area just over the mouth that often projects a bit compared to other places on the face
Coxa	The hipp, the part of the leg closest to the middle body.
Face	The area between the middle ocellus and the mouthparts.
Flagellomere	All antennal segments excluding the 2 closest to the head.
Mesopleuron	There is a plate over each pair of legs on each side, this is the plate over the middle pair of legs.
Metasoma	The hind body, the part that includes the waist (also called petiole) and al segments behind it.
Nervellus	 The blue on the picture of a *Cylloceria* hindwing is the nervellus (as it's intended in this article). The black line is the wing vein that interrupts the nervellus on different places depending on the specimen.
Ocellus	A type of eye that is much smaller than a compound eye and is typically located on top of the head quite close to the neck.
Ovipositor	Egg laying tube which females use to lay their eggs inside their hoast.
Pronotum	The shield just behind the head, this also goes down on both sides of the neck.
Tibia	 The part of the insect leg surrounded by blue circles in the picture.

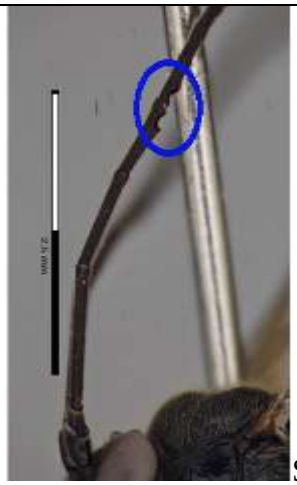
Tyloid	 Semicircular indentation on the male antenna, they have two on each antenna.

Table 3. Specimens used and origin.

C. alvaradoi 1 Female	Costa Rica (Sn José PvZurqui de Moravia) 1 600 m
C. aquilonia 3 Male	Canada (Muskox)
C. arizonica 6 Female	USA (Arizona)
C. barbouraki 7 Male	Costa Rica 3 000 m
C. borealis 2 Male	Finland (Aitolahti)
*C. borealis*18 Female	Finland (Aitolahti)
C. borealis 19 Male	Finland (Aitolahti)
C. borealis 23 Female	Finland (Aitolahti)
C. caligata 4 Female	Mexico (Omilteme Guererro) 2 500 m
C.caligata 5 Female	USA (Mich Ann Arbor)
C. caligata 20 Male	England
C. caligata 21 Male	Sweden (Skåne)
C. caligata 22 Female	England
C. imperspicua 15 Female	Austria (Tirol)
C. impolita 14 Female	USA (Main Dryden)
In determined (indet.) 8 Female	Netherlands
C. melancholica 9 Male	England
C. melancholica 24 Female	Sweden (Skåne)
C. melancholica 26 Male	Sweden (Skåne)
C. melancholica 30 Female	Switzerland (Grindelwald)
*C. new?*17 Male	Austria (Triol)
C. new? 27 Female	Netherlands
C. new? 28 Male	Sweden (Skåne)
C. new? 29 Female	United Kingdom (Berkshire May)
C. striatula 12 Male	Canada (Tuktoyaktuk)
C. sylvestris 10 Female	Netherlands
C. sylvestris 11 Male	England
C. sylvestris 25 Female	France (Puy-de-Dôme)
C. sylvestris 31 Male	England
C. trishae 13 Female	Costa Rica (Cartago Pv. Carro de la muerte) 3 000 m
C. ugaldevi 16 Male	Costa Rica (Sn José Pv Zurqui de Moravia) 1 600 m

Table 4. The 8 characters used in the cluster analysis.

- Where is nervellus intercepted by a wing vein?
- The colour of the metasoma.
- Dark (brown or black) or orange coxa.
- Hind tibia darker than fore and middle tibia or not
- The colour of the flagellar segments closest to the head
- Males with or without prominent tooth on the base of the first tyloid? Combined with: Females with or without wider last flagellar segment compared to the other flagellar segments on the same specimen.
- The structure of pronotum
- The structure of mesopleuron

Table 5. Time of capture of adult *Cylloceria*. The roman numbers corresponds to the number of the month.

Location	When found grownups	month
Finland, south border	27. vi. 1933	June
Finland, south border	26. vi. 1933	June
Sweden, most southern part	19. vi. 1938	June
Sweden, most southern part	3. vii. 1938	July
Sweden, most southern part	31. vii. 1938	July
England	24 v 2012	May
England	26. v. - 7. vi. 1976	May- June
England	vi. 1994	June
England	viii. 1980	August
England	ix. 1980	September
Netherlands	28. v. - 11. vi 1976	May- June
Netherlands	25. vi.- 9. vii. (19?)76	June- July
Netherlands	9-16. vii. 1976	July
Austria	vii. 1981	July
Austria	20. vii. - 5. viii. 1975	July-August
Switzerland	viii. 1973	August
France, middle and a bit into the south part	24. vi. - 6. viii. 1934	June- Aug
North western edge of Canada	22-28. vii. 1971	July
Northern part of Canada	4.viii. 1953	August
North east part USA	vii. 1976	July
North east part USA	15. vii. 1959	July
South west part of USA, border to Mexico	30.xi. 1967	November
South west part of Mexico	vii. 1904	July
Costa Rica	iv. 1989	April

Costa Rica	vi-vii. 1994	June- July
Costa Rica	xi-xii.1988 1989	Nov -Dec
Costa Rica	xi- 1988- i. 1989	Nov- Jan

Table 6. Time of capture of the individuals in the investigated species were more than one specimen were used.

C. caligata Mexico: Omilteme guererro vii. 1904
C. caligata USA: Michigan vii. 1976
C. caligata Sweden 3.vii.1938
C. caligata England viii.1980
C. caligata England ix.1980
Caught from July to September, probably just one generation
C. melancholica England 24.v. 2012
C. melancholica Sweden 31.vii.1938
C. melancholica Sweden 31.vii.1938
C. melancholica Switzerland viii.1937
Caught in May July and August not in June but that's just a month that could have been missed due to lots of human reasons other than that they have two generations.
C. new? UK. v.1986
C. new? Sweden 19.vi.1938
C. new? Netherlands 25.vi-9.vii.19?76
C. new? Austria vii.1981
Caught from May to July and the month in between, no indication of two generations.
C. borealis Finland 27.vi.1933
C. borealis Finland 27.vi.1933
C. borealis Finland 26.vi.1933
C. borealis Finland 26.vi.1933
They are all caught on the same event one day apart at max, so it's not possible to say anything about whether there are several generations or not.
C. sylvestris Netherlands 28.v.-11.vi.1976
C. sylvestris England 26.v.-7.vi.1976
C. sylvestris England vi.1994
C. sylvestris France 24.vi-6.viii.1934
Caught from the end of May to the beginning of August, no sign of two generation

I am interested of biology in general, my interest in biology started as general appreciation of nature. Entomology is the part of biology that I have had most contact with as I have worked within the Swedish Malaise Project (SMTP) from time to time during several yea

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