

Rapid Communication

First record of a species from the New World *Pheidole flavens*-complex (Hymenoptera: Formicidae) introduced to the southwestern Pacific

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Abstract

Ants are among the world's most destructive invaders, and Pacific Islands are particularly susceptible to invasion by non-native ant species. A species from the taxonomically problematic *Pheidole flavens*-complex is reported here for the first time from the southwestern Pacific. Specimens of the species reported here were collected November 2011 from an established colony on Espiritu Santo, Vanuatu, during a survey of the island's ant fauna. Morphological and genetic analyses revealed these Vanuatu specimens belong to the Neotropical *P. flavens* group. The DNA sequence data most closely matched those of two specimens previously determined as *P. moerens* Wheeler and *P. flavens* Roger. A closely related taxon currently being treated as *P. moerens* Wheeler was reported from Hawaii in 2005. Preliminary morphological analysis suggests that the Vanuatu population reported here represents a different species than the Hawaii *P. moerens*. However, a valid species name cannot be confidently applied to either the Hawaii population or the Vanuatu population until a comprehensive taxonomic revision of the *flavens*-complex is completed. Species of the *Pheidole flavens*-complex are occasionally considered pest ants, but have not been documented as causing significant harm to native species, food security or public health. However, the recent spread of species in this complex across the southeastern United States, recent introductions to California and Hawaii, and the recent discovery in Vanuatu suggests their potential for human-mediated dispersal and establishment. We hope that raising awareness of this new incursion will improve the chances of early detection and eradication before the species spreads further into the Pacific Island region. We provide specimen photographs of the major and minor caste and a brief diagnosis that can be used to separate this species from other *Pheidole* species introduced in the Pacific island region, including *Pheidole megacephala* (Fabricius) and the morphologically similar *Pheidole parva*.

Key words: tramp ants, invasive ants, Pacific islands, biological invasion, Vanuatu, Melanesia, *Pheidole*

Introduction

A species from the taxonomically problematic *Pheidole flavens*-complex is reported here for the first time from the southwestern Pacific. The *Pheidole flavens*-complex consists of a wide diversity of morphologically similar taxa native to the Neotropics and widespread across the Caribbean islands. *Pheidole flavens* Roger and *Pheidole moerens* Wheeler are the two names most often applied to species of this complex. However, a thorough taxonomic revision of the complex is required before either of these valid names or their many junior synonyms can be

confidently assigned to any of the taxa discussed. Taxa included in the *flavens*-complex belong to the more inclusive *Pheidole flavens*-group as defined by Wilson (2003). This larger *flavens*-group is not monophyletic, and is itself in need of taxonomic revision.

The *Pheidole flavens*-complex has been expanding its geographic range in recent years. One species, often reported as *Pheidole flavens* Roger or its junior synonym *P. greggi* Naves, is considered introduced in Florida, Louisiana (Dash and Hooper-Bùi 2008) and Texas (O'Keefe et al. 2000). A second species, referred to as *P. moerens* Wheeler, was first reported as introduced

in the United States by M.R. Smith (1967). This species is now recorded from Alabama (Glancey et al. 1976; Smith 1967), California (Garrison 1996; Martínez 1997), Florida (Deyrup et al. 1988; Deyrup et al. 2000; Wojcik et al. 1975), Louisiana (Dash and Hooper-Bùi 2008), Mississippi (MacGown and Hill 2010), North Carolina (Guénard et al. 2012) and Texas (Wilson 2003).

Further evidence of the capacity for this species complex to spread via human mediated dispersal includes specimens collected from a tropical butterfly house in the state of Washington, USA (Antweb 2014a), numerous quarantine interception records from various ports of entry in the United States (Suarez et al. 2005) and Europe (Forel 1901). Although specimens (e.g. CASENT0173263) determined as *P. flavens* are known from the Galapagos as early as 1990 (Herrera and Roque-Albelo 2007), the first population of a *flavens*-complex species to establish in the Pacific Island region (or anywhere outside of North Americas) was reported from Hawaii (Gruner et al. 2003), and is now known to occur on at least two islands of that archipelago (Hawaii and Maui). Noting that the ant was found nesting only around California fan palms, *Washingtonia filifera* (Lindley) Wendland, in lowland nearshore areas, Gruner et al. (2003) suggested that *P. moerens* was probably imported accidentally with potted plants for horticulture.

The collection from the Vanuatuan island of Espiritu Santo is the first report of the *Pheidole flavens*-complex in the southwest Pacific (Figure 1). Preliminary morphological analysis suggests that the Vanuatu specimens (Figure 2) are not conspecific with the Hawaii specimens, and represent a second introduction of that complex from the Americas into the Pacific.

Methods

Two major workers and seven minor workers were collected by Christian Rabeling and Edward Wilson on November 10, 2011 (collection code CR111110-15) from an established colony, nesting under the bark of a rotting palm tree located next to the entrance gate to the former Ratard Plantation (currently used as a cattle ranch), 8 km SW of Luganville, located 8 m above sea level, Espiritu Santo, Vanuatu [-15.5748°, 167.1233°] (Figure 1). The collection was made on agricultural land, consisting of ranch land and interspersed coconut plantations. One specimen (CASENT0283317) was included in a recent

phylogenetic study. The study was based on genetic data from one mitochondrial loci and eight nuclear loci. The analysis placed the Vanuatu species within a well-supported monophyletic clade that includes specimens previously determined as *P. moerens* Wheeler from the Dominican Republic and *P. flavens* Roger from Costa Rica. However, the more inclusive *flavens*-group as defined by Wilson (2003) (as opposed to the *flavens*-complex discussed here) was not recovered as monophyletic.

The Vanuatu specimens were compared with other *flavens*-complex taxa, including specimen images from Antweb (Antweb 2014b, Antweb 2014c) and Antwiki (<http://antwiki.org>) of type material for *P. flavens* Roger, *P. moerens* Wheeler and many of their junior synonyms. Physical specimens of material referred to as *P. moerens* from Hawaii and Dominican Republic, and *P. flavens* from Costa Rica were also examined. Observations were made at 40x magnification with a dissecting scope. Measurements were made with a micrometer stage with digital output in increments of 0.001 mm, and rounded to 0.01 mm. All measurements are reported in mm and follow the definitions given in Sarnat (2008).

Digital color images were created using a Leica DFC425 digital camera and Leica Application Suite software (ver. 3.8). The specimen photographs and collection data are available from Antweb (<http://www.antweb.org>) by searching the collection code (CR111110-15) or specimen codes (CASENT0248836 major worker, CASENT0248835 minor worker). These specimens, together with CASENT0283317, serve as vouchers and future updates of the taxonomic name applied to these specimens can be cross-referenced by entering the specimen codes into Antweb.

Results

Measurements of the Vanuatu specimens are listed here. Major worker (1 measured: CASENT0248836): HW 0.71, WL 0.75, SL 0.36, EL 0.9, PTW 0.10, PPW 0.15, CI 96, SI 51. Minor worker (2 measured: CASENT0248835, CASENT0282650): HW 0.40–0.42, HL 0.39–0.45, SL 0.34–0.35, EL 0.08–0.09, PTW 0.08, PPW 0.09–0.11, CI 93–99, SI 82–87.

Workers of the *Pheidole flavens*-complex reported here can be separated from other introduced *Pheidole* by the following characters.

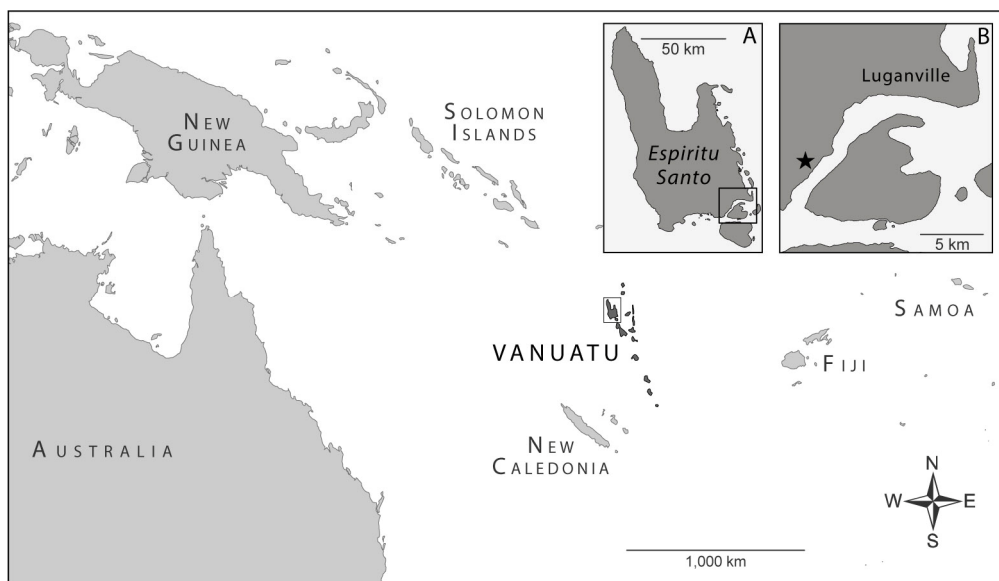


Figure 1. Map of Vanuatu and Southwest Pacific. Insert A illustrates an enlargement of Espiritu Santo, the island on which the collection was made. Insert B illustrates an enlargement of the Luganville area of southeastern Espiritu Santo, with a star symbol marking the collection site.

Major workers (Figure 2, Plate 1) | Color light brown yellow to dark red brown. Head rectangular shaped. Posterolateral lobes with varying amounts of rugulae and rugoreticula, but posterior head margin always free of distinct rugulae or rugoreticulum. Promesonotal dorsum variously sculptured (including transversely striate, foveolate or both), but never strongly rugoreticulate with distinct long longitudinal striae. Postpetiole relatively narrow; distinctly less than 2x petiolar width in dorsal view. Gaster with entire first tergite smooth and shiny. **Minor workers** (Figure 2, Plate 2) | Color light brown yellow to dark red brown. Dorsal surface of head entirely covered by reticulated network of punctures; occasionally with short lengths of indistinct longitudinal rugulae. Frontal carinae not distinct posterior to eye level. Antennal scapes with erect to suberect hairs; scapes reach posterior head margin but do not surpass it by a distance equal to or greater than eye length. Pronotal humeri not angular. Postpetiole narrow; distinctly less than 2x petiolar width in dorsal view. Hairs on mesosoma fine, flexuous, of unequal length and not arranged in pairs.

The strongly punctate minor workers of the *Pheidole flavens*-complex species can be easily confused with several other tramp ants. *Pheidole anastasii* Emery, *P. bilimeki* Mayr and *P.*

punctatissima Mayr are also Neotropical natives and likely close relatives. *Pheidole bilimeki* is placed in the *flavens* species group (Wilson 2003), but we do not consider it as part of the *flavens*-complex. Minor workers of the *flavens*-complex can be separated those of the aforementioned species by the following characters. Hairs on mesosoma fine, flexuous, of unequal length and not arranged in pairs *versus* hairs on mesosoma stout, stiff, of equal length and arranged in pairs. Antennal scapes with erect to suberect hairs *versus* antennal scapes with decumbent to subdecumbent hairs. Antennal scapes reach posterior head margin but do not surpass it by a distance equal to or greater than eye length *versus* antennal scapes surpass posterior head margin by a distance equal to or greater than eye. Gaster with entire first tergite smooth and shining *versus* gaster with at least anterior 1/3 of first tergite shagreened.

Minor workers of the *flavens*-complex can also be confused with those of the tramp ant, *P. parva* Mayr that is native to Asia. They can be separated by the following characters. Many short to medium length segments of striae distinctly interlaced among punctate ground sculpture lacking *versus* present. Antennal scapes often, but not always, surpass posterior head margin *versus* never surpassing head margin. Pronotal humeri indistinct *versus* protuberant.

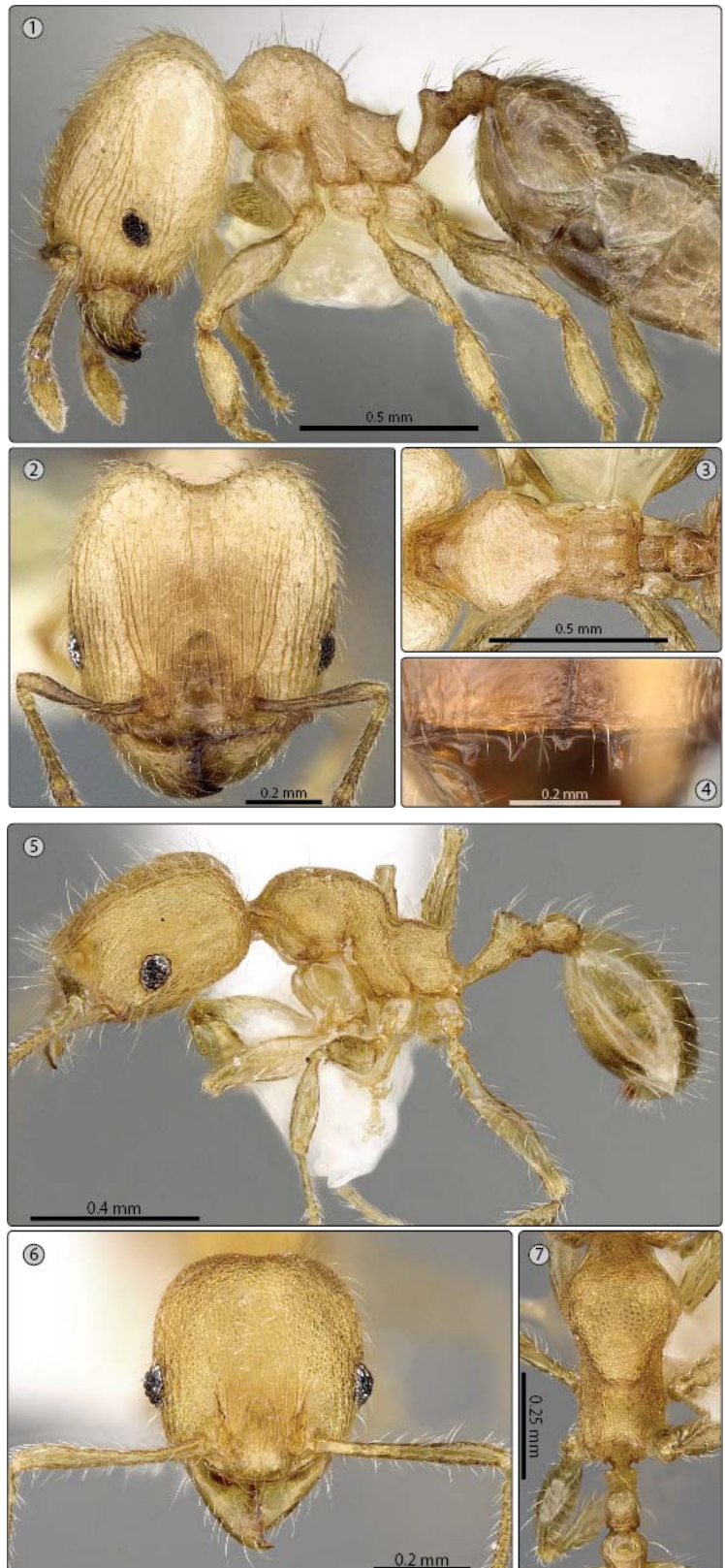


Figure 2. Plate 1: Major worker of a species from the *Pheidole flavens*-complex from Espiritu Santo, Vanuatu; collection code CR111110-15, specimen code CASENT0248836. (1) Lateral view, (2) full-face view, (3) dorsal view, (4) hypostomal bridge. **Plate 2:** Minor worker of a species from the *Pheidole flavens*-complex from Espiritu Santo, Vanuatu; collection code CR111110-15, specimen code CASENT0248835. (5) Lateral view, (6) full-face view, (7) dorsal view. Photographs by Eli Sarnat.

The Vanuatu *flavens*-complex specimens differ from the examined Hawaii *flavens*-complex specimens. The color of both the major and minor workers is pale yellow *versus* dark reddish brown. However, color is known to vary in *flavens*-complex species, even among conspecifics (Naves 1985), thus this character requires additional scrutiny if more material becomes available. The following characters refer only to the major workers. The frontal carinae are relatively weak and are interrupted along their length *versus* relatively strong and unbroken along their length. Distinct transverse striations on the pronotal dorsum absent *versus* present. Size is smaller (HW < 0.75 mm *versus* HW > 0.80 mm). Head wider (CI 96 *versus* CI 92–93).

All *flavens*-complex taxa introduced in the Pacific can easily be differentiated from *P. megacephala*, the most destructive and invasive member of the genus. The postpetiole of both major and minor workers of *P. flavens*-complex is not swollen relative to the petiole, *versus* postpetiole swollen relative to petiole in *P. megacephala*. The major workers of *P. flavens*-complex have rectangular heads with distinct longitudinal rugae and punctations on the posterolateral lobes, *versus* heart-shaped heads that are completely smooth and shining on the posterolateral lobes in *P. megacephala*. The minor workers of *P. flavens*-complex have entirely punctate heads giving them a dull appearance, *versus* completely smooth and shining heads in *P. megacephala*.

Discussion

Although the collection of *Pheidole flavens*-complex from Vanuatu is the most western occurrence reported to date, there is no evidence that the species is particularly noxious or that failing to eradicate it will precipitate significant damage to the ecosystems, public health or agriculture of Pacific Island nations. We do however caution that seemingly benign introductions can eventually turn into serious pests. As of November 2011, the collection evidence suggests the population on Espiritu Santo is best classified in the C3 category of biological invasion proposed by Blackburn et al. (2011), defined as: Individuals surviving in the wild in location where introduced, reproduction occurring, and population self-sustaining. The Ratard Ranch collection was the only collection of the 2011 survey to include specimens of the species.

Ratard Ranch is located 8 km southwest of Luganville. Luganville is the only international seaport on the Espiritu Santo and is the most likely point of introduction. There is no direct evidence that that the species is surviving (e.g. D1 in the Blackburn et al. framework) or reproducing (e.g. D2) a significant distance from the original point of introduction. However, the habitat this species was collected in (plantation converted to cattle ranch) is quite common across the Pacific Islands, especially in the vicinity of other ports, and there will likely be many opportunities for further introductions in the Pacific should the Vanuatu population continue to survive.

Forecasting the potential effects of this new introduction and its consequences for the region as a whole would be made easier if the identity of the species could be ascertained. A molecular based revision of the *P. flavens*-complex that includes sampling from across its known native and introduced range would significantly advance the study of this difficult lineage's taxonomy and invasion biology. At present, the taxonomy of the *flavens*-complex in its current state is too confused to confidently apply a valid name to the species that has become established in Vanuatu. Other invasive pest ant species, such as the little fire ant *Wasmannia auropunctata* and the bigheaded ant *Pheidole megacephala*, have already been introduced to Vanuatu, suggesting that ant species are frequently dispersed by humans in the South Pacific.

Perhaps the most pressing question is whether the Vanuatu population is conspecific with the species reported as *P. moerens* that is spreading across the United States (southeastern North America, California and Hawaii). Specimens examined from these three localities share consistent morphological features that the Vanuatu specimens lack—namely the dark reddish brown color of both majors and minors, the strong frontal carinae of the majors that are unbroken along their length, the distinct transverse striations on the pronotal dorsum of the majors, and the larger size and relatively narrower heads of the majors. However, color alone may not be a reliable character for species-level diagnosis (Naves 1985).

Preliminary morphological analysis suggests that the population from Vanuatu is potentially a different species than the dark form from the United States, or at the very least is derived from a different native population. Examination of

specimen photographs of the *P. moerens* holotype from Puerto Rico also calls into questions whether this dark form actually belongs to *P. moerens* Roger, to *P. flavens* Wheeler, or possibly to one of the infraspecific names that were recently synonymized with *P. flavens* (Wilson 2003). A molecular based revision of the *P. flavens*-complex that includes sampling from across its known native and introduced range would significantly advance the study of this difficult lineage's taxonomy and invasion biology.

Taxonomy aside, the dark form shows some potential for invasiveness. In addition to the recent long-distance dispersal events to California and Hawaii, it was listed in the "Possible Ecological Villains" section in Deyrup et al. (2000), which were defined as, "...exotic species that are abundant in both disturbed and undisturbed habitats, and appear to dominate their trophic roles, thus possibly displacing native competitors, affecting populations of native prey species, and having various indirect effects." These authors suggested that *P. moerens* could compete for nest sites with native species in the genera *Strumigenys*, *Nylanderia*, *Solenopsis*, *Hypoponera* and *Brachymyrmex*, and also proposed that dense populations of this species have some effect on native insects that serve as prey. (Deyrup and Trager (1986)) included *P. moerens* among the ants that appear to have, "...spread explosively through all or part of Florida in the last 50 years." Moreover, occurrence records listed here demonstrate that the species is spreading rapidly across the southeastern United States.

While the ant species reported here from Vanuatu is potentially not conspecific with the dark form spreading across the United States (including Hawaii), they are close relatives and both belong to *Pheidole flavens*-complex. This species complex has shown a propensity for human-mediated dispersal, and its success in spreading across the Caribbean islands could potentially be repeated across the Pacific Islands. Additional taxonomic work on the *flavens*-complex must be completed before valid names can be confidently applied to any of the introduced taxa, and additional ecological work is required before the effects of these taxa on native species can be ascertained. In the meantime we encourage quarantine staff and entomologists working in the Pacific to watch for new incursions, and we hope the photographs and morphological characters presented in this paper will assist in those efforts.

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