



## A new species of *Vespula*, and first record of *Vespa crabro* L. (Hymenoptera: Vespidae) from Guatemala, Central America

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### Abstract

*Vespula akrei* Landolt **sp. nov.** is described from Guatemala. The first record of *Vespa crabro* L. in Guatemala is given, and *Vespula inexpectata* Eck from Mexico is re-described. We place *Vespula akrei* **sp. nov.** in the *Vespula vulgaris* (L.) species group (= *Paravespula* Bluthgen) based on morphology, color pattern, and DNA sequences from two mitochondrial genes. It is presently known only from the Sierra de las Minas mountain range in southeastern Guatemala.

**Key words:** *Vespula*, yellowjacket, Vespidae, Neotropical Region, wasp, new species, Guatemala

### Resumen

Se describe la avispa *Vespula akrei* Landolt **sp. nov.** de Guatemala, se registra por primera vez la presencia en Guatemala de *Vespa crabro* L., y se re-describe *Vespula inexpectata* Eck de México. Basados en la morfología, el patrón de coloración y el análisis de secuencias de ADN mitocondrial se ubica a *Vespula akrei* **sp. nov.** en el grupo de especies de *Vespula vulgaris* (L.) (= *Paravespula* Bluthgen). La distribución actualmente conocida de *V. akrei* es la cadena montañosa de la Sierra de las Minas en el Sureste de Guatemala

### Introduction

Five yellowjacket and hornet specimens (Hymenoptera: Vespidae; Vespinae) were located in May 2005 in an unsorted collection of Hymenoptera at the Universidad del Valle de Guatemala, Guatemala City. Two were determined to be *Vespula squamosa* (Drury), which was reported by Landolt *et al.* (2009). A third specimen was determined to be a worker of *Vespa crabro* L., a new country record. We were unable to determine the two remaining specimens, which upon further study and the collection and location of additional material, are included in this paper as a new species.

The two undetermined specimens, a male and a worker, bore labels for Zacapa Department, the towns of San Lorenzo and Jones, respectively. These two towns are within and at the southern base, respectively of the Sierra de las Minas mountain range. This range runs west to east across much of southeastern Guatemala, and portions of it are within the protected Reserva de Biósfera Sierra de las Minas. Initial efforts by us to collect specimens of that wasp from that mountain range, at elevations of 300 to 1900 m in elevation near San Lorenzo, were unsuccessful. However, specimens were captured at a 2200 m elevation site approximately 12 km north of San Lorenzo, in April and May 2008, and again in May 2010. Additional specimens were then collected at a similar elevation site to the west of San Lorenzo on Cerro Piñalon in El Progreso Department. A specimen which had been collected near San Lorenzo was also located in the Entomology Collection of the Royal Alberta Museum, Alberta, Canada.

In order to determine if the wasps from Guatemala are distinct from *Vespula inexpectata* Eck, which was described from central Mexico (Eck 1994), we studied the type and a paratype of that species. In this paper, we re-describe *V. inexpectata* in order to provide a more direct comparison to the material from Guatemala. In order to better understand the relationship of the new Guatemalan species to the widely recognized species groups within the genus *Vespula* (Bequaert 1930, Jacobson *et al.* 1978, Akre *et al.* 1980), mitochondrial DNA sequences were obtained from specimens of the new species from Guatemala and from North American specimens of *Vespula acadica* (Sladen), *V. alascensis* (Packard), *V. intermedia* (du Buysson) (= *rufa* L.), *V. maculifrons* (du Buysson), and *V. squamosa*, as well as *Dolichovespula arenaria* (Fabricius). The name *V. alascensis* is recently assigned to Nearctic yellowjackets previously considered to be *V. vulgaris*, which applies to Palearctic specimens and populations introduced into Australia and New Zealand (Carpenter and Glare 2010).

***Vespula akrei* Landolt sp. nov.**

(Figs. 1A, B, C, D)

**Diagnosis.** *Vespula akrei* can be differentiated from *V. squamosa*, the only other currently known species of *Vespula* in Guatemala, by the all black mesonotum, all black antennae, absence of an orange tinge to the yellow of the gaster, black forecoxae, and differing gastral pattern (Fig. 1A). *Vespula akrei* can be differentiated from *V. maculifrons*, which is genetically close, generally by the oval to oblong yellow marks within the black band of the first gastral tergum, and by the all black forecoxae, all black sixth gastral sternum and tergum, and relatively heavy black margin of the clypeal apex. There is much variation in the coloration of *V. maculifrons*, including a coloration pattern on the first gastral tergum like that of *V. akrei* (Jacobson *et al.* 1978). Gastral terga 2 to 5 of *V. maculifrons* also possess lateral black spots that are partially enclosed within the anterior black band of each tergum (figured by Jacobson *et al.* 1978). Such lateral black spots are mostly absent in *V. akrei*. *Vespula akrei* can be differentiated from *V. inexpectata* by the yellow spots within the black band on gastral tergum 1, by the absence of lateral black spots partially enclosed within the black bands of gastral terga 2 to 5, the complete yellow genal band, and the ocular sinus completely filled with yellow.

**Description.** Worker female: Head yellow and black. Vertex mostly black, with ocular sinus completely yellow and continuing downward along the inner margin of eye to clypeus. Gena yellow anteriorly from vertex to base of mandible and black along posterior margin. Carina of gena complete from vertex to base of mandible. Antenna black. Frons mostly yellow with medial black marking contiguous with black marking on clypeus, and vertical black stripe encompassing each antennal lobe. Clypeus yellow with a medial vertical black mark extending from near antennal base to 2/3 of distance to bottom or distal margin of clypeus. Lower clypeal margin heavily marked with black on the protruding apex. Oculo-malar space short, less than width of antennal scape, black. Mandible yellow. Vertex, frons, clypeus, gena, and mandible dorsally with long black hairs.

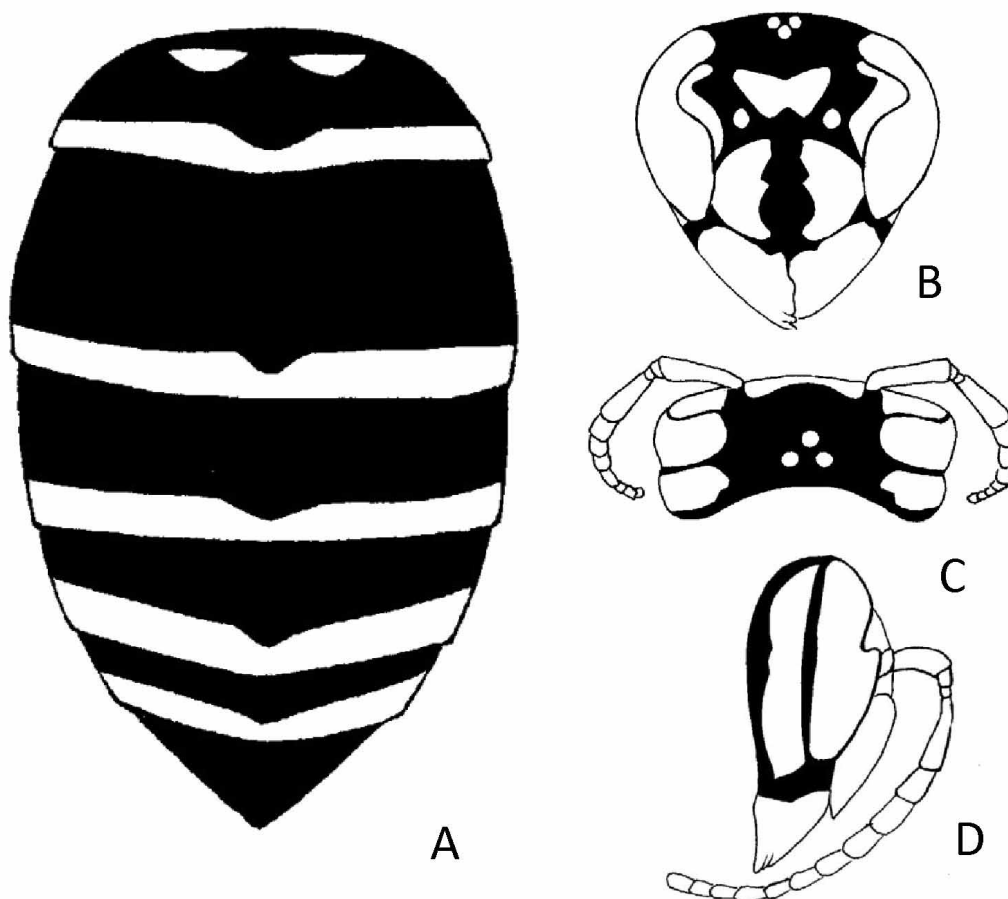
Thorax mostly black with yellow markings. Pronotum black with yellow border along mesonotum. Mesonotum entirely black. Dorsal-most area of mesepisternum adjacent to posterior-most pronotal margin yellow. Fore wing tegula yellow posteriorly. Two elongate yellow markings on anterior of scutellum and two elongate yellow markings on anterior of metanotum. Hind wing tegula yellow. Fore coxa black to dark brown, femur yellow except black mark on dorsum of femoral base and black stripe anteriorly, tibia orange-yellow with light brown marking dorsally, tarsus orange-yellow. Mid coxa yellow, femur yellow except black marking on dorsum of femoral base, tibia yellow, tarsus orange-yellow. Hind coxa black with yellow marking dorsally, femur yellow except ventral black area at base, tibia yellow-brown with longitudinal dark brown area dorsally, tarsus light orange-yellow. Thorax and femur with long black hairs. Propodeum black. Forewing length  $6.4 \pm 0.2$  (?  $\pm$  SE) mm, range 6.0 to 6.9 mm (n = 5).

Gaster black and yellow, with segments 1 to 5 black proximally and yellow distally. Yellow tergal bands of segments 1 to 4 of roughly equal width. First tergum with two yellow oval spots on either side of midline of black band dorsally. Midline of dorsum of each black band of terga 1 to 5 with narrow posterior extension into

the yellow band. Gastral sterna 2–5 with black spots extending posteriorly from each black band well into yellow band. For gastral sternum 2, this black spot is connected to the black band with an area of red-brown. Tergum 1 of gaster with long light brown hairs.

Queen: Coloration as in worker with the following exceptions. Pronotum posteriorly with yellow mark bordering yellow area of mesopleuron. Yellow areas of scutellum and metanotum expanded compared to workers, with metanotum yellow marks meeting at mid-line of dorsum, forming single transverse yellow band narrowed medially. Gastral tergum and sternum 6 black with yellow distally. Forewing length  $8.2 \pm 0.1$  (mean  $\pm$  SE) mm, range 7.7 to 8.5 mm (n = 5).

Male: Coloration of vertex, gena and mandibles as in worker. Frons mostly yellow with black diamond-shaped mark midway between antennal sockets. Clypeus yellow except for brown distal edge and black distal lateral extensions. Ocular malar space black, equal in length to width of antennal scape. Antennae black, except for small yellow spot distally on anterior of scape. Thorax black, as in worker. No yellow at posterior-most margin of the pronotum. Yellow on scutellum and metanotum reduced in comparison to worker and queen, with considerable black at mid-dorsum separating yellow markings. Gaster black and yellow, with each segment black anteriorly and yellow posteriorly. Yellow gastral bands of similar widths for segments 2–6. Gastral tergum 7 black with two small round yellow spots. Unlike females, there are no yellow spots within black area of gastral tergum 1. First gaster tergum with numerous long light colored hairs. Broad lateral reddish colored area bordering black area of first gastral sternum, and less pronounced red coloration in the black areas of other gastral sterna, as well as the most lateral area of tergum 2. Forewing length 7.3 mm (n = 1).



**FIGURE 1.** *Vespula akrei* sp. nov. A. gastral coloration, dorsal view, B. frontal view of head, C. dorsal view of head, and D. lateral view of head.

**Type material.** Holotype. The holotype worker is labeled “GUATEMALA, Zacapa, 12 km north of San Lorenzo, N15°06.86' W89°40.82', 2200 m. elev. Jose Monzon 14–20 April 2008/HOLOTYPE *Vespula akrei* Landolt 2010 [red label].” The Holotype is deposited in the entomological collection of the Universidad del Valle de Guatemala, Guatemala City, Guatemala.

Paratypes. Four workers, same data as holotype; 1 worker, GUATEMALA, Zacapa, above San Lorenzo, 2100 m elev, Sept. 1986, M. Sharkey; 1 worker, GUATEMALA, Zacapa Sierra de las Minas 12 km N of San Lorenzo, N15°06.86' W89°40.82', 2200 m elev., May 4–6, 2008, Peter J. Landolt, collector; 28 workers, GUATEMALA, Zacapa, Sierra de las Minas, 2250 m, San Lorenzo, Cerro Monos, 19–21 May 2010, N°15 116' W°89.685', J. Monzon, B. Sutton, G. Steck, and P. Skelley; 4 workers, GUATEMALA, El Progreso, Cerro Piñalon, Bosque pino, 2,219 m, 16–18 May 2010, N°15.073' W° 89.948', J. Monzon, B. Sutton, G. Steck, and P. Skelley; 3 queens, GUATEMALA, Zacapa Dept., ca 8 km NW of San Lorenzo, ca 27 km from CA-9 turn-off N15°06.959' W89°40.686', 4 May 2008, 2130 m, R. S. Zack, P. J. Landolt, & J. Monzon, coll.; 1 queen, same data as preceding except 5 May 2008; 2 queens, GUATEMALA, Zacapa, Sierra de las Minas, 2250 m, San Lorenzo, Cerro Monos, 19–21 May 2010, N°15 116' W°89.685', J. Monzon, B. Sutton, G. Steck, and P. Skelley, Paratypes are deposited in the James Entomological Collection, Washington State University, the Universidad del Valle de Guatemala, the Smithsonian Institution, the American Museum of Natural History, Florida State Collection of Arthropods, the Royal Alberta Museum, and the collections of Peter J. Landolt and José Monzón Sierra.

**Other specimens examined.** One worker. GUATEMALA, Zacapa, Jones, Rio Colorado, 500 m, F. Garcia 23/III/1996. One male. GUATEMALA, Zacapa, Sierra de las Minas 16-V-1987. L. M. Giron. Both specimens are in the entomological collection of the Universidad del Valle de Guatemala, Guatemala City.

**Distribution and habitat notes.** Nearctic: Guatemala. The species currently is known only from the Sierra de las Minas mountain range, Zacapa and El Progreso Departments within the Reserva de Biósfera de las Minas. The type habitat is at an elevation near 2200 m in a cloud forest with primarily broad leaf trees with some pines and a dense woody understory. The habitat at Cerro Piñalon is similar but with more extensive pine trees. The label localities for the two specimens collected previous to the type series are the towns of San Lorenzo and Jones. San Lorenzo is at an elevation of 1800 m but its surrounding habitat is open pine forest and grassland with little other vegetation. Jones is much lower in elevation, circa 500 m, and is in a dry rain shadow of the mountain range, with the dominant vegetation comprised of short seasonally deciduous trees and shrubs. It is doubtful that the specimens were collected in these towns and the locality labels for these two specimens probably indicate the towns that are nearest to the collection sites, rather than the specific collection sites themselves.

Most of the workers of *V. akrei* were captured in a malaise-type interception trap suspended across small dirt roads. One worker was netted while it hovered in thick underbrush in a forested area along a road. Three queens collected in 2008 were on flowers of a single unidentified shrub, while queens collected in 2010 were in the interception trap.

*Vespula squamosa* was also present at the type locality.

*V. akrei* currently is known only from a small area in Zacapa and adjacent El Progreso Departments, with the distribution at high elevations within the Sierra de las Minas mountain range, and within the Reserva de la Biósfera Sierra de las Minas. The species may also occur at other moist, high elevation sites in Guatemala but access to these areas generally is difficult.

**Etymology.** The species epithet, *akrei*, is in honor of our (PJL & RSZ) late mentor and friend, Roger D. Akre, who added so much to our understanding of the genus *Vespula*.

**Placement of *Vespula akrei*.** This species is aligned with the *V. vulgaris* species group (Bequaert 1930), based on the following key criteria indicated for *Paravespula* Blüthgen by Archer (1989a, b, c). The occipital carina is complete along the posterior margin of the head from the vertex to the base of the mandible. The first gastral tergum possesses numerous long pale hairs. There are no longitudinal stripes on the mesoscutum and the antennae are completely black. We have no information on the colony cycle, colony size, or foraging habits of *V. akrei*.

DNA sequences also assist in the placement of *V. akrei* within *Vespula*. A total of nine specimens, including one *V. acadica*, two *V. akrei*, one *V. alascensis*, one *V. intermedia*, two *V. maculifrons*, one *V. squamosa*, and one *D. arenaria* were used for sequencing of portions of two mtDNA genes. Following methods presented in Horton *et al.* (2008), DNA was extracted from three legs of each specimen with DNAeasy Blood and Tissue Kit (Qiagen Inc., Valencia, CA). Target regions of the genes were amplified using universal primers for CO1 (C-J-1718, C--2151) and cytB (CB-J-10933, CB--11367) (Simon *et al.* 1994). Products were cleaned with exoSAP (USB Corp., Cleveland, OH) and sequenced using the same primers. Sequences were trimmed and aligned using CLUSTALW in Bioedit (Hall 1999). DNA sequences are provided in Genbank as accessions HM031092-HM031100 for 472 bp of CO1 and HM031083-HM031091 for 433 bp of cytB.

Phylogenetic hypotheses for the combined 905 bp of mtDNA sequence (CO1 and cytB genes) were developed using a neighbor joining distance method with MEGA-4 (p distance; gamma distributed substitutions, k=0.07, 10,000 bootstrap replicates [Tamura *et al.* 2007]) and maximum parsimony as implemented in TNT (one technology sector search, find best tree 20 times, 34,540 trees examined, symmetric resampling p=33 and 10,000 replicates; [Goboloff *et al.* 2008]). Data were also analyzed with PAUP4 (Swofford 2003) and MrBayes 3.1 (Ronquist and Huelsenbeck 2003) testing gene-specific partitions and all base pair combinations. In all cases, *D. arenaria* was used to root the tree depicted and as an outgroup in parsimony analyses. The single phylogram presented in Fig. 3, with the shape of the tree (branch distances) defined by the NJ analysis shows the cladogram seen with all four methods of analysis. Statistics along branches of the tree were derived from NJ/TNT analyses. The number above the branch is the number of bp differences/number of synapomorphies. The number below the branch is the bootstrap support calculation/the symmetric sampling support calculation). The results show 100% support for the distinct clade for *V. akrei*, for the *V. akrei* plus *V. maculifrons* clade, and for the *V. akrei* plus *V. maculifrons* plus *V. alascensis* clade, placing *V. akrei* in the *V. vulgaris* species group. *Vespula maculifrons* and *V. alascensis* are closely allied to *Vespula vulgaris* L., and within the *V. vulgaris* species group (Bequaert 1930; Carpenter 1987, Carpenter and Perera 2006). The clade containing *V. acadica* and *V. intermedia*, members of the *V. rufa* species group (Bequaert 1930; Carpenter 1987) is also well supported. Addition of *V. squamosa* to this clade reduces support, and is not consistent with the placement of *V. squamosa* in the *V. rufa* group. Carpenter (1987) placed *V. squamosa* in a separate sister group with *Vespula sulphurea* (de Saussure). The differences seen between *V. akrei* and *V. maculifrons* were 26 bp substitutions (23 in CO1 and 3 in cytB), 15-16 of which were synapomorphies, and no amino acid substitutions (data not shown). The CO1 473 bp sequence for *V. akrei* shows 23 bp differences (4.9%) from the most closely related species that we sequenced (*V. maculifrons*), and similar distances from sequences of five other *V. maculifrons* in genbank. This represents a significant gap, and is greater than that observed for CO1 differences between *V. acadica* and *V. intermedia* (2.75%) for example.

### ***Vespula inexpectata* Eck 1994**

(Figs. 2A, B, C, D)

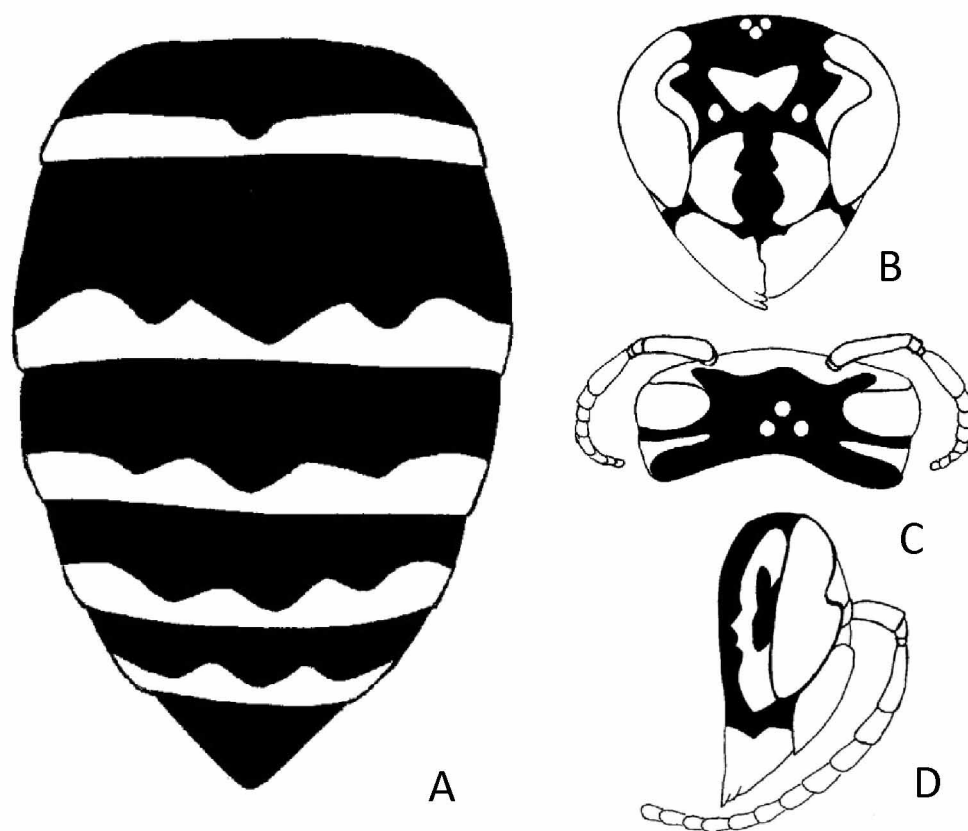
**Description.** Head yellow and black. Antenna black. Vertex mostly black and ocular sinus mostly yellow with a black intrusion. Yellow extending down from ocular sinus between eye and antennal base. Gena yellow anteriorly from near top of eye to near mandible, but interrupted midway by patch of black, and black along entire posterior margin. Frons yellow from eye to eye, with a butterfly-shaped black mark centrally positioned. Carina of gena is complete from vertex to base of mandible. Clypeus yellow with central black patch from top to bottom, and black border at top as well as at bottom of clypeus only along protruding apex. Oculo-malar space short, less than the width of the antennal scape, and black. Mandible yellow.

Thorax mostly black with yellow markings. Pronotum black with yellow border at mesonotum. Mesonotum entirely black. Mesopleuron black with yellow patch beneath wing. Metanotum black with two yellow patches at lateral proximal corners. Coxae black. Fore leg with femur mostly black with yellow-brown distally, tibia yellow brown with two darker brown longitudinal marks, and tarsi light brown. Mid leg with

femur nearly all black with some yellow brown distally, tibia yellow brown with two dark brown longitudinal markings. Tarsi light brown. Hind leg with femur nearly all black with some yellow-brown distally, tibia mostly dark brown with yellow patches. Tarsi light brown.

Propodeum black with yellow patch at each lateral proximal corner of dorsum. Gaster with each segment possessing black band proximally and yellow band distally. Yellow bands of gastral terga 2 to 5 of similar width. Yellow band of gastral tergum 1 narrower. Gaster segment 6 nearly entirely black, with some dark brown distally. Midline of dorsum of each black band with narrow posterior extension into yellow band.

**Material examined.** The holotype queen is labeled "W. Slope Popoca-Tepetl Mx. MEX. V-19'59 -10000' H. E. Evans/*Vespula* (*V*) *vulgaris* Linnaeus) Det. 1960 C. D. Miller/HOLOTYPUS *Vespula inexpectata* det. R. Eck 1994/Holotype Cornell U. No. 6907." The specimen is in good condition; holotype label is red and hand-written except for HOLOTYPUS, which is printed; it is deposited in the Cornell University Insect Collection. A worker paratype is labeled "MEXICO Mexico #16 13 mi. E. Sta. Barbara 16 Aug. 1969 10200' George W. Byers/Paratype/det. R. Eck 1994." The specimen is in good condition and is deposited in the Snow Entomological Collection at the University of Kansas.



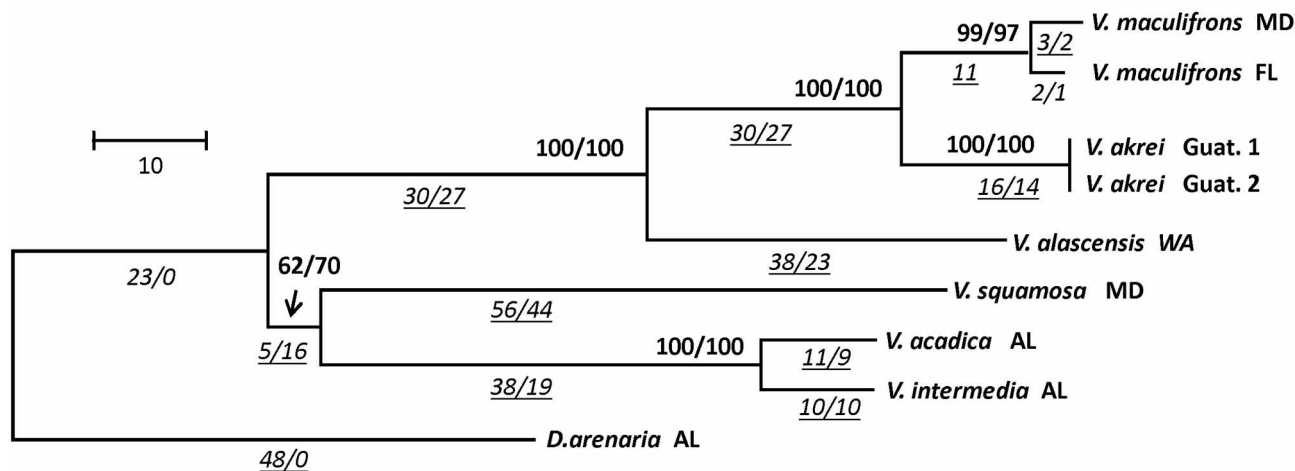
**FIGURE 2.** *Vespula inexpectata* A. gastral coloration, dorsal view; B. frontal view of head, C. dorsal view of head, and D. lateral view of head.

***Vespa crabro*.** A worker of *V. crabro* was located in the Entomological Collection of the Universidad del Valle de Guatemala. The collection locality is Guatemala City. *Vespa crabro* is widely distributed in temperate areas of Europe and Asia (Carpenter and Kojima 1997) and has been introduced into eastern North America where it is now widespread (Shaw and Weidhaus 1956). This Guatemalan specimen may have been an accidental introduction and *V. crabro* is not known to be established in Guatemala.

**Vespinae of Central America.** Eight species of *Vespula* are now reported south of the U.S. border; in Mexico and Central America. Carpenter and Kojima (1997) cite Mexican collection records for *V. atropilosa* (Sladen), *V. pennsylvanica*, and *V. sulphurea* (Saussure) in northwest Mexico (Baja California Norte), *V. maculifrons* in northeast Mexico, *V. vulgaris* (= *V. alascensis*) in the central highlands, *V. squamosa* from the

Texas border south through Mexico and in Guatemala, and *V. inexpectata* from two sites in central Mexico. *Vespula squamosa* is also reported from Honduras (Hunt *et al.* 2001) and Landolt *et al.* (2009) report records for the same species in Guatemala. We herein report *Vespula akrei* **sp. nov.** in Guatemala.

Adventive species of *Vespa* are not yet known to be established in the Americas south of Georgia (United States). A single specimen of *Vespa orientalis* L. was recently reported from Cozumel on the Pacific coast of Mexico (Dvorak 2006) and we report a single specimen of *V. crabro* from Guatemala City, but there is no evidence of establishment of either species at these sites.



**FIGURE 3.** Neighbor joining tree for eight *Vespula* specimens and *Dolichovespula arenaria* as an outgroup. Abbreviations for the United States, state where the specimen was collected is shown after the species name; Guat = Guatemala. The top five are all members of the *V. vulgaris* species group and show the close relationship of *V. akrei* to *V. maculifrons*. The bottom three are all members of the *V. rufa* species group. Trees were derived from 905 bp of mtDNA (472 bp from CO1 and 433 bp of cytB). Numbers in bold above a branch are percent support by bootstrap/percent support by symmetric resampling for various clades, and numbers in italics below a branch are the number of substitutions/number of synaporphies along that branch. The tree was rooted on a specimen of *Dolichovespula arenaria* from Alaska. Tree topologies were qualitatively identical using four distinct phylogenetic algorithms (see text for methods).

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