Morphological and molecular evidence support the synonymy of *Emperoptera* Grimshaw with *Campsicnemus* Haliday (Diptera: Dolichopodidae)¹

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*Campsicnemus* Haliday is a predominantly Holarctic and Polynesian genus of long-legged flies that is highly speciose in the Hawaiian Islands (over 160 species currently known from that island group; Evenhuis, 2007). *Emperoptera* Grimshaw was originally described (Grimshaw in Grimshaw & Speiser, 1902) for a single flightless species from O‘ahu, *E. mirabilis*. Subsequently discovered new flightless species from the Hawaiian Islands were described in *Emperoptera* (Zimmerman, 1938; Adachi, 1954). However, in their revision of the Hawaiian *Campsicnemus*, Hardy & Kohn (1964) sunk *Emperoptera* under *Campsicnemus* without discussion, and an additional flightless species (*hawaiien-sis*) was described in *Campsicnemus* by Hardy & Delfinado (1974). Evenhuis (1997) examined all available material of flightless Hawaiian dolichopodids proposed resurrecting *Emperoptera* based on characters of the wing and female ovipositor, described three new species in *Emperoptera* (*hardyi, montgomeryi, zimmermani*), placed two previously described *Campsicnemus* species in *Emperoptera* (*hawaiien-sis, mirabilis*), and retained three other previously described species in *Campsicnemus* (*aeptus* Hardy & Kohn, *bryophilus* Adachi, *haleakalaae* Zimmerman).

Recent molecular study of species of Hawaiian *Campsicnemus* and related genera as part of a larger NSF-funded study of biodiverse genera of Hawaiian Diptera shows *Emperoptera* to be nested well within other species of *Campsicnemus* (Fig. 1). This led to re-examination of material of *Emperoptera* and comparing to *Campsicnemus*, which resulted in the finding that the length of the spines of the ovipositor in *Emperoptera* (previously thought to be a good character in separating the two genera) are well within the range of lengths of these spines in *Campsicnemus*. We therefore propose reducing *Emperoptera* once again as a junior synonym of *Campsicnemus*.

**Materials and Methods**
Specimens from the following collections and institutions have been examined or are deposited there as vouchers in the course of this study: Natural History Museum, London (BMNH), Bishop Museum, Honolulu (BPBM), Canadian National Insect Collection (CNC), Hawaii State Department of Agriculture (HDOA), Royal Museum of Scotland, Edinburgh (RMSE), Essig Museum, University of California, Berkeley (UCB), University of Hawai‘i Insect Museum, Honolulu (UHM), National Museum of Natural History, Washington, DC (USNM). Data on taxa used in this analysis are listed in the Appendix.

¹. Contribution No. 2010-008 to the Hawaii Biological Survey.
Morphological terminology follows recent taxonomic studies in Evenhuis (1997, 2007, 2008, 2009). Molecular analyses were performed using five mitochondrial (12S, 16S, COI, COII, NADH2) and two nuclear (CAD, Ef1α) loci. Protein coding sequences were aligned using conceptual amino acid translations and were trivial to perform by eye. Ribosomal loci were aligned in Clustal W (Higgins et al. 1994) and then adjusted manually based on stem and loop regions. All noncoding regions (439 base pairs) were excluded, yielding a final matrix of 5,419 characters.

Analyses of individual and combined data matrices, using both maximum parsimony and Bayesian methods, were performed and were largely congruent with one another (data not shown). Here we present the results of parsimony analyses for the combined matrices containing all 63 taxa that have at least four of the seven loci sequenced (Fig. 1). We selected this analysis because it includes the most complete set of sequences that contain a representative of the genus *Emperoptera*. These results are comparable to analyses with fewer taxa but more complete character matrices and those with more species but more missing data (Table 1). Maximum parsimony analyses (PAUP*, ver 4.0; Swofford, 2002) were done using a heuristic algorithm with the following settings: number of replicates = 1000, addition sequence = random, branch swapping = TBR, non-coding regions = excluded. Support was assessed using 500 bootstrap replicates (Felsenstein, 1988) with the other settings as above.

**Systematics**

**Genus Campsicnemus** Haliday


Because of the results of molecular analysis that shows *Emperoptera* to be nested well within species of Hawaiian *Campsicnemus* (see discussion below) as well as examination of the female ovipositor spines, the length of which are within the range of variation shown by other species of Hawaiian *Campsicnemus*, we return *Emperoptera* to junior synonymy under *Campsicnemus* as originally proposed by Hardy & Kohn (1964).

As a result of the new synonymy of *Emperoptera* under *Campsicnemus*, the following taxa are here transferred to *Campsicnemus*.

*Campsicnemus elmoi* Evenhuis, new replacement name

*Emperoptera hardyi* Evenhuis, 1997: 5.

*Campsicnemus hardyi* (Evenhuis), n. comb. [Preoccupied by *Campsicnemus hardyi* Tenorio, 1969.]
Figure 1. Phylogenetic placement of the genus Emperoptera relative to Hawaiian Campsicnemus. Geographical abbreviations: FP = French Polynesia; HI = Hawaiian Islands; NE = Nearctic; PA = Palaearctic. Taxonomic abbreviations: Ad = Adachia; Ar = Arciellia; C = Campsicnemus; Em = Emperoptera; Eu = Eurynogaster; S = Swezeyella; U = Uropachys.
The transfer of *Emperoptera hardyi* to *Campsicnemus* results in secondary homonymy with *Campsicnemus hardyi* Tenorio. *Campsicnemus elmoi* is therefore proposed as a new replacement name and honors D. Elmo Hardy, the collector of the type specimens from Pu‘u Kukui, West Maui.

**Campsicnemus montgomeryi** (Evenhuis), **new combination**

*Emperoptera montgomeryi* Evenhuis, 1997: 11.

*Campsicnemus montgomeryi* (Evenhuis), **n. comb.**

This is apparently the only extant species of species formerly placed in *Emperoptera* and as such was the only material available for molecular analysis. Continued attempts to recollect *C. hawaiiensis* in kīpuka along the Saddle Road of the Big Island of Hawai‘i as well as recent collecting (November 2009) on Pu‘u Kukui to recover *C. elmoi* have thus far been unsuccessful.

**Campsicnemus zimmermani** (Evenhuis), **new combination**


*Campsicnemus zimmermani* (Evenhuis), **n. comb.**

**Molecular Analysis**

Figure 1 shows the results of maximum parsimony analysis of 63 dolichopodid species, including 17 members of the endemic Hawaiian *Eurynogaster* complex, 45 *Campsicnemus* species from Hawai‘i, Europe, North America, and the Pacific, and a single representative of the genus *Emperoptera, E. montgomeryi*. This work is the result of an ongoing project, additional character and taxon sampling is currently underway and will expand our understanding of phylogeny within this complex group. Statistical support for many relationships within the *Eurynogaster* group and some clades of *Campsicnemus* is strong. While some basal nodes are not well supported, this analysis does strongly support the placement of *Emperoptera* within the genus *Campsicnemus* (bold lines, bootstrap proportion 100%), a placement that is unlikely to change with additional character and species sampling.
Acknowledgments
We thank the following for their assistance with collecting or allowing examination of specimens during this study: J.M. Cumming and J.R. Vockeroth (CNC), D.E. Hardy and M.L. Goff (UHM), Brian R. Pitkin and John E. Chainey (BMNH), Bernarr Kumashiro (HDOA), F. Christian Thompson (USNM), A.E. Whittington (RMSE), and Karl Magnacca (UH Hilo). Pavla Bartosova helped organize and collect the DNA sequence data while visiting UC Berkeley. This study was supported in part with funding from the National Science Foundation (DEB 0842348).

Literature Cited


**Appendix. Taxa used for analyses**

**Eurygaster Complex**

*Adachia hispida* (Hardy & Kohn, 1964)  
HAWAIIAN ISLANDS: HAWAI’I: HAVO, Ola’a Pu‘u Unit, 13–14 Nov 2003, 4300’, KN Magnacca; O’Grady Lab 200978

*Adachia sp. nr. hispida*  
HAWAIIAN ISLANDS: KAUA’I: Kawaiikoi Stream, 3500’, 18 May 2007, KN Magnacca 07-0447; O’Grady Lab 205015

*Arciellia dolichostoma* (Hardy & Kohn, 1964)  
HAWAIIAN ISLANDS: KAUA’I: Pu‘u O Kila Rd, 4080’, 17 May 2007, KN Magnacca 07-0430; O’Grady Lab 205016

*Arciellia xanthepleura* (Hardy & Kohn, 1964)  
HAWAIIAN ISLANDS: KAUA’I: Pihea Trail, 3600’, 18 May 2007, KN Magnacca 07-0449; O’Grady Lab 205017

*Arciellia sp. nov.*  
HAWAIIAN ISLANDS: MAUI: Kaupo Trail, 5000’, 1 Aug 2007, KN Magnacca; O’Grady Lab 205039

*Eurygaster maculata* Parent, 1940  
HAWAIIAN ISLANDS: MAUI: Paliku, crater wall, 6600’, 1 Aug 2007, KN Magnacca 07-0719; O’Grady Lab 205058

*Eurygaster paludis* (Hardy & Kohn, 1964)  
HAWAIIAN ISLANDS: KAUA’I: Pihea Trail, 3600’, 18 May 2007, KN Magnacca 07-0450; O’Grady Lab 205018

*Eurygaster sp. nr. cilifemorata*  
HAWAIIAN ISLANDS: MAUI: Kaupo Trail, 5000’, 4 Aug 2007, KN Magnacca; O’Grady Lab 205049

*Eurygaster sp. female*  
HAWAIIAN ISLANDS: MAUI: Ha’ikū Uka, Kula Ppln. rd, 4150’, 31 Jul 2007, KN Magnacca 07-0705; O’Grady Lab 205051

*Eurygaster sp. nr. hawaïensis*  
HAWAIIAN ISLANDS: MAUI: Ha’ikū Uka, Heed Trail, 4200’, 31 Jul 2007, KN Magnacca 07-0702; O’Grady Lab 205051

*Eurygaster sp. nr. maculata*  

*Eurygaster sp. female*  
HAWAIIAN ISLANDS: MAUI: Ha’ikū Uka, Kula Ppln. Rd, 4150’, 31 Jul 2007, KN Magnacca 07-0705; O’Grady Lab 205047

*Sweziella tergoprolixa* (Hardy & Kohn, 1964)  
HAWAIIAN ISLANDS: MAUI: Ha’ikū Uka, Heed Trail, 4200’, 6 Aug 2007, KN Magnacca 07-0781; O’Grady Lab 205048


**Uropachys fusicercus** (Hardy & Kohn, 1964) HAWAIIAN ISLANDS: MAUI: Pihea Trail, 3600', 18 May 2007, KN Magnacca 07-0452; O’Grady Lab 205027

**CAMPSICNEMUS – Hawaiian**

*Campsicnemus amblytylus* Hardy & Kohn, 1964 HAWAIIAN ISLANDS: HAWAI’I, HVNP, Ola’a Forest, Pole 48 (left side of road), 6–7 Jul 2004, PM O’Grady, M. Giannullo & CD Specht, 247.8; O’Grady Lab 200725


*Campsicnemus brevitibia* Hardy & Kohn, 1964 HAWAIIAN ISLANDS: HAWAI’I: Saddle Road, Kipuka Mosaic, 6 Apr 2004, DJ Preston & MKK McShane; O’Grady Lab 201912


*Campsicnemus camptoplaux* Hardy & Kohn, 1964 HAWAIIAN ISLANDS: MAUI: Waikamoi Forest Preserve, Pig Hunter’s Trail, 16 Dec 2003, PM O’Grady, 241.H; O’Grady Lab 200128


*Campsicnemus dicondylus* Hardy & Kohn, 1964 HAWAIIAN ISLANDS: HAWAI’I: Pu’u Maka’ala Trailhead, off Stainback Hwy, 11 Jul 2004, PM O’Grady & M Giannullo, 257.7a; O’Grady Lab 200731

*Campsicnemus distinctus* Hardy & Kohn, 1964 HAWAIIAN ISLANDS: MAUI: Ha’ikū Uka, Heed Trail, 4200’, 6 Aug 2007, KN Magnacca 07-0778; O’Grady Lab 205042


*Campsicnemus hispidipes* Hardy & Kohn, 1964 HAWAIIAN ISLANDS: KAUA’I: Pu’u O Kila Road, 4080’, 17 May 2007, KN Magnacca 07-0431; O’Grady Lab 205019

*Campsicnemus hygrophilus* Hardy & Kohn, 1964 HAWAIIAN ISLANDS: HAWAI’I: Saddle Road, Kipuka 9, 13–15 Aug 2008, NL Evenhuis & M. Nicholson; O’Grady Lab 201928
**Campsicnemus impariseta** Hardy & Kohn, 1964
HAWAIIAN ISLANDS: HAWAI‘I, Pu‘u Maka‘ala Trailhead, off Stainback Hwy, 11 Aug 2004, PM O’Grady & M Giannullo, 257.8b; O’Grady Lab 200743

**Campsicnemus labilis** Hardy & Kohn, 1964
HAWAIIAN ISLANDS: MAUl: stream E of Heed Trail, 4200', 6 Aug 2007, KN Magnacca 07-0795; O’Grady Lab 205059

**Campsicnemus longitarsus** Tenorio, 1969
HAWAIIAN ISLANDS: KAUA‘I: Kumuwela Trail, 3500', 17 May 2007, KN Magnacca 07-0417; O’Grady Lab 205021
HAWAIIAN ISLANDS: KAUA‘I: Pihea Trail, 3500', 18 May 2007, KN Magnacca 07-0443; O’Grady Lab 205022

**Campsicnemus loxothrix** Hardy & Kohn, 1964
HAWAIIAN ISLANDS: HAWAI‘I: HVNP, Upper Ola‘a Forest, end of Wright Rd, 8 Jul 2004, PM O’Grady, M Giannullo, D. Foote, 251.7; O’Grady Lab 200755

**Campsicnemus mucronatus** Hardy & Kohn, 1964
HAWAIIAN ISLANDS: MAUl: Makawao Forest Reserve, 4500', 6 Aug 2007, KN Magnacca 07-0809; O’Grady Lab 205038

**Campsicnemus nigricollis** Van Duzec, 1933
HAWAIIAN ISLANDS: KAUA‘I, Lumahai River, 9 Nov 1994, DA Polhemus; O’Grady Lab 200114
HAWAIIAN ISLANDS: KAUA‘I: Namdokam Mtn, 4200', 22 May 2005, DA Polhemus; O’Grady Lab 201913

**Campsicnemus ornatus** Van Duzec, 1933

**Campsicnemus penicillatus** Parent, 1933
HAWAIIAN ISLANDS: HAWAI‘I: Saddle Rd, Kipuka 9, 2004, NL Evenhuis; O’Grady Lab 200737

**Campsicnemus perplexus** Hardy & Kohn, 1964
HAWAIIAN ISLANDS: MAUl: Ha‘ikū Uka, Carson Trail, 4200', 6 Aug 2007, KN Magnacca 07-0800; O’Grady Lab 205032
HAWAIIAN ISLANDS: MAUl: Ha‘ikū Uka, Heed Trail, 4200', 31 Jul 2007, KN Magnacca 07-0700; O’Grady Lab 205056
HAWAIIAN ISLANDS: MAUl: Haiku Uka, Heed Trail, 4200', 6.viii.2007, KN Magnacca 07-0775; O’Grady Lab 205057

**Campsicnemus petalicnemus** Hardy & Kohn, 1964
HAWAIIAN ISLANDS: MOLOKAI, Pu‘u Kolekole, 3854', 28–30 Jul 2004, PM O’Grady & CD Specht, 283.6; O’Grady Lab 201707

**Campsicnemus plautinus** Adachi, 1953
HAWAIIAN ISLANDS: KAUA‘I: Pu‘u O Kila Road, 4100', 17 May 2007, KN Magnacca 07-0439; O’Grady Lab 205023
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<td><em>Campsicnemus scolimerus</em></td>
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<td>HAWAIIAN ISLANDS: HAWAI‘I: Pu‘u Maka‘ala Trailhead, off Stainback Hwy, 11 Jul 2004, PM O’Grady &amp; M Giannullo, 257.7b; O’Grady Lab 200732</td>
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<td>HAWAIIAN ISLANDS: HAWAI‘I: HVNP, Upper Ola’a Forest, end of Wright Rd, 8 Jul 2004, PM O’Grady &amp; M Giannullo, D. Foote; O’Grady Lab 200756</td>
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<td><em>Campsicnemus sp. nr. biseta</em></td>
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<td><em>Campsicnemus sp. nr. penicillatus</em></td>
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**CAMPICNEMUS – Pacific**

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<td><em>Campsicnemus n. sp. “craigi”</em></td>
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<td><em>Campsicnemus limnobates</em></td>
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<td><em>Campsicnemus n. sp. “popeye”</em></td>
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<td><em>Campsicnemus rheocrenus</em></td>
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**CAMPICNEMUS – European and North American**

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Campsicnemus degener Wheeler, 1899
CANADA: NEW BRUNSWICK: Pokeshaw, 4 Sep 2001, SE Brooks & C. Chenard; O’Grady Lab 200774

Campsicnemus loripes (Halliday, 1832)
M Pollet; O’Grady Lab 200740

Campsicnemus scambus (Fallén, 1823)
M. Pollet; O’Grady Lab 200741

OTHER HAWAIIAN GENERA
Emperoptera montgomeryi Evenhuis, 1997
HAWAIIAN ISLANDS: O’AHU, Mt. Ka’ala, NL Evenhuis; O’Grady Lab 200777

Gene sequences generated in this study will be deposited in Genbank when sampling of Hawaiian and Pacific Campsicnemus and related dolichopodids has been completed.