Systematics of water mites (Acari: Prostigmata; Parasitengona, Hydrachnidiae)

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In 2016 I sampled mites at the Ringwood Ponds on April 18th and May 4th. I had good success on both days. Nineteen species were represented based upon both genetic and morphological evidence, and genetic bar codes were attempted on 107 specimens, with only 2 failures. Following is a species list, with notes. When sexes are readily distinguishable, specimens are listed separately as male and female; in cases where I have associated larvae, raised from females (i.e., species of *Arrenurus*), I list the numbers of family groups in parentheses. There are many undescribed species involved: where there are morphological differences from known species, I use 'sp' and a number to indicate the morphospecies; where species are currently only distinguishable by sequence data, I use '#' and a number to indicate the cryptic/pseudocryptic species. Groups that I feel will ultimately be described as distinct species are highlighted in boldface, given the clustering of cryptic/pseudocryptic species within nominative species.

Eylaoidea
- Piersigiidae
  - ***Piersigia americana*** [2 specimens]
    - 2 specimens submitted for bar coding, 1 successfully
    - originally described from a swamp in New Jersey, I myself have not encountered them elsewhere

Hydryphantoidea
- Hydryphantidae
  - *Hydryphantes ruber*
    - based upon sequence data, there are at least 5 distinct cryptic/pseudocryptic species
      - ***Hydryphantes ruber* #04** [1 specimen]
        - first record
      - ***Hydryphantes ruber*#05** [4 specimens]
        - also found elsewhere
  - *Parathyas barbgera* / *Parathyas stolli*
    - based upon sequence data, there are at least 6 distinct species hidden within these two nominative species; morphological differences may exist, more detailed analysis is needed
      - ***Parathyas barbigera*#02** [3 specimens]
        - I have also collected specimens from two localities in Ontario, Canada

Hygrobatoidea
- Limnesiidae
  - ***Limnesia* sp10** [2 males, 2 females]
    - a small, presumably unnamed species, thus far only collected from the Ringwood Preserve
    - I have encountered a number of undescribed species in this genus, it is badly in need of revision
- Pionidae
  - ***Piona* sp09** [2 males, 2 females]
    - as yet unidentified, however presumably a known species of temporary pool specialist
    - I have also collected in Algonquin Park, Ontario, Canada

Arrenuroidea

Arrenuridae

Arrenurus (Megalurcarus) mamillanus species group

- at least 4 distinct species occur, 3 from Ringwood Ponds, only 2 have been named
- two species (based upon morphological and genetic data) are potentially *A. mamillanus*, however it is not clear based upon the species description, careful examination of the type material is necessary

***Arenurus (Megaluracarus) neomamillanus* sp01** [males, 14 females (13)]

- potentially *A. mamillanus*
- common elsewhere

***Arrenurus (Megaluracarus) neomamillanus* sp03** [1 male, 2 females (2)]

- the nominative *A. neomamillanus*
- common elsewhere

***Arrenurus (Megaluracarus) neomamillanus* sp04** [5 males, 7 females (6)]

- potentially *A. mamillanus*
- common elsewhere

***Arrenurus (Megaluracarus)* n.sp., 'blue-grey coke'** [5 males, 4 females (1)]

- one of a series of species of a species group within the subgenus *Megaluracarus*, that specializes on seepage areas and temporary ponds; several undescribed species belong to the group and males have a 'coke-bottle' shape, hence my names include 'coke'
- so far, I have only collected this unnamed species in Ringwood Ponds

***Arrenurus (Megaluracarus) neobirgei* sp01** [1 male]

- there are at least 3 species within the nominative species, with distinct differences in sequence and subtle morphological differences; this is most likely the nominative *A. neobirgei*, as it is very common elsewhere and the other two are rare, but careful examination of the type material is necessary to confirm this premise

Arrenurus (Truncaturus) acuminatus

- this species was named by Gary Mullen (1976) based upon larvae found parasitizing mosquitoes in the Ringwood Preserve; based upon the larvae raised from females, and males identified through sequence data corresponding to that of females, we now know the appearance of adults; this species is within a species cluster including *Arrenurus kenki* and *Arrenurus palustris*, but also a series of unnamed species; adult *Arrenurus acuminatus* looks remarkably similar to *A. kenki*, and to add to the confusion, larvae corresponding to *A. acuminatus* are associated with females that form two distinct clades based upon their COI sequence data, so it is currently impossible to determine which is the nominative species

***Arrenurus (Truncaturus) acuminatus* #01** [3 males, 11 females (8)]

***Arrenurus (Truncaturus) acuminatus* #02** [8 males, 12 females (10)]

Arrenurus (Truncaturus) confractus [2 males]

- the species was described by Mullen (1976) based upon one adult male and one adult female raised from parasitic larvae associated with mosquitoes, that were collected from the Ringwood Preserve; the 'female' as illustrated was clearly an intersex male, and my specimens plus Mullen's (1976) illustrated male have intersex characteristics, e.g., leg IV genua lack the prominent spur and setal brush characteristic of the species group and used in mating; my specimens cluster in different places within *Arrenurus (Truncaturus) kenki/palustris*#01 (probably the nominative *A. palustris*), which again suggests that these are aberrant specimens; intersex individuals are infrequent but not rare in *Arrenurus* species, and an intersex condition can be one side-effect in arthropods infected by sex-ratio distoring endosymbiotic bacteria such as *Wolbachia*; while I have not found *Wolbachia* in *Arrenurus* species, I have found several other pathogens known as sex-ratio distorters
- the only specimens of this species ever recorded are Mullen's (1976) two specimens and my two specimens

Arrenurus (Truncaturus) danbyensis [2 females (1)]

- this is a very common and widespread species, based upon larvae associated with the mosquito *Coquillettidia pertubans*, but adults are only infrequently collected

Arrenurus (Truncaturus) kenki/palustris

- based upon sequence data, what is supposedly the two species *A. kenki* and *A. palustris* is really a confusing complex of morphologically highly variable species, involving at least 6 distinct clades, two of which can be now attributed to *A. acuminatus* (see above)

Arrenurus (Truncaturus) kenki/palustris#01

- adults most closely match *A. palustris*, however so do several other clades in the *kenki/palustris* group; a further complication is that while the K/P#01 clade is highly variable, it does appear to form two different subgroups that also conform to two different bar code BINs

***Arrenurus (Truncaturus) kenki/palustris*#01A,B,D** [5 males, 10 females (8)]

- originally appeared to be 4 of 5 different subgroups, based upon a limited number of specimens, however additional collected specimens filled in many of the apparent gaps; I now recognize this a single highly variable clade corresponding to one bar code BIN
- I have also collected this clade from various sites in Ontario, Canada

***Arrenurus (Truncaturus) kenki/palustris*#01C** [1 male, 3 females (2)]

- thus far, only known from Ringwood Ponds

Arrenurus (Truncaturus) ringwoodi

- sequence data indicate that there are two distinct clades within the nominative species; the second clade has thus far only been found in Algonquin Park, Ontario, Canada, but the first is widespread and common; the second clade is distinguishable based upon larval morphological characters, I suspect that I will find useful characters on adult males given more detailed examination

***Arrenurus (Truncaturus) ringwoodi*#01** [2 males, 1 female (1)]

Summary

One reason for this study was to collect additional specimens of *Arrenurus (Truncaturus)* species described by Mullen (1976) based upon specimens collected from the Ringwood Preserve; several had never been collected since, and several were only known from the larval stage. I have been quite successful to date, having found corresponding specimens of *A. palustris*, *A. acuminatus*, *A. confractus*, and *A. ringwoodi*. However, nothing is ever simple: the first two species and the last species apparently represent complexes of cryptic species, and currently it is not clear which clade is the nominative species, whereas *A. confractus* appears to represent intersex individuals of one of the *A. palustris* (sensu lato) clades. These collections were also part of a larger initiative, to collect specimens from southern Ontario and upstate NY and establish a library of morphological specimens with corresponding COI sequence ("genetic bar code") data, and within the *Arrenurus* species, to maintain females long enough to obtain eggs and subsequent larvae, hence tying together sexually-dimorphic adults and the heteromorphic larval stages.

A surprise to me in 2016 was to discover that what appeared to be two species, *Parathyas barbigera* and *Parathyas stolli*, were in fact a species complex of 6 clades, of which one (*Parathyas barbigera*#02) was recovered from the Ringwood Ponds and two sites in South-Eastern Ontario. While I had previously realized that *Hydryphantes ruber* was in fact a complex of cryptic species, material collected from Ringwood Ponds and elsewhere in 2016 turned out to include additional clades in the species complex, one represented by a single specimen.

In 2017 I hope to collect again at the Ringwood Preserve. I have most of the specimens I need for species of *Arrenurus*, although there is at least one of Mullen's (1976) species, *Arrenurus tarsostriatus*, which eludes me - and the species description is based only upon larval specimens, so it is a challenge. I hope to collect more *Hydryphantes ruber* (sensu lato) and *Parathyas barbigera/stolli* (sensu lato) to help elucidate the species groupings, and in specific to raise larvae from females, so that I have additional morphological characters for analysis. *Parathyas barbigera* is known to be a parasite of mosquitoes, so is of special interest, as are the *Arrenurus (Truncaturus)* species. Several authors have noted that some *Parathyas stolli* produce typical eggs that result in larvae, whereas others lay larger eggs that result in larvae that forego parasitic association with insects and transform directly into deutonymphs; the suggestion has been that these two life history forms may in fact represent two different but cryptically similar species.