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## Revision of the Nearctic *Thereva* (Diptera: Asiloidea: Therevidae)

### Abstract

This revision provides identification tools for the 35 *Thereva* species recorded from the Nearctic Region and collecting locality data for over 9500 specimens, allowing species distributions to be described and examined in detail. Characters of the male genitalia and the female frons are of primary importance in distinguishing species of *Thereva* and are illustrated for all species. Diagnostic morphological characters are described in dichotomous keys to males and females, tables of characters for species groups, and species diagnoses. The nomenclature for Nearctic *Thereva* species is updated, and lists of specimens examined and distribution maps are provided. Eleven new species are described as new to science; one European species found in the vicinity of Vancouver, British Columbia, *Thereva nobilitata* (FABRICIUS), represents the first documented introduction of a stiletto fly species. A major geographic boundary in species distributions can be observed at the western edge of the North American Cordilleras, which distinguishes five *Thereva* species found in the eastern Nearctic Region. Distributions of western species are predominately montane and circumscribed by the Rocky Mountains, Coastal Ranges, or coastal lowlands. Eastern species are collected predominately at non-montane localities and appear to be restricted to areas north of 40° and 45° latitude, a southern limit that closely follows the southern Nearctic boundary of the Humid Microthermal (Cold Snowy Forest) Climate and has not been observed for eastern stiletto fly species of other Nearctic genera. The endemic Nearctic species are arranged in the following four species groups: 1) the *foxi* group (*T. foxi* COLE, *T. macdunnoughi* COLE, *T. strigipes* LOEW, *T. webbi* spec. nov.) 2) the *comata* group (*T. comata* LOEW, *T. hirticeps* LOEW), 3) the *flavipilosa* group (*T. bakeri* COLE, *T. cordata* spec. nov., *T. diversa* COQUILLET, *T. elizabethae* spec. nov., *T. flavipilosa* COLE, *T. fucata* LOEW, *T. fucatoides* BROMLEY, *T. kristinae* spec. nov., *T. leucosoma* spec. nov., *T. nelsoni* spec. nov., *T. niveipennis* KRÖBER), and 4) the *johnsoni* group (*T. albopilosa* KRÖBER, *T. aurofasciata* KRÖBER, *T. brunnea* COLE, *T. cingulata* KRÖBER, *T. clamona* spec. nov., *T. colorado* spec. nov., *T. duplisis* COQUILLET, *T. egressa* COQUILLET, *T. flavicauda* COQUILLET, *T. flavicineta* LOEW, *T. frontalis* SAY, *T. johnsoni* COQUILLET, *T. krafti* spec. nov., *T. nudotermina* spec. nov., *T. schlingeri* spec. nov., *T. utahensis* HARDY). Biological data reported for species represent accessory results from field collecting or ecological studies of other insects (and evaluations of species distributions developed during this study), but the known natural history of Nearctic *Thereva* suggests areas for further ecological and behavioral research. The majority of Nearctic *Thereva* species appear to have an association with high altitude and latitude mixed conifer-deciduous forest, and particular species are associated with coastal sand dunes, chaparral, deciduous forest, coniferous forest, or tundra. Males of *T. frontalis*, an eastern forest species, are among the dominant prey selected by *Crabro monticola* (PACKARD) to provision nest cells, although behavior accounting for the male biased sex ratio and preference of *T. frontalis* has not yet been observed. An additional, previously unsuggested link between Nearctic *Thereva* and stinging hymenoptera concerns the putatively mimetic, conspicuous yellowish orange and black thoracic and abdominal patterns in *flavipilosa* group species. Among the less conspicuously patterned species in the *flavipilosa* group, *T. niveipennis* has an exceptionally restricted distribution in the coastal sand dunes of the Monterey Bay area; relatively short wings may reduce the flight capabilities of females with a limiting effect on dispersal and species distribution. This taxonomic revision of the Nearctic *Thereva* has removed a significant obstacle to developing international and interdisciplinary research projects on stiletto flies concerning morphology, behavior, and ecology as well as conservation biology for rare species such as *T. niveipennis*.

## Revision der nearktischen *Thereva*-Arten (Diptera: Asiloidea: Therevidae)

### Zusammenfassung

Die vorliegende Revision ermöglicht die Determination der 35 *Thereva*-Arten, die aus der nearktischen Region bekannt geworden sind. Funddaten für mehr als 9500 Individuen erlauben zudem detaillierte Aussagen zu ihrer Verbreitung. Merkmale des männlichen Genitalapparates sowie der Stirn der Weibchen sind von besonderem Wert für die Unterscheidung der Arten. Diese Merkmale werden für alle 35 Spezies abgebildet. Die diagnostischen Merkmale werden in dichotomen Schlüsseln für die Männchen und Weibchen verwendet. Daneben finden sich zusammenfassende Tabellen mit Merkmalen der Spezies der Artengruppen sowie Art-Diagnosen. Elf Arten werden als neu für die Wissenschaft beschrieben. Der erste Nachweis der europäisch verbreiteten *Thereva nobilitata* (FABRICIUS) auf dem nordamerikanischen Kontinent in der Umgebung von Vancouver (British Columbia, Kanada) stellt zugleich die erste Meldung über die Verschleppung einer Stiletfliege dar. Als eine Hauptverbreitungsbarriere für die nordamerikanischen *Thereva*-Arten muss der westliche Rand der Nordamerikanischen Kordillere gelten, die fünf Arten abtrennt, die nur in der östlichen Nearktis vorkommen. Die Verbreitung der westlichen Arten ist vornehmlich montan und wird durch die Rocky Mountains, die Küstengebirge und vorgelagerten Tieflandgebiete der Küstenregion umschrieben. Die östlich verbreiteten Arten wurden dahingegen meistens in nicht-montanen Gebieten gesammelt. Sie scheinen auf Bereiche nördlich des 40. bis 45. Breitengrades beschränkt zu sein. Diese südliche Grenze folgt im Wesentlichen der Verbreitungsgrenze der borealen Wälder und wurde nicht für andere östlich verbreitete *Thereviden*-Gattungen registriert. Die endemischen nearktischen *Thereva*-Spezies werden in den folgenden vier Artengruppen zusammengefasst: 1) die *foxi*-Gruppe (*T. foxi* COLE, *T. macdunnoughi* COLE, *T. strigipes* LOEW, *T. webbi* spec. nov.); 2) die *comata*-Gruppe (*T. comata* LOEW, *T. hirticeps* LOEW); 3) die *flavipilosa*-Gruppe (*T. bakeri* COLE, *T. cordata* spec. nov., *T. diversa* COQUILLET, *T. elizabethae* spec. nov., *T. flavipilosa* COLE, *T. fucata* LOEW, *T. fucatoides* BROMLEY, *T. kristinae* spec. nov., *T. leucosoma* spec. nov., *T. nelsoni* spec. nov., *T. niveipennis* KRÖBER), und 4) die *johnsoni*-Gruppe (*T. albopilosa* KRÖBER, *T. aurofasciata* KRÖBER, *T. brunnea* COLE, *T. cingulata* KRÖBER, *T. clamona* spec. nov., *T. colorado* spec. nov., *T. duplicis* COQUILLET, *T. egressa* COQUILLET, *T. flavicauda* COQUILLET, *T. flavicincta* LOEW, *T. frontalis* SAY, *T. johnsoni* COQUILLET, *T. krafti* spec. nov., *T. nudotermina* spec. nov., *T. schlingeri* spec. nov., *T. utahensis* HARDY). Bei den Daten zur Biologie handelt es sich um Befunde aus der Sammeltätigkeit oder sie ergaben sich beim Studium anderer Insekten im Freiland. In der Gesamtschau verbleibt jedoch ein großer Forschungsbedarf hinsichtlich der Habitatpräferenzen, der Ökologie und des Verhaltens der einzelnen Arten. Die Mehrzahl der nearktischen *Thereva*-Arten scheint höhere Lagen und Breiten zu bevorzugen und dabei vornehmlich in Mischwäldern vorzukommen. Andere Arten leben in Sanddünen der Küstenstreifen, im Chaparral, in Laubwäldern, in Nadelwäldern oder der Tundra. Männchen der in östlichen Wäldern verbreiteten *T. frontalis* finden sich in großer Zahl in den Nistzellen von *Crabro monticola* (PACKARD) obwohl beim Beutefang eine einseitige Bevorzugung der Männchen von *T. frontalis* nicht beobachtet werden können. Ein weiterer bislang nicht beachteter Zusammenhang zwischen den nearktischen *Thereva*-Arten und stacheltragenden Hymenopteren betrifft die vermeintlich mimetischen, auffallenden schwarz und gelb-orangen Farbmuster der Abdomina innerhalb der *flavipilosa*-Artengruppe. *Thereva niveipennis* hat ein sehr stark begrenztes Areal in den Küsten-Sanddünen des Monterey Bay Gebietes. Die relativ kurzen Flügel der Weibchen mögen die Verbreitungskapazität der Spezies begrenzen. Diese Revision beseitigt einige Hindernisse für die zukünftige Entwicklung internationaler und interdisziplinärer Forschungsprojekte an Stiletfliegen sowohl in Hinblick auf die Morphologie, auf das Verhalten und die Ökologie, als auch bezüglich der Naturschutz-Biologie – z.B. bei *T. niveipennis*.

## Introduction

A recent surge of phylogenetic and taxonomic research has focused on stiletto flies (Diptera: Therevidae), a cosmopolitan group that is well represented in the Holarctic Region, emphasizing the need for improved species-level data (HOLSTON 2004). Nearly 1000 species of Therevidae have been described worldwide, and this number is estimated to increase as much as threefold as the stiletto fly fauna of understudied regions is sampled more intensively. Although a detailed natural history has been recorded for only a few species, all known stiletto fly larvae are soil-dwelling predators of other arthropods, particularly beetle larvae, and can be prominent members of the invertebrate soil fauna (HONCZARENKO 1976, KAPLIN 1977, KRIVOKHATSKII 1982, STRAKA 1982, IRWIN & LYNEBORG 1981a–b). Stiletto fly larvae have been recorded as predators of agricultural pests including the lesser cornstalk borer, *Elasmopalpus lignosellus* (ZELLER) (SMITH & JOHNSON 1989) and the red sunflower seed weevil, *Smicronyx fulvus* LECONTE (PINKHAM & OSETO 1987a–b). *Thereva* is the most species rich stiletto fly genus found in both the Nearctic and Palaearctic Regions, which makes *Thereva* an interesting and challenging genus in biological studies of Holarctic Diptera. Revising the Nearctic *Thereva* would obviate a significant taxonomic obstacle to developing international and interdisciplinary research projects on stiletto flies, providing modern tools for identifying these flies to a wide audience and a new perspective for studying the Holarctic fauna.

The lack of accurate identification tools has been a major obstacle in recognizing species of *Thereva*. COLE (1923) stated that “the genitalia [of Therevidae] have not been made use of in the past in classification of the group, but they possess specific differences which are of great importance.” He predicted a leading role for internal male genitalia characters in taxonomic studies of Therevidae, and male genitalia characters have been primary diagnostic features for Palaearctic *Thereva* species since COLE’s Nearctic revision (HOLLIS 1964, LYNEBORG 1968a–b, TOTH 1970, LYNEBORG & SPITZER 1974, TÓTH 1977, BÁEZ 1982). COLE (1923) provided figures of the external male genitalia for seven stiletto fly species and illustrated the female frons to distinguish among six *Thereva* species (*sensu* IRWIN & LYNEBORG, 1981a). Although the female frons has been a source of diagnostic features since the earliest descriptions of *Thereva* species (HOLSTON 2004), internal features of the male genitalia were not illustrated for Nearctic *Thereva* species except *Thereva fucatooides* BROMLEY (YEATES, 1994: 92, misidentified as *T. fucata* Loew in a paper on bombyliid and asiloid systematics). COLE (1923) included 53 species in *Thereva* in his revision of North American Therevidae, 24 of which were removed to other genera in Therevidae by IRWIN & LYNEBORG (1981a). Major changes in the circumscription of *Thereva* have reduced the precision of COLE’s keys, and the use of male genitalia characters would establish a modern taxonomic context for Nearctic *Thereva* species descriptions and diagnoses.

This monograph updates the taxonomy of Nearctic *Thereva*, with an emphasis on characters of the male genitalia and female frons for recognizing species and compilation of specimen locality data for establishing revised species distributions. Of the 29 *Thereva* species recognized by IRWIN & LYNEBORG (1981a), seven are recognized herein as synonyms. Twelve species of *Thereva* new to science are described in this revision; and *Thereva nobilitata* (FABRICIUS), a European species, is reported for the first time from Canada, bringing the total number of *Thereva* species recorded from the Nearctic Region to 35. The species are arranged in four taxonomic groups, excluding the European species, which reflect hypothesized phylogenetic relationships. The internal male genitalia and female frons have been illustrated for all species, and dichotomous keys to males and females are provided as well as character distribution tables for species groups. Lists of specimens examined are presented for all 35 species, and distribution maps are provided for 31 species.