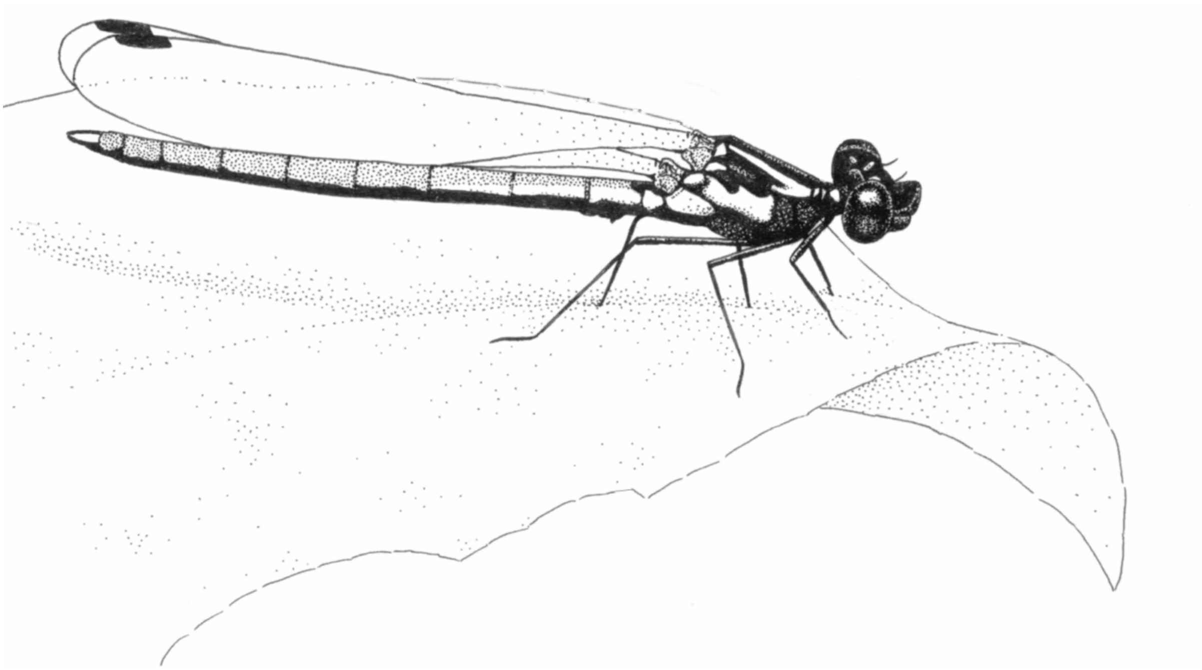
ISSN 0012-8317

Journal of East African Natural History

Volume 111 Part 2 2022



A Journal of Biodiversity

Journal of East African Natural History

A Journal of Biodiversity

Production: Lorna A. Depew
Published: 30 December 2022

Front cover: Chlorocypha tenuis*, a species of damselfly found in Kakamega Forest. Drawing by K.-D. B. Dijkstra.*

NatureKenya
THE EAST AFRICA NATURAL HISTORY SOCIETY

NATIONAL MUSEUMS OF KENYA
WHERE HERITAGE LIVES ON

Journal of East African Natural History 111(2): 69–79 (2022)

CHECKLIST OF ANT (HYMENOPTERA: FORMICIDAE) SPECIES FROM NYUNGWE TROPICAL RAIN FOREST, SOUTH-WESTERN RWANDA

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ABSTRACT

Tropical rain forests are inhabited by a wide range of plant and animal diversity. However, little is known about the diversity of ant (Hymenoptera: Formicidae) species in these areas. To fill the gap, a study has been conducted in seven sites inside Nyungwe National Park, a tropical rain forest located in South-Western Rwanda. Data have been collected in October 2021 through a quick sampling using pitfall traps, arboreal traps, baiting, Winklers, and hand searching of nests in leaf-litter, soil, rotten and fallen wood, and under stones. Collected ant specimens have been identified to subfamily, genus and species levels by using the identification keys. Names of species have been confirmed after comparing the findings with the specimens housed at the Royal Belgian Institute of Natural Science (Brussels, Belgium) and at Kiko Gomez's personal collection (Barcelona, Spain). A total of 7 subfamilies, 28 genera and 74 species were sampled. The subfamily Myrmicicnae had more genera and species compared with other subfamilies. Further, 9 genera and 43 species were collected in Rwanda for the first time, while 13 species were potentially undescribed ant pecies. High number of species has been sampled in the sites located in secondary forest at Karamba (53 species) and Pindura (33 species). We recommend intensive sampling in other locations of Nyungwe tropical rainforest and in the rest of Rwanda mountain tropical rain forests to get a clear view on the diversity of ant species in Rwanda.

Key words: Rapid assessment, ant species, tropical rain forest, genus, species

INTRODUCTION

Tropical rainforests are among the most species-rich ecosystems of the world inhabited by a wide range of plant and animal species (Scheu *et al.*, 2008). Considering animals, arthropods form the richest phylum dominated by class Insecta (Basset *et al.*, 2012; Culliney, 2013), mainly Hymenoptera, Diptera, Coleoptera and Lepidoptera (Eggleton, 2020). In terrestrial ecosystems, insects play key ecological roles such as nutrient cycling, seed dispersal, bioturbation (Fincher *et al.,* 1981; De Groot *et al.*, 2002; Nichols *et al.*, 2008), pollination (Gabriel & Tscharntke, 2006), and pest control (Landis *et al.*, 2000; Brewer & Elliot, 2004; Bell *et al.*, 2008; Lonsdorf, 2009). On the other hand some insects are known to be the vectors of different kinds of diseases and contaminants (Rodhain 2015). Others are pests causing damages to different types of vegetation, particularly crop plants (Kenis *et al.*, 2019).

Ants (Hymenoptera: Formicidae) are among the most frequently encountered taxa of the phylum Arthropoda (Lavelle *et al.*, 2022; Bernadou *et al.*, 2013). They occupy the third place in the class Insecta after Lepidoptera and Coleoptera (Eggleton 2020). Within Insects, ants show numerous advantages over other insects. They are extremely abundant, have a relatively high species richness, and can exhibit different trophic levels from simple herbivores to complex predators (Majer, 1983). Further, ants respond quickly to changing environmental conditions such as land use change (Griffiths *et al.*, 2018). This is the reason why they have been used as biological indicators of environmental change in different studies (Majer, 1983; Ribas *et al.*, 2011; Tiede *et al.*, 2017; Nsengimana *et al.*, 2018). Another study has indicated that the abundance and species richness of ants may predict soil conditions and they may be used to inform management of agricultural land to promote crop growth and crop production (Peck *et al.*, 1998).

In terrestrial ecosystems, ants constitute a large fraction of animal biomass (Graham *et al.*, 2009) and they form the most divergent group among social insects (Mahalakshmi & Channaveerappa, 2016). In soil, ants contribute to different ecological functions essential for soil health and quality (Nsengimana *et al.*, 2018). In this regard, a recent study has revealed that ant species are leaf-litter decomposers, contribute to soil aeration, and improve soil texture (Culliney, 2013). Moreover, ants contribute to nutrient transport at different soil horizons and hence enrich soil in essential nutrients (Fatima *et al.*, 2008; Outtara *et al.*, 2021). In the same regard, some species of ants are used by humans as source of food (Ayieko *et al.*, 2012), whereas others are used in pharmaceutical and biomedical studies (Ramón & Donoso, 2015.

The global estimated total abundance of ground-dwelling ants is over $3x10^{15}$ and the number of all ants on Earth is almost $20x10^{15}$ individuals (Schultheiss *et al.*, 2022). Further, Schultheiss *et al.* (2022) have indicated that in tropical and subtropical regions, the abundance of ants varies substantially across habitats, with high leaf-litter ants having higher abundance in forests, while ground-foraging ants have highest numbers in arid regions. In the Afrotropical region and Madagascar ants have been studied at sub-family and genus levels (Fisher & Bolton 2016). However, few studies have been conducted and identified ants to species level, hence the number of ant species in the Afrotropical region is not yet known. Most studied countries include Ivory Coast (Gómez *et al.*, 2022; Outtara *et al.*, 2021; Sylvain *et al.*, 2020; Yeo *et al.*, 2019), South Africa (Braschler, 2018; Hawkes, 2020) and Cameroon (Kuate *et al.*, 2015; Tadu *et al.*, 2014), while few studies have been conducted in Uganda (Schulz & Wagner 2002; Vanderhaegen *et al.*, 2019); Kenya (Hita Garcia *et al.*, 2009; Hita Garcia *et al.*, 2012), and Gabon (Braet & Taylor, 2018).

In Rwanda, studies on ants have been conducted and generated a number of species records in literature and collections outside of Rwanda. Recently, a preliminary checklist of ants from Rwanda has been published (Nsengimana & Dekoninck, 2021) and different studies have been conducted in coffee plantations (Bizimungu & Majer 2019), forests, coffee and banana plantations (Nsengimana *et al.*, 2018). Only one study has been conducted in tropical rainforest (Nsengimana & Dekoninck, 2021). So far, known ant species from Rwanda comprise 6 subfamilies, 26 genera and 71 species, from which 10 are endemic to Rwanda (Nsengimana & Dekoninck, 2021). However, considering the fact that Rwanda is located in a region with high biodiversity, most of them being endemic (Küper *et al.,* 2004) more ant species might be not yet sampled and described (Schultheiss *et al.*, 2022). To fill the gap, a study has been conducted in Nyungwe tropical rainforest using a rapid assessment. The study was in line with the framework of a taxonomic course focusing on ants as a stepping stone towards the ant community composition in tropical rain forests of Rwanda.

MATERIALS AND METHODS

Study area

Nyungwe tropical rainforest is located in South-Western Rwanda (2°17´– 2°50´S, 29°07´– 29°26´E), at the altitude ranging from 1600 to 2950 m above the sea level (Nyirambangutse *et al.*, 2017) and covers the surface area of 111 561 ha (REMA, 2021). The mean annual temperature of Nyungwe is 15^0C, while the mean rainfall varies between 1800 and 2500 mm per year (Mujawamariya *et al.*, 2021). The forest receives the rain throughout the year with the dry season (June to September) alternating with the rain period (October to May). The forest is the largest middle elevation tropical rainforest in Central Africa. Its biodiversity includes 1105 vascular plants, 280 bird species and 13 species of primates (Plumptre *et al.*, 2007). Further, the forest is dominated by various ecosystems from dense forests and bamboo groves to marshes, and its big part consists of a mixture of primary and secondary forests (Fashing *et al.*, 2007; Plumptre *et al.*, 2002) from past forest disturbances (Masozera *et al.*, 2006). The secondary forest was mainly caused by human induced disturbance through tree cutting, fire, and mining. However, natural disturbances such as landslides and fallen trees are also frequent.

Data collection

Data were collected in October 2021 by a group of 14 entomologists at seven sites located in Nyungwe tropical rainforest for 10 consecutive days. From East to West of the forest, sampling was done at Kitabi site (2°31'39.25"S, 29°25'00.48"E, altitude: 2360 m) located at the entrance of the forest and dominated by tea plantations. Inside the forest sampled sites were Pindura 1 (2°28'17.22"S, 29°13'51.53"E, altitude: 2330 m) secondary forest, Pindura 2 (2°28'28.02"S, 29°13'31.76"E, altitude: 2330 m) garden vegetation, Igishigishigi trail (2°28'34.97"S, 29°11'48.7"E, altitude: 2320 m) primary forest, Uwinka (2°28'38.89"S, 29°11'50.96"E, altitude: 2450 m) garden vegetation and Karamba (2°28'51.42"S, 29°06'42.3"E, altitude: 1980 m) secondary forest. At the exit of the forest, Gisakura site offices (2°26'28.5"S, 29°05'25.37"E, altitude: 1900 m) were sampled (figure 1). Data have been collected using pitfall traps, arboreal traps, baiting, and searching nests in leaf-litter, soil, under the rotten and fallen wood, and under stones. Arboreal traps and pitfalls were left in the area and collected after three days. Further, leaf-litter was sifted at the field and the remainings were placed in Winklers, which were hanged in a room and ants were collected after three days.

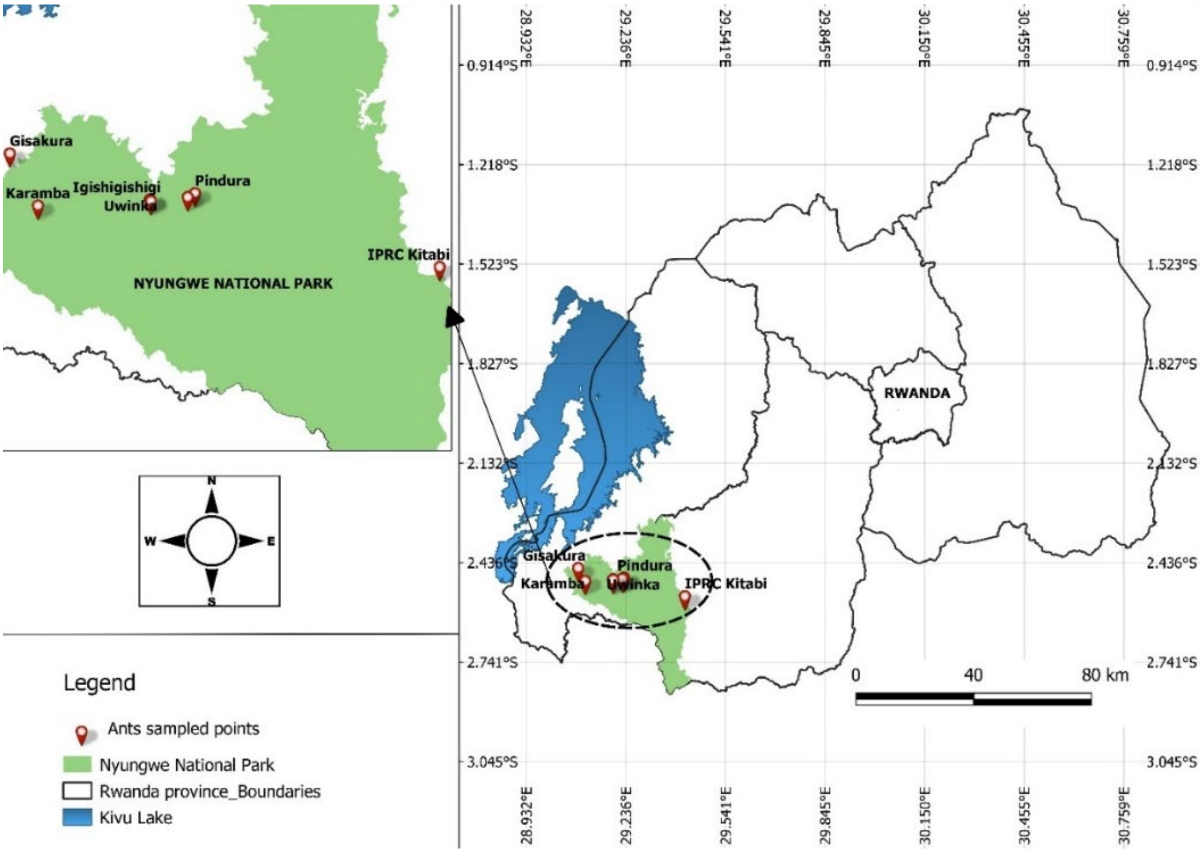

Figure 1. Location of Nyungwe tropical rain forest in Rwanda and location of sampling sites in Nyungwe mountain tropical rain forest

Presence/absence has been used to indicate the location where the ant species has been collected (table 1). This is because the sampling was not systematic and hence mathematical analysis should bring biases in statistical data analysis. In particular, there has been no attempt to characterise the altititudinal ranges of the species since sampling was opportunistic. Findings have been uploaded at the AntWeb portal (https://www.antweb.org) after the verification by myrmecologists about the correctness of species names with references to the ant specimens housed at the Royal Belgian Institute of Natural Sciences (RBINS) located at Brussels, Belgium, and the Kiko Gomez Personal Collection located at Barcelona, Spain. Duplicates of collected ant specimens are kept at the Museum of the Royal Belgian Institute of Natural Sciences (RBINS) in Belgium, Kiko Personal Collection (KGCOL) in Barcelona, Spain, and at Rwanda Ant Collection (RWAC) located in the Centre of Excellence in Biodiversity and Natural Resource Management, University of Rwanda. Accession number for each of the species located at KGCOL is indicated in table 1.

*Table 1. Subfamilies, genus, species, subspecies, and sampling locations (X: presence of ant species, * found in Rwanda for the first time, Sampling sites: 1=Gisakura, 2=Kitabi, 3= Igishigishigi, 4=Pindura 1, 5=Pindura 2, 6=Karamba, 7=Uwinka).*

Subfamily, genus, species subspecies	Accession number	1	2	3	4	5	6	7
Dolichoderinae								
Axinidris acholli Weber, 1941*	KGCOL02128						x	
Axinidris bidens Shattuck, 1991*	KGCOL02040						x	
Technomyrmex pallipes (Smith, 1876) *	KGCOL02240				x		x	
Dorylinae								
Dorylus sp01	KGCOL01992			x				
Dorylus sp02	KGCOL02102					x		
Dorylus spininodis Emery, 1901*	KGCOL02092					x		
Dorylus wilverthi Emery, 1899*	KGCOL02142				x		x	

Subfamily, genus, species subspecies	Accession number	1	2	3	4	5	6	7
Formicinae								
Camponotus flavomarginatus Mayr, 1862	KGCOL02245						x	
Camponotus orinobates Santschi, 1919*	KGCOL02126				x		x	
Camponotus rufoglaucus syphax Wheeler, 1922	KGCOL02238		x				x	
Camponotus sp01*	KGCOL02008			x				
Lepisiota depressa (Santschi, 1914)	KGCOL02246				x		x	
Lepisiota hirsuta (Santschi, 1914) *	KGCOL02231						x	x
Nylanderia jaegerskioeldi (Mayr, 1904) *	KGCOL02223		x				x	
Paraparatrechina brunnella LaPolla & Cheng, 2010*	KGCOL02081						x	
Paraparatrechina umbranatis LaPolla & Cheng, 2010*	KGCOL02217						x	
Myrmicinae								
Calyptomyrmex barak Bolton, 1981*	KGCOL02009			x	x	x		
Cardiocondyla shuckardi Forel, 1891*	KGCOL02176						x	
Carebara sp01*	KGCOL02228				x		x	
Carebara perpusilla (Emery, 1895)	KGCOL02216			x	x		x	
Carebara polita (Santschi, 1914) *	KGCOL02079						x	
Cataulacus kenyensis Santschi, 1935*	KGCOL02206						x	
Crematogaster castanea inversa Forel, 1907	KGCOL02200						x	
Crematogaster flaviventris Santschi, 1910*	KGCOL02172						x	
Crematogaster jeanneli Santschi, 1914*	KGCOL02197						x	
Crematogaster sp01*	KGCOL02207						x	
Crematogaster sp02*	KGCOL02247						x	
Crematogaster rugosa André, 1895*	KGCOL02103					x		x
Crematogaster sp03*	KGCOL05570						x	
Microdaceton viriosum Bolton, 2000*	KGCOL02080						x	
Monomorium crawleyi Santschi, 1930*	KGCOL02209			x	x		x	
Monomorium sp01*	KGCOL02218						x	
Monomorium sp02*	KGCOL02249						x	
Myrmicaria opaciventris Emery, 1893	KGCOL02250						x	
Pheidole megacephala (Fabricius, 1793)	KGCOL02254	x					x	
Pheidole sp01*	KGCOL02252		x	x				x
Pheidole sp02*	KGCOL02251		x				x	
Pheidole sp03*	KGCOL02215						x	
Pristomyrmex trogor Bolton, 1981	KGCOL02144			x	x	x	x	
Solenopsis punctaticeps Mayr, 1865*	KGCOL02255						x	
Strumigenys adrasora Bolton, 1983	KGCOL02214						x	
Strumigenys concolor Santschi, 1914*	KGCOL02047						x	
Strumigenys gatuda (Bolton, 1983)	KGCOL02050			x				
Strumigenys lujae Forel, 1902	KGCOL02054			x	x	x		
Strumigenys rukha Bolton, 1983*	KGCOL02227						x	
Strumigenys sahura (Bolton, 1983)	KGCOL02058				x			
Strumigenys sarissa Bolton, 1983	KGCOL02057			x	x	x		
Strumigenys transenna Bolton, 2000*	KGCOL02052			x				
Strumigenys truncatidens (Brown, 1950)	KGCOL02059				x			
Syllophopsis cryptobia Santschi, 1921*	KGCOL02225						x	
Syllophopsis sersalata (Bolton, 1987)	KGCOL02189			x	x		x	
Tetramorium aculeatum (Mayr, 1866)	KGCOL02178						x	
Tetramorium sp01	KGCOL02112							x
Tetramorium caldarium (Roger, 1857) *	KGCOL02204			x		x		
Tetramorium candidum Bolton, 1980*	KGCOL02257						x	
Tetramorium edouardi Forel, 1894*	KGCOL02210						x	

Subfamily, genus, species subspecies	Accession number	1	2	3	4	5	6	7
Tetramorium metactum Bolton, 1980	KGCOL02026				x			
Tetramorium simillimum (Smith, 1851)	KGCOL02191						x	
Tetramorium zambezium Santschi, 1939*	KGCOL02229						x	
Tetramorium zonacaciae (Weber, 1943)	KGCOL02256		x				x	x
Ponerinae								
Bothroponera soror (Emery, 1899) *	KGCOL02190						x	
Hypoponera angustata (Santschi, 1914)	KGCOL02181						x	
Hypoponera dema Bolton & Fisher, 2011	KGCOL02219					x	x	
Hypoponera jeanneli (Santschi, 1935)	KGCOL02222			x	x	x	x	
Hypoponera occidentalis (Bernard, 1953) *	KGCOL02220						x	
Hypoponera segnis Bolton & Fisher, 2011	KGCOL02205			x	x	x		
Hypoponera tristis Bolton & Fisher, 2011	KGCOL02221			x		x	x	
Hypoponera venusta Bolton & Fisher, 2011	KGCOL02148			x	x			
Loboponera edentula Bolton & Brown, 2002	KGCOL01976					x		
Parvaponera sp01*	KGCOL02078						x	
Phrynoponera gabonensis (André, 1892)	KGCOL02169						x	
Proceratiinae								
Discothyrea damato Hita-Garcia & Lieberman, 2019	KGCOL02011			x	x			
Discothyrea mixta Brown, 1958	KGCOL01997					x		
Pseudomyrmecinae								
Tetraponera mocquerysi (André, 1890) *	KGCOL02039						x	

RESULTS

A total of 7 subfamilies, 28 genera and 74 species have been collected (table 1). The subfamilies recorded are Dolichoderinae (2 genera and 3 species), Dorylinae (1 genus and 4 species), Formicinae (4 genera and 9 species), Myrmicinae (14 genera and 44 species), Ponerinae (5 genera and 11 species), Proceratiinae (1 genus, 2 species) and Pseudomyrmecinae (1 genus and 1 species). The sampled ant species include two species that are endemic to Rwanda, namely *Strumigenys gatuda* (Bolton, 1983) and *Hypoponera venusta* Bolton & Fisher, 2011. Further, 9 genera and 43 species were sampled in Rwanda for the first time. More species have been sampled at Karamba (53 species), Pindura (33 species) and Igishigishigi trail (18 species). Table 1 gives details of their distribution across the 7 sites that wrere sampled. The genera *Strumigenys* Smith, 1860, *Tetramorium* Mayr, 1855 and *Crematogaster* Lund, 1831 (Myrimicinae) and *Hypoponera* Santschi, 1938 (Ponerinae) had a higher number of species as compared to other genera (table 1).

DISCUSSION

In accordance withprevious studies in Rwanda, Myrmicinae had higher number of genera and species (Nsengimana *et al.*, 2021; Nsengimana & Dekoninck, 2020). This was similar to another study conducted in Kakamega Forest in Kenya, where the Myrmicinae included 21 genera and 157 species (Hita Garcia *et al.*, 2009). In the Afrotropical and Malagasy region, Myrmicinae outnumber all other subfamilies of ants (Fisher & Bolton, 2016) with 62 genera (32 in the Afrotropical region and 30 in the Malagasy region) compared to ten genera of Dolichoderinae (five in the Afrotropical region and five in the Malagasy region), 18 genera of Dorylinae (nine in the Afrotropical region and eight in the Malagasy region), 27 genera of Formicinae (18 in the Afrotropical region and 9 in the Malagasy region), 39 genera of Ponerinae (28 in Afrotropical region and 11 in the Malagasy region), six genera of Proceratiinae (three in the Afrotropical region and three in the Malagasy region) and two genera of Pseudomyrmicinae (one in the Afrotropical region and one in the Malagasy region). A higher number of Myrmicinae may be associated with their adaptation to different land uses and modes of life. In line with this, most Myrmicinae species are generalist omnivores, even though some have become specialised predators, granivores, or fungus-growers (Yoshimura & Fisher, 2007). The members of the subfamily Myrmicinae are highly polymorphic and arboreal ants that nest in living wood

(Kenne *et al.*, 2009). Some others forage in the vegetaion or on the ground and their diet is variable since it can consist of honeydew or small arthropds (Hita Garcia *et al.*, 2009).

The findings of this study confirmed three species belonging to *Axinidris* Weber, 1941 and *Technomyrmex* Mayr, 1872 genera of the sub-family Dolichoderinae. *Axinidris* is endemic to the Afrotropical region and it is restricted from the West Africa rain forests to the Kakamega Forest in Western Kenya (Hita Garcia *et al.*, 2012). Its occurrence in Rwanda confirms another study which predicted the occurrence of few species of *Axinidris* in Eastern and Southern Africa (Snelling, 2007). Considering their mode of life, *Axinidris* is an arboreal genus with an omnivoruous diet (Shattuck, 1991). They prefer moist rainforest habitats where they nest in hollow, living and dead stems or in rotten wood (Senelling, 2007). On the other hand, the genus *Technomyrmex* is mainly distributed in the Afrotropical region (Bolton & Fisher, 2012), with around one-third occurring in Sub-Saharan Africa, and 25 endemic species in the region. The majority of *Technomyrmex* species are arboreal or sub-arboreal, and a few species can nest in soil or forage in leaf-litter, tree trunks and canopy. They mainly feed on hemipteran honeydew, dead or living arthropods (Bolton, 2007). Furthermore, four species of the genus *Dorylus* Fabricius, 1793 belonging to the subfamily Dorylinae have been sampled. Two species could not be identified due the lack of a revised taxonomic key.

Other taxa belonging to the Formicinae subfamily were distributed over four genera and nine species. The genus *Camponotus* Mayr, 1861 had four species with one undescribed species; the genus *Lepisiota* Santschi, 1926 had two species; *Nylanderia* Emery, 1906 had one species and *Paraparatrechina* Donisthorpe, 1947 had two species. *Camponotus* was found to be among the most species-rich genera in Kenya, and it is an extremely large and complex genus globally (Hita Garcia *et al.*, 2012). *Camponotus* live in variety of habitats and microhabitats and are almost ubiquitous, occurring from humid rainforests to arid savannahs, from the ground to the forest canopy. The nests are built in the ground, rotten branches or twigs, and rarely into living wood. They have a highly generalistic diet (Bolton, 1973). Besides *Camponotus*, the genus *Lepisiota* is also among widely distributed ant species in the Afrotropical region (Bolton & Fisher 2012). Species belonging to this genus nest in rotten wood, in the ground or in standing trees and they can be considered as generalist foragers (Brown, 2000). Another genus sampled was *Nylanderia* which comprises species able to live in a variety of habitats, from deserts to rain forests, nesting in the leaf litter, soil, and rotten wood. Most species are epigaeic generalist foragers (LaPolla *et al.*, 2011). *Paraparatrechina* is another Formicinae genus, which LaPolla *et al.* (2011) reported from Afrotropical species in rain forests and cleared forests, in the leaf-litter or in rotten logs, and some species live in vegetation or the canopy. The same authors have indicated that *Paraparatrechina* are generalistic feeders and often live in trophobiotic relationships with hemipterans.

Ponerinae, with 5 genera and 11 species, is another subfamily that has been sampled in this study. They are dominated by the genus *Hypoponera* Santschi, 1938 with seven species, compared to *Bothroponera* Mayr, 1862 and *Phrynoponera* Wheeler, 1920 each with one species. The genus *Parvaponera* Schmidt & Shattuck, 2014 was found in Rwanda for the first time and had one undescribed species. A study has shown this genus to be small and rarely encountered with seven known species and sub-species distributed in tropical Africa, Madagascar, South-East Asia and the Australian region (Schmidt & Shattuck, 2014). In contrast, *Hypoponera* is a large cosmopolitan genus most of which being general predators, with some others being widespread tramp species. Several species are known to have highly unusual reproductive strategies, including the presence of combative ergotoid males (Schmidt & Shattuck, 2014). *Bothroponera* is restricted to Africa and Madagascar, while *Phrynoponera* is a small genus restricted to the African tropics. Litlle is known about their ecology and behaviour (Schmidt & Shattuck, 2014),

This study indicated that, with two and one species respectively, the subfamilies Proceratiinae and Pseudomyrmecinae are less well represented. This was also found in Kakamega Forest in Kenya where Proceratiinae consisted of two genera and three species, while Pseudomyrmecinae only consisted of one genus and four species (Hita Garcia *et al.*, 2009). In the Afrotropical and Malagasy region, the subfamilies Proceratiinae and Pseudomyrmecinae, as well as Amblyoponinae and Dorylinae, are less species-rich as compared to Formicinae, Dolichoderinae, Myrmicinae and Ponerinae, which are the world's four largest subfamilies (Fisher & Bolton, 2016). The subfamily Proceratiinae comprises the genera *Discothyrea* Roger, 1863 and *Proceratium* Roger, 1863. Their distribution is restricted to tropical and subtropical climates (Bolton 2003; Ouellete *et al.*, 2006), and they are specialised in consuming various arthropods (Brown 1979). On the other hand, Pseudomyrmecinae comprises three genera of arboreal ants, namely *Pseudomyrmex* Lund, 1831, *Myrcidris* Ward, 1990 and *Tetraponera* Smith, 1852 that are widely distributed in tropical and subtropical regions (Ward & Downie 2005).

The findings of this study increased the number of ant species from 71 to 105 (Nsengimana & Dekoninck, 2020) and added 34 species (almost 50%) to the known ant species from Rwanda. Even though comparing our findings with other ant studies in the Afrotropical region might be problematic due to differences in sampling methodology, elevation of the study area, as well as the geographic range covered or habitats investigated (Hita Garcia *et al.*, 2009), Rwanda might have a high species richness. However, it has less ant species as compared to Kenya (Hita Garcia *et al.*, 2012), Ghana (Belshaw & Bolton, 1994) and Cameroon (Deblauwe & Dekoninck, 2007; Watt *et al.*, 2002). Nevertheless, it has more ant species compared to Tanzania (Robertson, 2002). This study has also revealed that the most species-rich location was Karamba trail, a secondary forest. This result echoes the results found by Deblauwe & Dekoninck (2007), which is a sign of adaptation by ants to changing environments, even though further studies must support this.

We can conclude that the Rwanda ant diversity is grossly underestimated, and more sampling efforts will increase the current number. Further sampling in Nyungwe tropical rainforest and neighboring tropical rainforests such as Volcanoes National Parks may reveal a much higher diversity of ant species in Rwanda.

ACKNOWLEDGMENTS

Authors thank the Belgian General Directorate for Development and Cooperation (DGD), part of the Global Taxonomy Initiative (GTI) within the framework of Capacities for Biodiversity and Sustainable Development (CEBioS) for the financial support to conduct this study. Further, authors thank the Centre of Excellence in Biodiversity and Natural Resource Management (CoEB) for the support to get laboratory materials and they thank the managers of Nyungwe tropical rainforest for the provision of study permit. Finally, authors thank the managers of the Integrated Polytechnic Regional College (IPRC) Kitabi for the rent of the laboratory room.

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