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FIRST RECORD OF FIVE ANT SPECIES (HYMENOPTERA: FORMICIDAE) FROM RWANDA

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ABSTRACT

Ant studies conducted in Rwanda have reported a total of 105 ant species. However, this is an underestimation of the total ant richness since Rwanda is in a region rich in biodiversity. To fill the gaps, ants have been sampled in planted forests, coffee plantations, and different other land use types since 2017. Specimens have been collected using pitfall traps and hand collection, digitized, and identified to subfamily, genus, and species level. Results indicated that five ant species were found in Rwanda for the first time. These are *Camponotus acvapimensis, Camponotus schoutedeni*, *Camponotus sericeus*, *Odontomachus assiniensis* and *Tetramorium sericeiventre.* Specimens are deposited at the Royal Belgian Institute of Natural Science and the Rwanda Ant Collection. We recommend more ant studies focussing on their mode of living. This will result in more ant species newly recorded in the country and possibly new to science.

Keywords: Arthropoda, Insecta, Ant Species, Sampling, Rwanda, First Records

INTRODUCTION

Rwanda is located in the highlands of the Albertine Rift, an important ecosystem in the eastern and central Afrotropical region. It is a generally mountainous region heavily dissected by a complex network of rivers, lakes, and wetlands (REMA, 2022). Rwanda's landscapes and natural forests are very rich in biodiversity including numerous plants and animals that are endemic (GoR, 2022). The diverse ecosystems range from humid montane and planted forests to savannahs, water resources and wetlands. In terms of biodiversity, Rwanda is home to 402 mammal species, 1061 bird species, 293 reptiles and amphibians and 5793 higher plant species (REMA, 2019). Some studies on soil and leaf-litter arthropods have been conducted but mostly they have been limited mainly to the family level (Nsengimana *et al.*, 2021; 2022; 2023).

Only a few studies focused on species level, namely Odonata (Uyizeye *et al.*, 2021), Lepidoptera (Uwizelimana *et al.*, 2022b, 2022a) and ants [Hymenoptera: Formicidae] (Nsengimana *et al.*, 2018; Nsengimana & Dekoninck, 2021; Nsengimana *et al.*, 2021; Nsengimana *et al.*, 2023). A recent study on ants has indicated that 105 ant species are known so far from Rwanda and highlighted that this number is an underestimation because Rwanda is in a biodiversity hotspot region for many other taxonomical groups too (Nsengimana *et al.*, 2023).

Ants make a diverse and abundant group of insects used as biological indicators to monitor rehabilitated and restored lands (Andersen & Majer, 2004; Fernandes & de Souza, 2018; Nsengimana *et al.*, 2018). Their abundance and species richness predict soil conditions and may inform the status of agricultural land and crop growth (Peck *et al.*, 1998). Due to their ubiquity, ant communities can be a useful model system for studying biodiversity across different dimensions and scales (Kass *et al.*, 2022). Furthermore, ants are an important and an integral component of terrestrial ecosystems serving as seed dispersers (Martins *et al.*, 2009), form

mutualism with sap-sucking insects (Styrsky & Eubanks, 2007), and act as both predator and prey (Mirenda *et al.*, 1980). Ants contribute also to the decomposition of soil nutrients and soil turnover (Frouz & Jilková, 2008) and are known as ecosystem engineers in soil ecosystems (Kovář *et al.*, 2013; Meyer *et al.*, 2013). In soil, they facilitate the creation and maintenance of sustainable microhabitats for other microorganisms (Robinson & Robinson, 2013; Swanson *et al.*, 2019). A study on effects of land use change on ants indicated that they respond differently compared to other groups of insects in terms of diversity and abundance (Apolinário *et al.*, 2019; Nsengimana *et al.*, 2018).

In Rwanda ants count for more than 50% of all studied individual specimens of arthropods from different land uses such as pasture (Nsengimana *et al.*, 2022), coffee, banana (Nsengimana *et al.*, 2023), and different planted tree species (Nsengimana *et al.*, 2021b). There is no doubt that more ant species new to science or new to the country will be recorded in Rwanda and that the real number of ant species is much higher compared to what is reported in the checklist of ants from Rwanda (Nsengimana & Dekoninck, 2020) and a current publication on ant species from Nyungwe tropical rain forest, Western Rwanda (Nsengimana *et al.*, 2023). This motivated us for a continuous ant sampling since 2017. The main objective was to develop the Rwanda Ant Collection (RWAC), and identify ant species that are recorded in Rwanda for the first time, or that are new to science.

MATERIALS AND METHODS

Study areas

Ant specimens have been collected in Southern Rwanda at the Arboretum of Ruhande in 2017 using pitfall traps. Sampling took place in *Senna spectabilis* (DC.) H.S.Irwin & Barneby (Plot 264), and *Calliandra calothyrsus* Meisn (plot 273) plots of tree species. Further, sampling was done in banana plantations at Rubona Agricultural Research Centre. In 2021, other ant specimens were sampled around the office of the Centre of Excellence in Biodiversity and Natural Resource Management (foraging on ground), around the office of the National Herbarium of Rwanda (foraging on a tree) and in Kigali city (foraging on ground) using hands. In 2022, specimens were collected at Mukundanyana and Rwambanda villages in the Eastern Province of Rwanda and in coffee plantations treated with organic mulches in Kigoma Sector, Southern Rwanda using pitfall traps. Furthermore, specimens were collected using hands at Musengo village, Cyeza Sector, Muhanga district, Southern Rwanda from the nest in the soil. Areas of study have been purposively selected to represent most of the land use found in Rwandan landscapes.

Identification

Collected specimens were preserved in 75% ethanol and taken to the laboratory of the Royal Belgian Institute of Natural Sciences in Belgium. There, specimens were digitized using a Canon EOS 600D Camera equipped with a Canon MP-E 65 mm and 1:2.8-5x Macro Photo Lens mounted on Stack Shot (Mertens *et al.*, 2017). Mounted specimens were first morphologically identified to subfamily and genus level (Fisher & Bolton 2016). After the identification to genus, species keys were used when available (for *Odontomachus*: Brown 1976), and specimens were identified by comparison with images on AntWeb (www.antweb.org). Only images with full information (collection, number of specimens, area of collection, and local geographic information) were considered for morphological comparison, except for the type specimen. The visited image banks of *Camponotus* were (1) collection ANTC44319, ANTWEB1025363 from Ghana (2°46'12"S, 9°44'12.01"E, elevation 225 m), (2) collection CEPF-TZ-17.4, CASENT0235421 from Tanzania (11°00'30.31"E, 39°23'24.25", elevation 170 m) and (3) collection CASENT0251578, BIO2013ds-62wp851-N from Mozambique (15°42'54.18"S, 33°46' 21.43"E, elevation 252 m).

Visited images for *Odontomachus* Latreille, 1804 were (1) collection RRS01-240, CASENT0178262 from Kakamega (Kenya) at 0°14'24"N, 34°51'36"E, elevation 1800 m; (2) collection ANTC9250, CASENT0217181 from Kakamega at 0°27'11.02"N, 34°51'49"E, elevation 1650 m; (3) collection CEPF-TZ-4.1, CASENT0235558 from Tanzania, Tanga/Koragwe at 4°54'52.42"S, 38°40'37.63"E, elevation 1006 m; (4) collection LN-RC1-Apit11, CASENT02500098 from Congo, Niari/Loucomé forest at 2°18'57.71"S, 12°48'33.26"E, elevation 683 m; (5) collection ANTC18561, CASENT0270614 from Uganda, Kabarole/Kanyawara at 0°34'0.01"N, 30°22'00.01"E, elevation 1625 m; (6) collection BLF29536, CASENT0354600 from Uganda, Kabarole/Kibare at 0°33'51.73"N, 30°21'32.08"E, elevation 1519 m; and (7) collection RT013, CASENT0785948 from South Africa, KwaZulu-Natal at 28°57'40.28"S, 31°45'20.98"E, elevation 25 m.

Ants identified as *Tetramorium* Mayr 1855 have been identified to species level using the identification key published by Hita Garcia & Fisher (2011) and the collections (1) ANTC9161, CASENT0217080 from Kenya, Kakamega at 0°20'29"N, 34°51'59"E, altitude 1650 m; (2) collection CEPF-TZ-14.1, CASENT0235773 from

Tanzania, Ndimba forest at 9°37' 37.67"S, 39°37'46.74"E, altitude 138 m; and the (3) collection BRN1-PT, CASENT0249025 from South Africa, Brenthurst Garden at 26°10' 26.65"S, 28°02'42.4"E, altitude 1739.

Names of the identified ants were confirmed by qualified myrmecologists. They are now housed at the Royal Belgian Institute of Natural Science (RBINS), Belgium and at Rwanda Ant Collection (RWAC) located in the Centre of Excellence in Biodiversity and Natural Resource Management, University of Rwanda (CoEB, UR) as follows: *Camponotus acvapimensis* (RWC129), *Camponotus schoutedeni* (RWAC130), *Camponotus sericeus* (RWAC131), *Odontomachus assiniensis* (RWAC132), and *Tetramorium sericeiventre* (RWAC133).

TAXONOMIC TREATMENT

Five ant species were recorded for the first time in Rwanda.

Camponotus acvapimensis Mayr, 1862
Material examined: RWANDA: ● Southern Rwanda, Kigoma Sector, coffee plantations, Plot 2, subplot 2, 2°28'00.0012"S, 29°37'59.9988"E, 1707m, 12/X/2021, pitfall traps, 5 workers (figure 1).

Camponotus schoutedeni Forel, 1911
Material examined: RWANDA: ● Southern Rwanda, Kigoma Sector, coffee plantations, Plot 2, subplot 2, 2°28'00.0012"S, 29°37'59.9988"E, 1707m, 14/X/2021, pitfall traps, 8 workers (figure 2).

Camponotus sericeus (Fabricius, 1798)
Material examined: RWANDA: ● Southern Rwanda, Kigoma Sector, coffee plantations, Plot 2, subplot 5, 2°28'00.0012"S, 29°37'59.9988"E, 1707m, 14/X/2021, pitfall traps, 4 workers (figure 3).

Odontomachus assiniensis Emery, 1892
Material examined: RWANDA: ● Southern Rwanda, Arboretum of Ruhande, in *Senna spectabilis*, Plot 264, 2°36'34.596"S, 29°44'20.868"E, 1737 m, 14 /VI/ 2017, pitfall traps, 10 workers ● idem in *Calliandra calothyrsus* tree species, Plot 273, 2°36'34.596"S, 29°44'20.868"E, 1737 m, 21/VI/2017, pitfall traps, 8 workers ● Rubona agricultural research centre, in banana plantations, 2°29'16.872"S, 29°46'29.604"E, 1750 m, 26/VI/2017, pitfall traps, 7 workers ● Huye, around the office of the Centre of Excellence in Biodiversity and Natural Resource Management, 2°37'04.62"S, 29°44'33"E, 1700 m, 21/X/2021, hand collection, 10 workers foraging on ground ● Huye, around the office of the National Herbarium of Rwanda, 2°37'12.468"S, 29°44'28.788"E, 1700 m, foraging on a tree, 20/X/2021, hand collection, 5 workers ● Kigali city, 1°56'09.312"S, 30°06'2.448"E, 1427 m, foraging on ground, 8/X/2021, hand collection, 6 workers ● Mukundanyana, Eastern Province, 2°19'25.9572"S, 30°31'28.5024"E, 1334 m, foraging on ground, 21/VIII/2022, pitfall traps, 5 workers ● Rwambanda villages, Eastern Province, 2°19' 20.982"S, 30°31' 35.6412"E, 1334 m, pitfall traps, 20/VIII/2022, 9 workers (figure 4).

Tetramorium sericeiventre Emery, 1877
Material examined: RWANDA: ● Southern Rwanda, Musengo village, 2°03′15.01″S, 29°47′53.02″E, 1826 m, 25/XII/2022, hand collection, 9 workers (Figure 5).

In Rwanda there is limited information on the diversity and distribution of the species in genera *Camponotus*, *Odontomachus* and *Tetramorium*. Only *Odontomachus troglodytes* Santschi, 1914 (Nsengimana *et al.*, 2018; Nsengimana & Dekoninck, 2020) has been reported in Rwanda. However, a recent review of the ant species collected from Rwanda and housed at the Royal Belgium Institute of Natural Science (IG 33.894) has indicated that this is a misidentification, and all the available specimens from Rwanda are *Odontomachus assiniensis* (Kiko Gómez. pers. com). Only eight species of *Camponotus i.e. Camponotus fulvopilosus* (De Geer, 1778), *Camponotus cinctellus* (Gerstäcker, 1859), *Camponotus flavomarginatus* Mayr, 1862, *Camponotus rufoglaucus syphax* Wheeler, 1922, *Camponotus zimmermanni* Forel, 1894, *Camponotus caesar* Forel, 1886, *Camponotus maculatus* (Fabricius, 1782) (Nsengimana & Dekoninck, 2020) and *Camponotus orinobates* Santschi, 1919 (Nsengimana *et al.*, 2023), are known from Rwanda.

a.

b.

c.

Figure 1: Major worker of Camponotus acvapimensis *(a: dorsal view, b: frontal view, c: lateral view).*

a.

b.

c.

Figure 2: Major worker of Camponotus schoutedeni *(a: dorsal view, b: frontal view, c: lateral view).*

a.

b.

c.

Figure 3: Major worker of Camponotus sericeus *(a: dorsal view, b: frontal view, c: lateral view).*

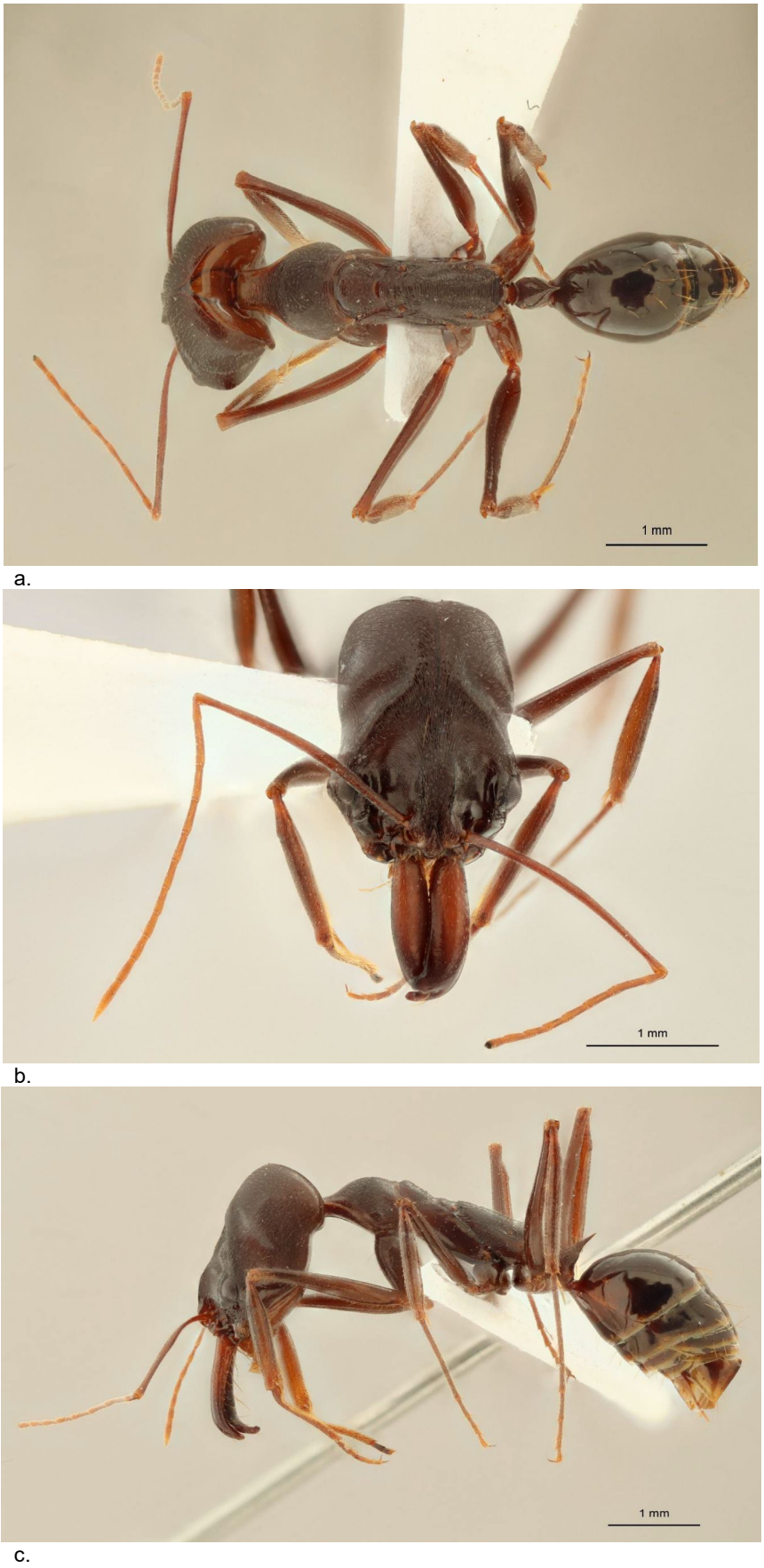

Figure 4: Worker of Odontomachus assiniensis *(a: dorsal view, b: frontal view, c: lateral view).*

a.

b.

c.

Figure 5: Worker of Tetramorium sericeiventre *(a: dorsal view, b: frontal view, c: lateral view).*

DISCUSSION

For the genus *Tetramorium*, eight species have been recorded in Rwanda so far. These are *Tetramorium aculeatum* (Mayr, 1866), *Tetramorium caldarium* (Roger, 1857), *Tetramorium candidum* Bolton, 1980, *Tetramorium edouardi* Forel, 1894, *Tetramorium metactum* Bolton, 1980, *Tetramorium simillimum* (Smith, 1851), *Tetramorium zambezium* Santschi, 1939, and *Tetramorium zonacaciae* (Weber, 1943) (Nsengimana *et al.*, 2023). However, the list might be more extensive as some species in this genus are not yet described to species level (Nsengimana *et al.*, 2023), and ant inventories in Rwanda only started recently.

The *Camponotus* species reported here have been sampled in coffee plantations treated with organic mulches. Other studies have indicated that *Camponotus acvapimensis* was recorded in different types of habitats including different types of agricultural lands, grasslands, woodlands, and forest galleries. The species is mainly found in nests under stones, foraging on ground and in tree branches (https://AntWeb.org). It may live associated with other insects such as Homoptera and mealybugs (*Pseudococcus* spp.) and occurs at an altitude ranging from 5 to 2100 m. *Camponotus schoutedeni* was recorded in agricultural lands, woodlands, and grasslands. Based on the information from AntWeb, this is the first time the species is recorded in higher altitudes as the known altitudinal range varied between 10 to 1508 m elevation. *Camponotus sericeus* was recorded in deep sandy soil, in woodlands, dry sandy riverbed, agricultural lands, savannah, grassland, and woodland at the altitude from 10 to 1949 m elevation (https://AntWeb.org).

Two *Odontomachus* species are known in the Afrotropical region, namely *Odontomachus assiniensis* Emery, 1982 and *Odontomachus troglodytes* Santschi, 1914 (Fisher and Bolton 2016; Brown 1976). The biology of *Odontomachus assiniensis* is not yet well documented and the available information is generalized to the subfamily and genus. The little information available for *Odontomachus assiniensis* shows that the species nests in rotten wood or in the ground, either under surface objects or at the bases of trees (Fisher & Bolton, 2016). Foraging is mainly on the surface of the ground and in the leaf-litter layer, but workers may also be found on trees (Brown, 1976). *Odontomachus* species are opportunist predators that take a wide range of prey but on occasion, they may also gather drops of honeydew (Fisher & Bolton, 2016). They hunt other arthropods, often termites, and a few may also hunt hemipterans (Hita Garcia *et al.*, 2013).

The *Tetramorium sericeiventre* group is primarily an Afrotropical group within the genus *Tetramorium* with around 13 valid species in the region, all of which adapted to arid or semi-arid habitats (Hita Garcia & Fisher, 2011). The species have been recorded in grassland, urban, gardens, lowland, woodland, and agricultural lands. They are mainly ground foragers establishing nest on the ground, under stones, trees, low vegetation and in the soil (Kone *et al.*, 2010). They occur at different ranges of altitudes from 2 to 2700 m elevation. Ecologically and biologically, species from this group thrive in a wide variety of open habitats, ranging from intact natural areas to sites heavily disturbed by human activities (Al-Keridis *et al.*, 2021). Further, *Tetramorium sericeiventre* might be an opportunistic explorer of human associated habitat, and it is even referred to as an invasive species in some studies (Borowiec & Salata, 2018).

Tetramorium sericeiventre displays a wide range of colour variations ranging from distinctly contrasting body colour with head, mesososma, petiole and postpetiole clear yellow, light brown or dark brown and gaster frequently dark black, brown to black (Al-Keridis *et al.*, 2021). Some workers are uniform black with superficial sculpture on the head, mesososma, petiole, and post petiole, while some workers are relatively smooth and shiny. Due to the wide range of variation within the species, a total of 25 synonyms of the species (Bolton, 1980), 13 of which from a single reference (Santschi, 1918) are recognised. Eight synonyms from the Malagasy fauna were added later (Hita Garcia & Fisher, 2011). In a nutshell, the species has a wide range of habitats worldwide and genetic analyses would be useful in determining the origin of the species.

CONCLUSION AND RECOMMENDATION

Since Rwanda is a region rich in biodiversity, more ant species might be recorded either for the first time or being new to science. In addition, only a small area has been studied so far (Nsengimana *et al.*, 2018; Nsengimana *et al.*, 2021; Nsengimana & Dekoninck, 2021; Nsengimana *et al.*, 2023), hence a big part of the country remains unexplored. Furthermore, the studied areas have been sampled only once using rapid sampling. We recommend more, intensive, and systematic sampling of ants in the areas that have been already studied, as well as in the new areas focussing on different land uses, altitudinal various and different ecological zones of Rwanda to fill the gaps that are still existing in the country. Furthermore, we recommend that species identified for the first time or new to science must be digitized and kept in publicly accessible collections to serve as reference in future myrmecological studies in Rwanda and the region.

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