A NEW ANAGRUS\textsuperscript{1} IMPORTANT IN THE BIOLOGICAL CONTROL OF STEPHANITIS TAKEYAI\textsuperscript{2} AND A KEY TO THE NORTII AMERICAN SPECIES

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ABSTRACT

A new species of Anagrus Haliday is described, and biological information is provided regarding the parasite's effectiveness in attacking eggs of the introduced tingid Stephanitis takeyai Drake and Maa. We suspect that the parasite was fortuitously introduced with its host and that it is not an endemic Anagrus. The parasite has the capability of reducing host egg populations by at least 35\% in Connecticut. A key to the 6 species of North American Anagrus is given and taxonomic comments are made on these species.

The cosmopolitan mymarid genus Anagrus Haliday is composed of egg parasites of various species of Homoptera, Hemiptera, and possibly Lepidoptera. Five species are known from North America; for extensive bibliography on each see Peck (1963). This paper describes a sixth species which may be important in the biological control of the imported tingid Stephanitis takeyai Drake and Maa. Investigative responsibilities have been divided such that Gordh is responsible for taxonomic aspects and Dunbar is responsible for biological information about the new species.

Anagrus Haliday, 1833

Type-species: Ichneumon atomus Linnaeus. Desig. by Westwood, 1840.

The number of Anagrus is questionable. Bakkendorf (1933) contends that there is only 1 highly variable species; Soyka (1955) recognizes 44 species in Europe. Part of the problem stems from the fact that the genus is poorly known biologically and geographically. Past taxonomic studies have placed emphasis on antennal characters, especially the relative lengths of funicular segments. Sample sizes have been small, however, and no effort has been made to quantify these data. Measurements of specimens available for study reveal that these characters should be used with caution because there is variation in absolute length of segments.

The following characters distinguish Anagrus from all other North American genera of Mymaridae. For an explanation of various morphological or taxonomic terms see Graham (1969): Female antenna 9 segmented (1,1,0,6,1); medial surface of scape with parallel striae perpendicular to its long axis. Metasoma broadly attached to propodeum and endosternal

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phragma projecting into the metasoma; lateral margins of terga 2-6 with pairs of setae; base of ovipositor curved (bowed) inwards such that in lateral aspect the ovipositor appears C-shaped, apical outer surface of each gonostylus with a single seta. Mandible 3-toothed; middle and posterior teeth darkly pigmented, anterior tooth pale; middle tooth slightly longer than others. Oral fossa darkly pigmented along gena; clypeal margin pale. Metanotum with a pair of sclerotized lobes. Tarsi 4-segmented.

**KEY TO NORTH AMERICAN SPECIES OF Anagrus**

1. Second funicular segment longest (Fig. 4), ovipositor and gonostylus markedly exerted beyond apex of metasoma; gonostylus 0.86-0.98 times as long as hind tibia; body uniformly pale ......................................................... *A. delicatus* Dozier

1'. If second funicular segment is longest (some *giraulti*), then ovipositor and gonostylus not markedly exerted beyond apex of metasoma; gonostylus less than 0.70 times as long as hind tibia; body not uniformly pale ........................................................................... 2

2. Second and third funicular segments subequal (Fig. 5), combined length equal to fourth funicular; posterior margin of pronotum medially emarginate (Fig. 2); mesoscutum without a pair of setae near notaulices......... *A. takevanus* Gordh. new species

2'. If second and third funicular segments subequal, then combined length nearly 2 times length of fourth funicular; posterior margin of pronotum not emarginate medially; mesoscutum with a pair of setae near notaulices ................................................... 3

3. Body dark brown; scape dusky, rhinaria on second and third funicular segments ......................................................... *A. puella* Girault

3'. Body pale or not uniformly dark brown; scape concolorous with pedicel and first funicular segment; rhinaria not on second and third funicular segments ......................................................... 4

4. First funicular segment about half as long as second; forewing with wing blade sparsely setose, setae arranged in 2-3 irregular lines, posterior half of wing blade along distal third asetose or with a few setae along posterior margin only ................................................................. *A. epos* Girault

4'. If first funicular segment half as long as second (some *armatus*), then posterior half of wing blade along distal third with numerous setae; forewing with numerous setae; forewing with numerous setae on wing blade arranged in 4-7 irregular lines ............... 5

5. Total length of funicular segments less than 2.75 times length of club (Fig. 7); maximal width of forewing more than 2 times width of wing at apex of venation ......................... *A. armatus* (Ashmead)

5'. Total length of funicular segments more than 2.75 times length of club (Fig. 8); maximal width of forewing less than 2 times width of wing at apex of venation ..................... *A. giraulti* Crawford
Anagrus takeyanus Gordh, New Species

Fig. 1-3, 5

Female: Length 0.9 mm. Head, mesoscutum, anterior half of scapula, axilla, metasoma, antennal funicular segments 2-6 and club dusky; scutellum, metanotum, thoracic sterna, propodeum, antennal scape, pedicel, first funicular segment, and legs straw colored. Forewing marginal vein and wing blade posterior and slightly distad to marginal vein dusky; remainder of forewing hyaline (Fig. 3). Hindwing venation at hamuli dusky; remainder of hindwing hyaline.

Head in frontal aspect subtrapezoidal (Fig. 1); in dorsal aspect oval; vertex with a few lightly incised striae laterad; area between ocelli smooth; face below pigmented bar and between toruli with lightly incised striae; ocelli forming an obtuse triangle, POL 0.65 times OOL. Compound eye asetose, medial margins of compound eyes diverging ventrally. Torulus adjacent to medial margin of compound eye and at imaginary transverse line bisecting eye height. Head chaetotaxy as follows: 1 pair of setae lateral to and 1 pair dorsolateral to occipital foramen, 1 pair of setae in sulcus extending from foramen to compound eye margin and adjacent to eye margin, 2 pairs of setae along medial margin of compound eye dorsal to toruli, 1 pair of setae between toruli (distance separating them equal to width of pigmented portion of transverse frontal bar), 4 pairs of setae distributed over face and gena. Antenna (Fig. 5) sparsely setose, scape slightly

Fig. 1-3. Anagrus takeyanus, new species (female): 1) Frontal aspect of head, 100X (paratype); 2) Dorsal aspect of body, 100X (paratype); 3) Left forewing, 120X.
expanded ventrally, mean ratio of relative length of antennal segments beginning with pedicel (excluding scape): 1, 0.38, 0.65, 0.64, 1.12, 0.99, 1.17, 2.28 (n=41). Mandible with 3 apically acute teeth; maxillary and labial palp reduced.

Mesosoma (Fig. 2) 0.84 times as long as metasoma. Pronotum with lightly incised reticulate sculpture, a pair of setae halfway between lateral margin and midline, posterior margin at midline emarginate. Mesoscutum, scapula asetose; scutellum, metanotum, propodeum smooth, asetose; endosternal phragma projecting into metasoma to posterior margin of second tergum.

Metasoma smooth, lateral margins of terga 2-6 each with 2 pairs of setae; medial portion of tergum 7 with 4 setae; pygostylus with 4 setae subequal in length and extending to apex of gonostylus; ovipositor and gonostylus slightly exerted; gonostylus 0.56 times as long as hind tibia.

 Forewing (Fig. 3) marginal vein with 3 robust and 1 small setae; 3 small setae at apex of marginal vein; wing blade sparsely setose, setae arranged in 3-4 irregular lines; marginal fringe dark, but pale near wing margin, 2.38 times as long as forewing width. Hindwing with anterior and posterior margins parallel; wing blade with a single row of setae along posterior margin.

M ALE. Unknown.

ETYMOLOGY: The specific name alludes to the host species, Stephanitis takeyai.


PARATYPES: 63 females (same data as holotype except some collected summer 1974): Canadian National Collection, Ottawa (3); British Museum (Natural History), London (3); Zoological Institute, Leningrad (2); Plant Protection Research Institute, Pretoria, South Africa (2); Ehime University, Matsuyama, Japan (2).

VARIATION: The type-series is morphologically uniform, probably because all the specimens came from a single host species that was collected in a geographically small area. Variation in lengths of antennal segments is given in Table 3; maximal length of marginal fringe in ratio to forewing width varies from 2.30-2.72 times; mesosoma is 0.71-0.88 times as long as the metasoma.

COMPARATIVE COMMENTS: The taxonomic affinities of this species are difficult to determine because of the morphological similarity among Anagrus species. Biologically A. takeyani is peculiar in that it is thlep-tokous; all other species of Anagrus in North America are arrhenotokous. Morphologically, A. takeyani resembles A. epos, A. armatus, and A. giraulti. It may be distinguished from those species by the characters given in the key.

DISCUSSION: The andromeda lacebug, S. takeyai, was introduced into the United States near Greenwich, Connecticut from Japan about 1945 (Bailey 1950). It has since become a serious pest of Japanese andromeda, Pieris japonica (Thunberg) David Don, in 10 eastern and midwestern states (Dunbar 1974). Schread (1968) was first to report natural enemies of this pest in North America. He found that approximately 15% of overwintering host eggs were parasitized by a small mymarid, Anaphes sp. Dunbar (1974)
found that 35.5% of overwintering host eggs in Mt. Carmel, Connecticut, were parasitized by another mymarid, Anagrus sp. (= takeyanus, new species). With our current information on parasites of S. takeyai, it is highly probable that Schread's species was an Anagrus and not an Anaphes. Egg parasites are not common on other species of Stephanitis in America; hence, it is postulated that the new species of Anagrus was introduced with its host.

The parasite overwinters in the host egg and begins to emerge in Connecticut during mid-June (Table 1). Emergence continues into early July. To determine seasonal emergence, we collected 10 leaves infested with host eggs from the field prior to any parasite emergence. These were placed in cartons in an outdoor insectary and observed daily for parasite emergence. During the period 17-23-VI-1975 maximum emergence occurred (81.52%).

**TABLE 1. SEASONAL EMERGENCE (1975) OF ANAGRUS TAKEYANUS NEW SPECIES FROM FIELD RECOVERED STEPHANITIS TAKEYAI EGGS COLLECTED AT MT. CARMEL, CONNECTICUT.**

<table>
<thead>
<tr>
<th>Period</th>
<th>Number Emerging</th>
<th>Percentage Emerging</th>
<th>Cumulative Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-16</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17-23</td>
<td>97</td>
<td>81.52</td>
<td>81.52</td>
</tr>
<tr>
<td>24-30</td>
<td>13</td>
<td>10.92</td>
<td>92.44</td>
</tr>
<tr>
<td>July</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-7</td>
<td>9</td>
<td>7.56</td>
<td>100.00</td>
</tr>
<tr>
<td>8-14</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>

Further studies showed that less than 35% of the field-collected eggs of S. takeyai hatch (Table 2). This figure was established in the following manner. Leaves were collected from the field and examined for S. takeyai eggs. Leaves with eggs were washed with water and the number of eggs per leaf was determined by visual count. The leaf stems then were placed individually in plastic cups filled with water, held for 5-6 weeks (at 25 ± 1 °C, RH=60-70%, and LD 16:8), and leaves were inspected daily for tingid e Nicol and parasite emergence. From these studies we determined that parasitism ranged from 15.1-35.3%, egg hatch ranged from 1.8-28.6%, and egg inviability ranged from 36.6-83.0%. It is difficult to understand the poor host egg hatch unless the parasite is somehow involved. Inviable eggs were not dissected, but we suspect that parasite stinging and/or host feeding, in addition to other factors, were responsible for the high percentage of inviability observed in field-collected eggs. The method of holding eggs probably was not involved, with no observable differences in results because that was checked several times by subjecting eggs to different conditions.

That parasite emergence reaches 35% in Connecticut suggests the parasite is successful in reducing host populations and thus is of potential importance in biological control programs against this pest.

<table>
<thead>
<tr>
<th>Collection Date</th>
<th>Number Leaves</th>
<th>Number Eggs</th>
<th>Percentage Parasites</th>
<th>Percentage Egg Hatch</th>
<th>Percentage Inviable Eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>28-VI-1974</td>
<td>18/381</td>
<td>35.3</td>
<td>21.1</td>
<td>43.6</td>
<td></td>
</tr>
<tr>
<td>8-VII-1974</td>
<td>22/722</td>
<td>16.8</td>
<td>14.3</td>
<td>68.9</td>
<td></td>
</tr>
<tr>
<td>15-VII-1974</td>
<td>17/1080</td>
<td>21.0</td>
<td>13.2</td>
<td>65.8</td>
<td></td>
</tr>
<tr>
<td>22-VII-1974</td>
<td>15/464</td>
<td>34.1</td>
<td>10.9</td>
<td>55.0</td>
<td></td>
</tr>
<tr>
<td>29-VII-1974</td>
<td>14/621</td>
<td>31.7</td>
<td>1.8</td>
<td>66.5</td>
<td></td>
</tr>
<tr>
<td>4 III 1975</td>
<td>93/3679</td>
<td>26.0</td>
<td>28.6</td>
<td>44.8</td>
<td></td>
</tr>
<tr>
<td>18-VI-1975</td>
<td>20/412</td>
<td>29.9</td>
<td>31.6</td>
<td>38.5</td>
<td></td>
</tr>
<tr>
<td>25-VI-1975</td>
<td>32/1548</td>
<td>32.3</td>
<td>31.1</td>
<td>36.6</td>
<td></td>
</tr>
<tr>
<td>3-VII-1975</td>
<td>28/1568</td>
<td>22.3</td>
<td>16.2</td>
<td>61.5</td>
<td></td>
</tr>
<tr>
<td>10-VII-1975</td>
<td>25/680</td>
<td>15.1</td>
<td>1.9</td>
<td>83.0</td>
<td></td>
</tr>
</tbody>
</table>

The mean, standard deviation, and coefficient of variation for the measurements of antennal segments for each of the North American species of *Anagrus* are presented in Table 3. One antenna was measured for each specimen, and the scape was not measured because in many instances antennae were attached to unclipped heads and the radicle could not be seen clearly. Variation probably can be attributed to season, host species, host size, and geographical distribution.

The coefficients of variation provide an estimate of variation independent of the magnitude of the means. Overall variation is greatest for *A. armatus* (probably due to the heterogenous population that was sampled); overall variation is least for *A. takeyanus* (probably due to the homogenous population that was sampled). Future taxonomic studies of this group should focus on establishing more precise limits of variation with regard to various morphological parameters and the factors that are responsible for generating the variation.

*A. armatus* (Ashmead)

(Fig. 7)

*Litus armatus* Ashmead, 1887:193.

*Eustochus xanthothorax* Ashmead, 1887:193-194.


*Anagrus armatus* var. *nigriventris* Girault, 1911b:291-292.

*Anagrus armatus* var. *nigriceps* Girault, 1915:276.


Type-locality: Florida.

Girault (1911b) describes a variety of *armatus* that he called *nigriventris* (type-locality: Centralia, Illinois) based on dark pigmentation on the head, pronotum, and metasoma. Specimens in the USNM collection identified as *nigriventris* by Girault and Gahan show that variation in coloration is nearly continuous from dusky to almost black. We can find no
### Table 3

**Mean, Standard Deviation, and Coefficient of Variation for Antennal Segment Lengths (in mm) for North American Anagrus spp.**

<table>
<thead>
<tr>
<th>Species</th>
<th>Pedicel</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Club</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. crnatus</td>
<td></td>
<td>0.043</td>
<td>0.023</td>
<td>0.052</td>
<td>0.049</td>
<td>0.054</td>
<td>0.054</td>
<td>0.056</td>
<td>0.108</td>
</tr>
<tr>
<td></td>
<td>SD=</td>
<td>±0.004</td>
<td>0.009</td>
<td>0.011</td>
<td>0.010</td>
<td>0.012</td>
<td>0.009</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CV=</td>
<td>9.63</td>
<td>17.98</td>
<td>17.40</td>
<td>21.71</td>
<td>17.95</td>
<td>23.01</td>
<td>16.41</td>
<td>9.99</td>
</tr>
<tr>
<td>A. delicatus</td>
<td>0.053</td>
<td>0.026</td>
<td>0.100</td>
<td>0.084</td>
<td>0.082</td>
<td>0.075</td>
<td>0.070</td>
<td>0.108</td>
<td>1</td>
</tr>
<tr>
<td>A. epos</td>
<td>0.038</td>
<td>0.017</td>
<td>0.036</td>
<td>0.040</td>
<td>0.044</td>
<td>0.045</td>
<td>0.048</td>
<td>0.104</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>0.003</td>
<td>0.002</td>
<td>0.008</td>
<td>0.004</td>
<td>0.004</td>
<td>0.004</td>
<td>0.004</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>A. girauiti</td>
<td>0.045</td>
<td>0.025</td>
<td>0.088</td>
<td>0.067</td>
<td>0.067</td>
<td>0.064</td>
<td>0.067</td>
<td>0.121</td>
<td>10</td>
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<tr>
<td></td>
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<td>0.008</td>
<td>0.006</td>
<td>0.006</td>
<td>0.006</td>
<td>0.004</td>
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<td></td>
<td>8.95</td>
<td>15.00</td>
<td>11.62</td>
<td>8.49</td>
<td>9.65</td>
<td>9.30</td>
<td>6.17</td>
<td>3.06</td>
<td></td>
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<tr>
<td>A. puella</td>
<td>0.053</td>
<td>0.027</td>
<td>0.071</td>
<td>0.071</td>
<td>0.070</td>
<td>0.064</td>
<td>0.067</td>
<td>0.138</td>
<td>5</td>
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<td></td>
<td>0.002</td>
<td>0.001</td>
<td>0.006</td>
<td>0.004</td>
<td>0.006</td>
<td>0.006</td>
<td>0.005</td>
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<tr>
<td></td>
<td>3.97</td>
<td>4.74</td>
<td>7.93</td>
<td>6.36</td>
<td>9.12</td>
<td>8.80</td>
<td>7.27</td>
<td>4.08</td>
<td></td>
</tr>
<tr>
<td>A. takeyanus</td>
<td>0.036</td>
<td>0.014</td>
<td>0.024</td>
<td>0.023</td>
<td>0.041</td>
<td>0.036</td>
<td>0.043</td>
<td>0.083</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>0.002</td>
<td>0.002</td>
<td>0.001</td>
<td>0.002</td>
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<tr>
<td></td>
<td>5.29</td>
<td>8.47</td>
<td>6.43</td>
<td>8.59</td>
<td>6.49</td>
<td>6.59</td>
<td>4.84</td>
<td>3.93</td>
<td></td>
</tr>
</tbody>
</table>
structural characters to differentiate *nigriventris* from the other “subspecies” of *armatus*, and their geographical distributions overlap. The ratio of gonostyler length to hind tibial length is somewhat lower in *nigriceps* than *nigriventris*, but there is overlap among all 3 “subspecies”. It seems that the creation of subspecies in *armatus* is for nomenclatural convenience rather than to indicate zoological relationship.

**Anagrus delicatus** Dozier

(Fig. 4)

*Anagrus delicatus* Dozier, 1936:177-178.
Type-locality: Elizabethtown, Illinois.

Dozier (1936) does not indicate the dispensation of the types designated in that paper. His collection was acquired by the USNM following his death, but the holotype was located in the Illinois Natural History Survey collection (hereafter INHS). This is a morphologically distinctive species, characterized by an elongate gonostyly and ovipositor. Its biology is unknown, but specimens in the USNM collection are labeled as parasites of *Psallus seriatus* (Reuter) eggs. Only 1 specimen is mounted well enough to determine that the posterior margin of the pronotum is medially emarginate. *A. delicatus* shares this character with *takeyanus*.

We cannot determine whether *delicatus* females have a pair of setae between the toruli because the specimens are poorly mounted. Head chaetotaxy appears constant among North American representatives of *Anagrus*, and if *delicatus* does not have these setae, it is the only species that does not.

**Anagrus epos** Girault

(Fig. 6)

*Anagrus epos* Girault, 1911b:292.
Type-locality: Centralia, Illinois.

This species is distributed throughout North America and has been recovered from several host species. We cannot see rhinaria on funicular segments 3 and 4 in some specimens. This may be due to character variability or because the specimens are not well preserved in Canada balsam. In the INHS collection are several slides containing specimens identified as *epos*. Among these slides is one with a label in the hand of Girault reading “*Alaptus caecilli* Girault *Anagrus epos* sep 4, 09 Centralia, Illinois 1 male 5 female’s. Types male/female 44,222 s 1461”. On the right hand side of the slide are 3 labels reading “Lectotype Anagrus epos Girault female” (red), “Allotype Anagrus epos Girault male” (blue), and “Paratype Anagrus epos Girault female” in the hand of B. D. Burks. We here validate the lectotype designation. An etched circle in the coverslip surrounds the lectotype.

**Anagrus giraulti** Crawford

(Fig. 8)

Type-locality: El Monte, California.

Crawford notes that the sixth funicular segment is shorter than the fifth.
Measurement of the type-series with an eyepiece micrometer shows that the sixth segment is slightly longer than the fifth (Table 3). The sixth segment is slightly wider than the fifth, and this undoubtedly creates an optical illusion.

In the original description Crawford compared this species to *A. armatus* noting that the antennal structure differed between the species. These species are exceedingly similar, and the only characters that we have found to

![Antennae Diagrams](image)

Fig. 4-9. Female antennae, inner aspect (R = right, L = left), all at 100X: 4) *A. delicatus* (R); 5) *A. takeyanus* (L) (paratype); 6) *A. epos* (L); 7) *A. armatus* (L); 8) *A. giraulti* (R) (holotype); 9) *A. puella* (L).
separate them are based on ratios of linear measurement of antennal segments. It seems inadvisable to synonymize these species although this may be necessary when hybridization tests are performed and their biologies are better known.

*Anagrus puella* Girault

(Fig. 9)

*Anagrus puella* Girault, 1911b:293-294.

Type-locality: United States.

We have not examined the type-material of this species; it should be in the INHS collection, but we were unable to locate it. Our concept of *puella* is based on Girault's description and 5 females and 1 male in the USNM collection (determined by Dougt and Gahan from material collected in California by Dougt). The dark-brown body, dusky scape, rhinaria on funicular segments 2-6, and relatively large body size make this a distinctive species.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge Drs. E. E. Grissell and Z. Bouček for reviewing this manuscript. We also thank Donald Webb (Illinois Natural History Survey) for the generous loan of the type-specimens of *Anagrus epos* Girault and *A. delicatus* Dozier.

LITERATURE CITED


**Photo Story**—The torn intersegmental membranes of this hickory horned devil pupa became thoroughfares, and 21 tachinid maggots emerged (Sarcodexia sternodontis Townsend, = Sarcophaga lambens not Wiedemann). When put in a dish of sand the parasites dug in and pupated. Flies identified by R. Sailer; photo by J. Lloyd.