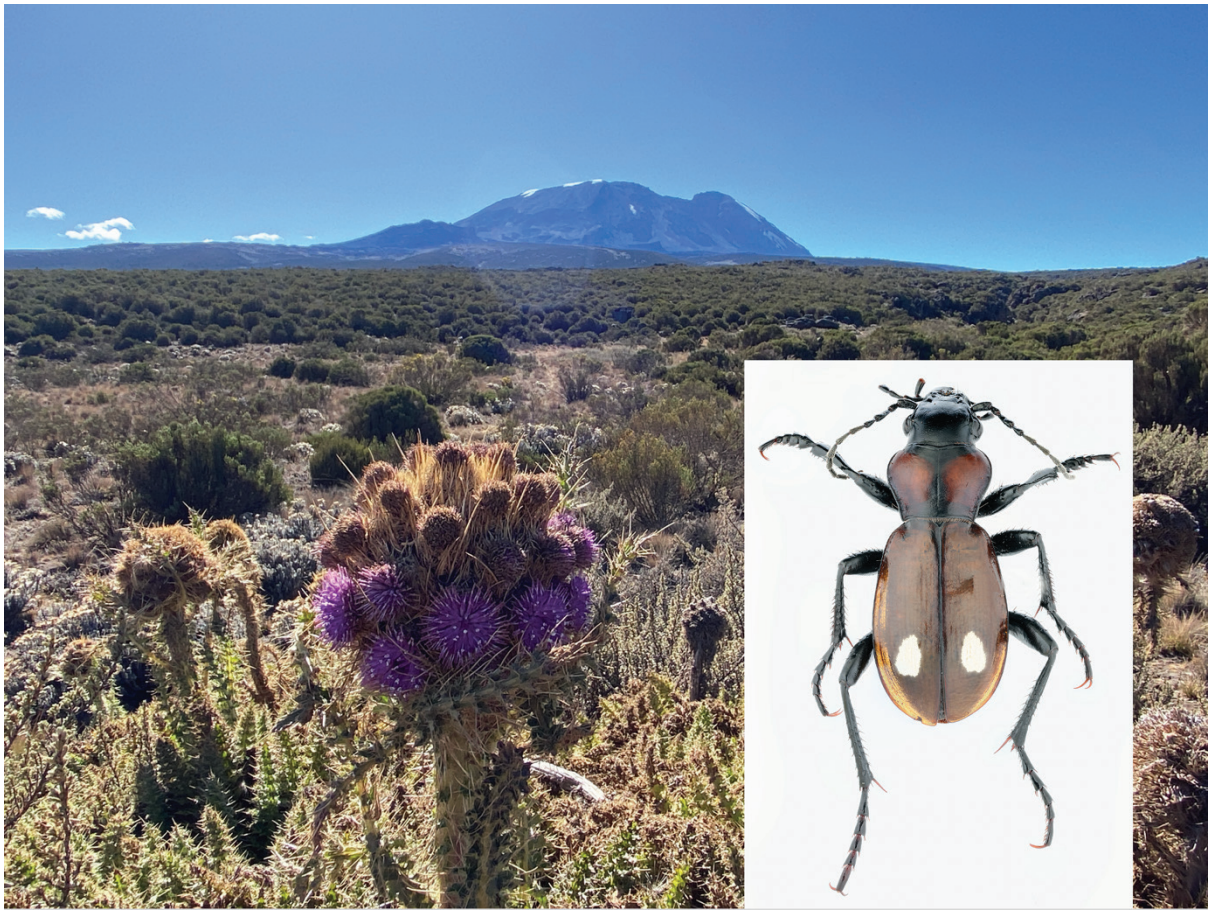
TAWIRI Newsletter

Implementing a Tanzanian National Collection of Invertebrates

and

Invertebrate Surveys in the Highest Afromontane Ecosystems with the support of the JRS Biodiversity Foundation



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THE DIRECTOR GENERAL SPEECH

Our dearest readers, with great pleasure I am pleased to invite you to read and enjoy this new edition of our newsletter. We are presenting to you our new project entitled: Invertebrate Surveys in the Highest Afromontane Ecosystems. This is a trans-boundary project studying insect diversity in the four highest mountains of East Africa.

I would like to express special thanks to JRS Biodiversity Foundation for providing support to this project, without their support, this project would have not been implemented. JRS have been in hand in hand with TAWIRI for the past years and we are still calling for more collaboration in other areas of study.

Through this project young scientists are trained on how to conduct invertebrate surveys in the four mountains. The information collected will be used to develop a database of insects in the highest mountains. It is very crucial to study and understand the biodiversity in the mountains since the environmental change such as climate change can easily be revealed. I am therefore welcoming you read and enjoy this special edition about entomology.

Implementing a National Collection of Insects

(by Alain PAULY, Associate Researcher, TAWIRI)

Most of the research projects in Tanzania have focused on large charismatic species of herbivores and carnivores while invertebrates like insects are underrepresented. The lack of local capacity in insect taxonomy is among the factors that contribute to lack of national information on invertebrate biodiversity in Tanzania. To fill this gap, we have initiated the management of a first national collection of macro Invertebrates, mainly insects, but also spiders, millipedes, crabs, etc… The collections are hosted in the new building of the Tanzania Wildlife Research Institute (TAWIRI) in Arusha.

Climatic conditions in Arusha are ideal because the city is located at 1250 meters asl. The climate is therefore cold and dry enough not to have to air-condition the conservatories. In fact, in other localities with hot and humid climates, collections are quickly damaged by moulds and various parasites.

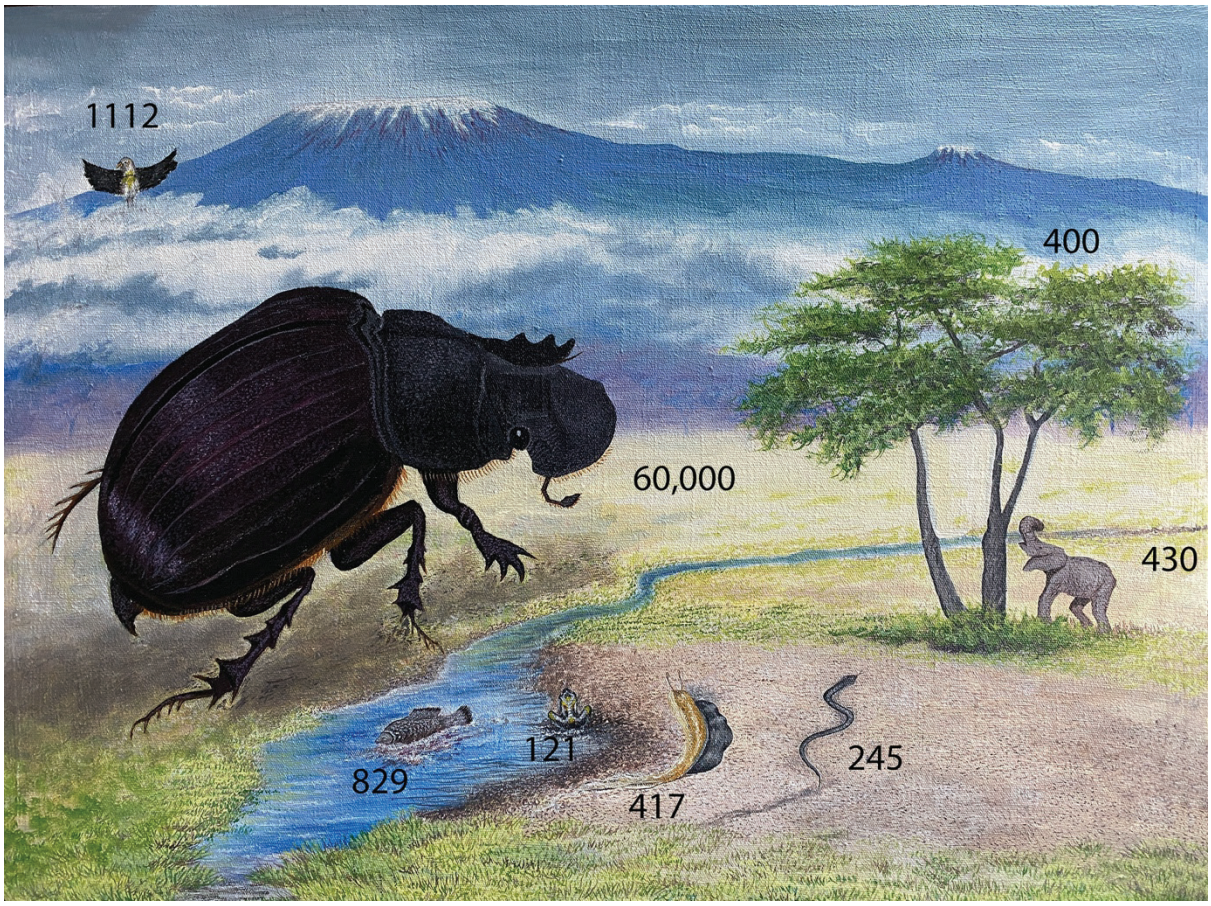
The national collection is intended to house the specimens collected by students in universities during their end-of-study dissertation, their master's or doctoral theses. Indeed, universities are not equipped with adequate conservatories, or are located in hot and humid climates, or do not always aim to preserve these collections over the long term, which most of the time end up abandoned and unattended on shelves. Students, once their thesis is completed, whether in Tanzania or abroad, often change direction or move on to other occupations. We know that the "shelf time" for a new species, that's to say between the time the specimen is collected and the date it is described, the average is 20 years. So long term preservation of specimens is fundamental.

Tanzania attracts by the diversity of its wild fauna many naturalists, explorers or entomologists who collect insects. Once their mission is complete, they leave with the specimens that will enrich the collections in Europe or America. These researchers are in theory required to return reference collections, but until now no structure existed to accommodate and preserve them in the long term. These researchers will therefore be able to contribute from now on to the enrichment of the national collections and help to local expertise.

Indeed, Africa has a deficiency in entomological expertise. It is estimated that around 1.3 million different insect species have been described so far, which is enormous compared to the number of entomologists currently active worldwide. Many insect groups currently do not have specialists who can identify them, even on a global scale. In student publications, specimens are identified most of the time to family level, or at best to genus or morpho-species. The field to be investigated is immense and there are not enough entomologists, especially in tropical countries where the majority of species live. Thus, it is important to collaborate with a network of the most qualified international specialists. After identification, specimens are returned to TAWIRI to enrich the national collections of reference. With such a reliable collection of reference, it is realistic for a student to begin the study of a particular group of insects.

Knowledge of an insect group is also correlated to large amounts of specimens available in the collections for study. It is therefore important to carry out sampling in different regions. Insect fauna is particularly diverse and endemic in Tanzania because its strongly fragmented montane and coastal moist forests. In particular, the Eastern Arc Mountains are well-known for their high degree of endemism and are considered as one of the world's biodiversity hotspots (Myers et al. 2000).

We could call our planet "the planet of insects", given the number of species found there. We will never be able to know them all, so is it even worth starting to study them?



The number of insect species in Tanzania far exceeds the number of species of all other groups of animals and plants:

Insects: 60,000	Reptiles: 245	Non Marine Molluscs: 417
Mammals: 430	Amphibians: 121	Trees: 400
Birds: 1112	Fresh water fishes: 829	

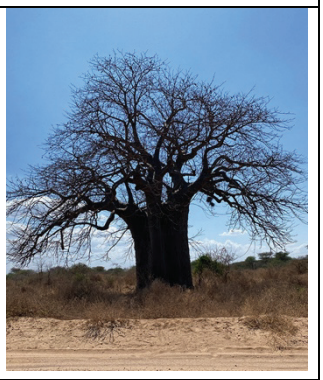
Biomass: Arthropods represent 1.2 GT C on the planet compared to 0.007 GT C for wild mammals. Note that terrestrial plants are the dominant group on earth (450 GT C = gigatons of carbon)

The objectives of a Tanzanian National Collection of Invertebrates

The main objectives of the National Collections are:

(1) Management of a national collection of insects pinned in entomological boxes and/or preserved in ethanol.
(2) Building a virtual collection thanks to new digital technology.
(3) Sequencing specimens for a genetic library.
(4) Digitising Invertebrate data.

Some important functional groups of invertebrates are selected as target groups during our surveys:

Pollinators	Aquatic insects	Dung beetles	Insects of trees
			

Pollinators: Pollinators are an element of crop associated biodiversity, and provide an essential ecosystem service to both natural and agricultural ecosystems. Bees are the most important group of pollinators for all flowering plants. With a large sampling effort we can expect more than 800 species to be discovered in Tanzania.

Aquatic Insects: In Tanzania as elsewhere in the world, freshwater resources will be a major issue in the future in the face of growing needs due to increasing human population, droughts and the effects of climate change. Invertebrates are excellent potential indicators of healthy freshwater ecosystems where they live.

Dung Beetles: Africa is not only the continent of large mammals, but consequently also the one of dung beetles. The Tanzanian fauna of Scarabaeidae is very rich and is estimated to around 500 species.

Insect of trees: Collecting and collating knowledge about the insect fauna of trees today will be crucial to assess, and perhaps reduce damage over the coming decades. It is estimated that there are over 400 species of trees in Tanzania and virtually nothing is known of the diversity of insects that inhabit them. The project will develop new techniques to inventory this often inaccessible microfauna in the crowns of the tallest trees.

March 2021. Constructing the first shelves for hosting the collections. Fridge and freezer were used to store the butterflies collected during the first JRS project "*Assessing Landscape Level Impacts of Climate Change on Montane Forest Pollinators in Tanzania*" (August 2018 – March 2021).

To start a collection of insects, one does not need benches or multiple taps as in a traditional laboratory of chemistry or physics. What we need are above all shelves, boxes and pins to store the collections.

June 2023: The new lab with 360 large entomological boxes on the shelves. Four graduated students are mounting and sorting the specimens. The project was initiated with the support of the Global Taxonomy Initiative (GTI) "Tanzanian Invertebrates: "*Capacity building for a reference national collection*" (13,490 Eur) (July 2021 – March 2022) and continued by the JRS Biodiversity Foundation Project "*Invertebrate surveys in Afromontane ecosystems*" (inAfrEco) (143,000 $) (May 2022 – May 2025).

The Hymenoptera collections (August, 2023)

JRS providing fund to support a project to survey insects in the four highest peaks in East Africa

(by Neema Kilimba and Janemary Ntalwila)

From May 2022 TAWIRI received fund from JRS Biodiversity Foundation for implementing a project entitled: Capacity-Building to Conduct Baseline Wildlife Surveys of Invertebrates in Alpine and Montane Forests Ecosystems in the Highest Mountains in East Africa, Short title: Invertebrate Surveys in Highest Afromontane Ecosystems, Acronym: InAfrEco. This is the trans- boundary project supervised by Tanzania Wildlife Research Institute (TAWIRI) in collaboration with Embu University in Kenya and Makerere University in Uganda. The main aim of the project is to assess biodiversity of insects while building capacity to conduct surveys in the four highest Mountains of East Africa. The four peaks include Mt. Kilimanjaro, 5892m in Tanzania, Mt. Kenya 5199m in Kenya, Rwenzori Range, Mt Stanley, 5109 m in Uganda and RDC Congo and Mt. Meru 4565m also in Tanzania.

The high mountains of East Africa are among the richest ecosystems in terms of biodiversity levels. They serve as a refuge for animal and plant species provided the present climatically changes and other environmental disturbances such as forest fragmentation, human-caused fires and others. Insects decline has recently been reported and a more decline is anticipated in the next decades. These facts stimulated this project to study these mountains by assessing insect diversity. Different groups of insects are playing remarkable ecological roles in ecosystems including pollinators, decomposers, natural enemies (predators and parasitoids), pests and some are indicators for climatically changes in both terrestrial and aquatic ecosystems.

Two groups of insects are studied in this project, the pollinators and fresh water insects. It is very crucial to documents these taxa because they are endangered groups of insects and they are poorly documented. Through field surveys conducted, species distributional trends in different altitudinal ranges will be recorded.

We are very grateful and we give appreciation to JRS Biodiversity Foundation for their endless support

Mt Kilimanjaro, 4000m hanging traps to giant *Dendrosenecio,*

Mt Kilimanjaro, putting yellow pan traps around Mawenzi Pic, 4585 m, August 2023

Mt Kilimanjaro, Shira plateau, 3600m, September 2022, with a view on the Uhuru peak (5892 m asl) in the background. flowers of *Carduus keniensis* visited by Hymenoptera

Mt Meru, montane forest near Miriakamba camp, 2500m: collecting bees on flowers with hand net.

Mt Kenya, Collecting bees on flowers of *Senecio* sp. (Asteraceae)

add Photo Rwenzori (see Anne original here in Kampala)

Bees for producing honey but also for pollination of plants

Bees are well known for their production of honey but also for their role in pollination. The most popular species is the honeybee (*Apis mellifera* Linnaeus, 1758). Three geographic races or subspecies occur in Tanzania: *Apis mellifera scutellata* on the high plates, *Apis mellifera monticola* in the mountain forest of Mt Kilimanjaro, and *Apis mellifera litorea* on the coast and in Zanzibar.

The other group of bees producing honey are the "stingless bees" of the subfamily Meliponinae. These include around twalf species in Tanzania. Two species, *Meliponula togoensis* and *Meliponula ferruginea*, are traditionally domesticated in hives. Honey is harvested in smaller quantities, generally not exceeding two liters per hive and per year, but its particular properties make it a highly valued product in traditional medicine. Tanzania is probably the leading producer of stingless bee honey in Africa.

Besides those "domesticated" bees, there are a large number of bee species belonging to different families. These wild bees do not produce honey but play a very important role in the pollination of wild plants and many cultivated plants. We estimate that the 400 species currently recorded from Tanzania should be regarded as being less than half of the number of species really occurring in the country.

Pollinators play an important role in the pollination of a diversity of wild plants and of agricultural crop and often increase crop production and quality. Various pollinating agents are known such as animals; insects, birds, and bats and other agents are water; wind; and even plants themselves, when self-pollination occurs within a closed flower, however it has been estimated that 85% of wild plants depend on insects for pollination. Moreover, some important agricultural crops rely on pollinators to produce fruits. Other plants produce better quality seeds and fruits when pollinated by insects. Pollination is crucial for sustaining 75% of the top produced food crops in the world and accounts for 35% of the global production volumes, with insects being the most important pollinators in both natural and agricultural settings.

Pollination brings a lot of environmental benefits as it plays key role in the function of the whole ecosystem, 85% of wild plants depend on insects for pollination hence improving their reproduction and the different ecosystem services provided by that vegetation. Through this process plants can provide other important ecosystem services such as water purification, carbon sequestration, organic matter degradation and improved biodiversity that are all utmost importance for our wellbeing and health.

Bees (Hymenoptera) and butterflies (Lepidoptera) are the leading pollinating agents, they pollinate nearly 85% of all flowering plants. In this project, bees are the mainly pollinators studied. We are assessing the diversity of bees in the highest mountains to know what species of bee pollinators are there in different altitudinal gradients. Bees living in groups such as honey bees and solitary bees are all assessed.

Honeybee (*Apis mellifera scutellata*)

Stingless bee (*Meliponula ferruginea*)

Carpenter bee (*Xylocopa flavorufa*)

Small carpenter bee (*Ceratina* sp.)

Leaf cutter bee (*Megachile rufiventris*)

Halictid bee (*Seladonia jucunda*)

More than 800 species of wild bees are expected to be discovered in Tanzania.

Helichrysum

Dendrosenecio

Lobelia

Erica arborea

Assessing pollinator - plant interaction in the highest mountains: The fauna of bees living at high altitudes on Mt Kilimanjaro are still poorly known. By using different new technics, like pans traps and chain traps, we succeed to capture bees never collected in the past. By studying pollen loads on the bees, we hope to be able to identify interactions between plants and their pollinators. A new species discovered at high elevation (4500 m) is foraging on flowers like *Helichrysum* and *Dendrosenecio,* and is the "highest" bee discovered in Africa.

Aquatic invertebrates, remarkable indicators for environmental changes and quality of fresh water

In Africa as elsewhere in the world, water resources (freshwater) will be a major issue in the future in the face of growing needs due to the population explosion, droughts and the vagaries of climate change.

Not only the quantity but also the quality of the water becomes a real challenge. Aquatic ecosystems can indeed deteriorate rapidly as a result of human activities (pollution due to wastewater and pesticides, agriculture, hydraulic installations). These environments are rich in biodiversity. While consumable animals (fish, amphibians) are relatively well known, the same is not true of aquatic invertebrates.

However, these are excellent indicators of the quality of the waters where they meet. Invertebrates are also food for fish. It is therefore useful to obtain data concerning the faunistics and the ecology of this microfauna which inhabits streams, rivers, lakes, ponds, fish ponds, marshes, swamps, waterfalls, urban purification basins, reservoirs, and cold and hot springs... Few studies that focus on the aquatic insects of Tanzania have been published Among all the invertebrates, aquatic beetles (Coleoptera) and water bugs (Hemiptera) will receive special attention, but also some other groups will be considered.

Tanzania shares with neighboring countries the largest lakes in Africa: Lake Victoria (No. 1 by surface), followed by Lake Tanganyika (No. 2 by surface), Lake Malawi (= Nyassa sea). Many other small lakes punctuate the country. These large lakes are home to a large fauna of endemic fish (288 species in Lake Victoria, 301 in Tanganyika and 545 in Malawi) and also endemic invertebrates. For example the genus Aneurocoris includes only two known species, both of which are endemic to Lake Tanganyika: *Aneurocoris insolitus* Montandon and *Aneurocoris marlieri* Poisson (Hemiptera Naucoridae).

Much of the country is an arid plateau and 25% of the water consumed comes from the mountains. Many of the mountain systems associated with the Rift remain poorly investigated for aquatic insects, and we suspect that additional, new, species of the genus remain undiscovered.

Some aquatic insects collected in a pond: (1) dragonflies larvae, (2) Hydrophilus larvae,
(3) Ranatra, (4) Nepidae, (5) Notonectidae, (6) Naucoridae), (7) Coleoptera (Dytiscidae & Hydrophilidae)

A forest pool on Mt Kilimanjaro. Among aquatic insects, most interesting is the rediscovery of *Neprioporus kilimandjarensis* Régimbart, 1906, an aquatic beetle of the family Dytiscidae. The species was not collected since its discovery by Alluaud in 1904 on Mt Kilimanjaro and is remarkable because it is the species-type of the genus and it is considered as an endemic of the Mt Kilimanjaro. It occurs in the small streams descending from the glacier, in the montane forest between 3000 and 3500 m asl. Here on the picture Daudi Mihambo collecting *Nebrioporus kilimanjarensis* in a forest pool around Machame Camp (3100m asl).

Collecting whirglig beetles (Gyrinidae) in the Themi river, Arusha

Materuni Waterfalls near Moshi

Waterscorpion (Nepidae)

Water-stick bug (*Ranatra* sp.)

Redaction of an Atlas of Dung Beetles from Tanzania

This first Atlas on dung beetles (Coleoptera: Scarabeoidea) will be the first in a series devoted to the invertebrate fauna of Tanzania. Our project aims to illustrate these species through a virtual collection that would be available to researchers, students or tourists in search of nature. Tanzania indeed contains an exceptionally rich fauna and is therefore a true paradise for naturalists. In today's digital age, it is indeed possible to illustrate all these species through a virtual collection which would be available to researchers, students or tourists in search of nature and who visit the country's numerous parks and nature reserves.

Tanzania is indeed a paradise for naturalists as the landscapes are so varied, from the highest mountain in Africa, Kilimanjaro which culminates at 5800m, the largest lakes (Victoria, Tanganyika, Malawi), forest with the highest trees in Africa, large savannah on the high plates, coastal areas and islands (Zanzibar, Pemba, Mafia), etc… Coprophagous beetles or “dung beetles” are not left out since the country is also the richest in Africa in terms of mammals with around 430 species…

Wilfried Sengo has been trained to take pictures of insects with the best equipment currently available for photomacrography. He is also in charge of mounting on pins and sorting the collections of Coleoptera.

Wilfred Sengo mounting insects on pins

Question: Could you explain what equipment you use to make professional pictures of insects ?

Sengo: Most important is the light. We use a pyramid in altuglass to diffuse the light around all the parts of the insect. A good camera like a Canon eos 5Ds 50 million pixels, a lens Canon MP-E 65mm f/2.8 1–5x Macro and for the light a Canon MT-24EX Macro Twin Lite Flash.
We take around 25 five pictures with a stackshot Cognysis and then we combine the pictures in a software like Zerene Stacker. Finaly the pictures are edited in Photoshop.

picture: *Liatongus militaris*

Wilfred Sengo classifying dung beetles (Coleoptera Scarabaeidae)

Question: What is the role of the dung beetles in our environment ?

Sengo: We often don't think much about the small creatures that share our planet, but some of them have incredibly important roles in the environment. One such creature is the dung beetle, which may seem unremarkable at first glance, but plays a vital role in ecosystems all over the world. Dung beetles are a group of insects that belong to the family Scarabaeidae. As their name suggests, these beetles feed and live in animal dung. They come in a wide variety of shapes and sizes, ranging from small beetles that are only a few millimeters long to large beetles that can be up to several centimeters long. Some species are brightly colored, while others are dull brown or black

Dung beetles are known for their ability to break down animal dung and recycle it into the soil, playing important roles of decomposition in ecosystems, a process that is essential for availability of nutrients required for the rangelands hence it is part of nutrient cycle. Decomposition enhances soil nutrients and plant growth hence improving pastures by recycling soil nutrients in the rangelands and the whole environment at large through the incorporation of manure into pasture soil enhancing plant growth.

They do this by rolling the dung into balls and burying it in the ground, where it provides valuable nutrients for plants and helps to improve soil fertility. Some species of dung beetles can bury up to 250 times their body weight in dung each day. Dung beetles are scavengers feeding on manure and use it to provide housing and food for their young.

But dung beetles do much more than just improve soil health. They also play a crucial role in secondary seed dispersal, controlling pests and reducing the spread of disease. By removing animal dung from the surface of the ground, they reduce the breeding sites for pests like flies and other insects that are attracted to dung. This, in turn, helps to control their populations and reduce the spread of diseases that these insects may carry.

Dung beetles are also important in the fight against climate change. When dung is left on the surface of the ground, it releases methane, a potent greenhouse gas that contributes to global warming. By burying the dung, dung beetles reduce the amount of methane that is released into the atmosphere, helping to slow down the effects of climate change. Dung beetles clean the rangelands by removing the dung soon after deposited by the ungulates, the dung that would otherwise be left in piles for years, reducing the feeding ground for ungulates.

Despite their important roles in the environment, dung beetles are often overlooked and underappreciated facing challenges like, habitat loss, pesticide use, invasive species, and habitat destruction as a result of human activities. So next time you see one of these little creatures rolling a ball of dung across the ground, take a moment to appreciate the important work that they are doing. Addressing these challenges will be important in ensuring that dung beetle continues to play their vital role in ecosystem around the world. Let's conserve them to conserve the environment.

Different methodologies are used to collect dung beetles including use of baited pitfall buried in the ground, or by removing directly from the dungs and trapping them by the use the bucket. Dung beetles were removed directly from the dungs or by trapping them by the use the bucket or by the use pit fall traps that are buried in the ground.

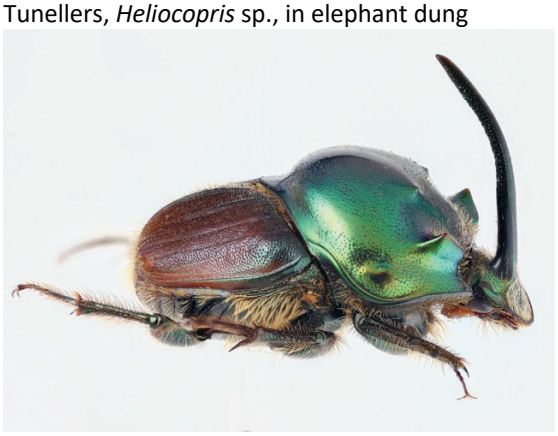
Proagoderus atriclaviger d'Orbigny, 1905, male

Collecting dung beetles in buffalo dung (Arusha National Park)

Rollers

Tunellers, *Heliocopris* sp., in elephant dung

One elephant dropping can weigh up to 5 kg



Proagoderus atriclaviger, male

Are Ants pests or beneficial insects ?

Most ants are fascinating tiny creatures, with exceptional working group strategies. They are among earth's oldest living creatures, as they actually existed since 140 million years. They survived mass extinction events and they will dominate the Earth if humanity were to disappear.

More than 459 species of ants are recorded from Tanzania. The best known are probably the safari ants (*Dorylus* spp.), the small invasive red ant (*Pheidole megacephala*), the *Carebarra* ants, the "weaver ants" ants (*Oecophylla longinoda*), or the ants that live in symbiosis with the acacia trees (several species including *Crematogaster* spp.). Ants are among the leading predators of other insects, helping to keep pest populations low in many ecosystems. But when they invade a home, when they carry on plants sap-sucking pests like mealybugs, scale, aphids or whiteflies in exchange of honeydew, when they move seeds from crops, or simply when they sting, these ambiguous insects can be a serious nuisance.

The invasive "big-headed ant" (*Pheidole megacephala*)

This small red ant measuring around 3 mm is a invasive species in Tanzania and other parts of the world. It has probably its origin in Madagascar or Mauritius. It tends to thrive in open, disturbed habitats: in the cities, near homes, in gardens and crops where it replaces native species. In individual combat with local species, it is often the loser, but thanks to the millions of individuals that constitute its super-colonies, it always ends up winning. It's a real domestic pest because it seeps inside buildings to feeds on human foodstuffs, and is disturbing in the gardens because it is commonly found under almost every rock, flower pot or log. It is also an important agricultural pest because it transports mealybug, scale insects, and aphids among and within cultivated plants to feed on the honeydew these pests can produce. They can also eat all the seeds sown in the vegetable garden. In the savannah, invasive ants replace other ants like *Crematogaster* living in symbiosis with the *Acacia* trees. The trees lose their defense against herbivorous mammals and end up withering away, because invasive ants do not have the same aggressiveness towards herbivores than the ants naturally associated with *Acacia*. The negative ecological impact on native invertebrate biodiversity may be greater than that of any other invasive ant species, but this remains undocumented or anecdotal. It is practically impossible to eliminate this ant which always ends up coming back: insecticidal powder in the house, spreading ashes in the garden or using "bait stations", for example with *Hydramethylnon* which works as a slow-acting toxin that needs to be ingested. Fortunately, it seems that this species does not penetrate intact natural habitats. Its geographic distribution in Tanzania is not exactly known but worth studying.

Major worker of the invasive "big-headed ant" (*Pheidole megacephala*)

Pheidole and mealybugs

The safari ants (*Dorylus* spp.)

Dorylus, also known as safari ants, driver ants, magnans (french) or siafu (swahili), is probably the more famous ant from Africa. These "army ants" have enormous colonies and can contain over 20 million individuals. The charactersitic long columns of these ants is formidable because it cleans everything in its path and can even attack large animals. These ants have no eyes and all their communication relies on pheromones. This group of ants comprise around 60 species in Africa.

Head without eyes of a "Safari Ant" (*Dorylus* sp.)

The weaver ant (*Oecophylla longinoda*)

These ants form colonies with multiple nests in trees, each nest being made of leaves stitched together using the silk produced by the larvae. As they help to control other insects, colonies are used in some parts of their range as a natural form of pest control on trees like cashew, citrus, mango, coconut, cocoa and coffee.

The weather ant *Oecophylla longinoda*

Crematogaster and *Acacia* trees

Mutualistic relationships between the whistling-thorn Acacia (*Acacia drepanolobium*) and ants are the subject of fascinating research by ecologist. The ant *Crematogaster mimosae*, constructing its nest in the swollen thorn, is very aggressive against giraffes and elephants and protect the trees against these mega-herbivores. When *Crematogaster* are replaced by the invasive ants *Pheidole megacephala*, we observe a dramatic reduction in growth and survival of the trees.

The swollen spines ("domatia") of the whistling thorn acacia (*Acacia drepanolobium*) are naturally hollow and occupied by several symbiotic ant species. In exchange, these ants defend the tree against herbivores such as elephants and giraffes.

Carebara, an edible ant

The fat queens of this species are hunted as edible insect, in the regions like Lake Victoria, Arusha and Morogoro. These ants are notable for the vast difference in size between queens and workers. The worker are very tiny, without eyes, and nesting in the leaf-litter. Winged queens and males are swarming in great quantity after the long rains. Localy they are called "wadudu mafuta", which means "fat insect".

Queen of *Carebara* ant and tiny workers

Esther Kimario works both on the preparation of insects in general but also specializes in the study of ants. How to identify species and use some of them to ward off elephants, which often come into conflict with villagers outside reserves. Esther participated twice in an international field training in Rwanda, the "ant course" organized by the Belgian technical cooperation, the Royal Belgian Institute for Natural Sciences (Brussels, Belgium) and CoEB (Centre of Excellence in Biodiversity and Natural Resource Management, University Rwanda).

Question: What do you learn during your two workshop on ants in Rwanda ?

Esther: "During our training course in Rwanda the field work involved of doing different methods of collecting ants. These methods are for sampling ants from the leaf litter, ants living underground, ants in the trees and the canopy. Also we inventory nests by searching in dead woods, under bark of the trees, under the grasses, under the rocks, in holes of the floor and in termites mounds. Collecting ants in nest is a good method because it simplify the identification work as you can collect ant workers, male and queen in same nest. We also learn on how to prepare a clear sample from a sample full of soil and dust, and also different tips of mounting well an ant for identification and photography. The trainers taught us different website that are helpful in ant identification. These websites are Antweb, Antwiki and Antmaps.org. Whereby in Antwiki we can easily get the keys to specie level, in Antweb we can easily see the pictures of ants and in Antmaps we can see the distribution of ants in any region. We learn also on how to prepare databasing of ants we collect. Databasing is important because when one keep information of a certain ant anyone can get the information of that Ant. Information provided in databasing is such as project name, collection code, subfamily, genus name, specie name, subspecie, located at, owned by, type status, locality name, elevation, method, habitat, and etc."

Recording chirping sound of ants

Installing a pitfall trap in the ground

Sampling leaf litter with a Winkler

Beating branch with a stick over a Japanize umbrella

Question: And what about ants and elephants ?

Esther: " Elephants have an inherent fear of ants and some other insects. Ants can enter in the elephant trunk which can also be fatal. In this case we have been making trials of recording the chirping sounds produced by ants and experimenting on ant pheromone extraction. We hope by using some application. After recording these sounds they are going to be played in a man-made machine that emits a sound that is threshold level by human beings. This will be in trials to see if it has an effect on elephants or not."
"

Grasshoppers and crickets: crop pests and edible insects

Nosim Ritte, volunteer in the lab, mounting collections of grasshoppers, crickets and mantis

Many people, having locusts in mind, think of Orthoptera as harmful insects that damage the crops of arid and semi-arid Africa. Claudia Hemp, in her new book " Bushcrickets, Wetas and Raspy Crickets of Tanzania and Kenya" show they are also perfect bioindicators, reflecting the habitat quality of e.g. forests. She recorded more than 270 species in Tanzania.

The Hymenopodidae are the most attractive of the mantids often mimicing flowers.

Some species like crikets are the most consumed insects across the globe. In Tanzania, the most famous Orthoptera is the Longhorn grasshoppers (Ruspolia differens) commonly known as "Senene" and largely consumed during the rainy season in the area of lake Victoria.

New technologies like acoustic monitoring systems are now used to record and analyze insect sounds. These recordings help researchers identify specific insect species, estimate population densities, and track changes in their habitats over time.

Zonocerus elegans is a significant agricultural pest, especially for smallholder farmers. The species has aposematic colours (= to warn of its toxicity)

Grasshopper (find another picture ?)

An edible Cricket (Gryllidae) nesting in the ground

Parasphena pulchripes is completely apterous (without wings) and occurs in the moorland zone of Mt Kilimanjaro between 2400 and 4400 m asl.

Longhorn grasshoppers (*Ruspolia differens*) commonly known as "Senene" in Tanzania is one of the most appreciated edible insects by societies around Lake Victoria crescent. Senene is primarily an essential treat for the tribes around the lake, e.g., the Haya of Tanzania. Senene are highly in fats , protein and more taste. They even made a say for it, “senene ni tamu kuliko nyama” [senene are more delicious than meet] (©AP)

A collection of butterflies and moths
to develop tools for ecotourism and citizen science

Lepidoptera (butterflies and moths) are probably the best known insects of Tanzania. Butterflies are also a favorite group for students making surveys in National Parks and forest preserves, and a group of interest for ecotourism and citizen science.

The famous book of Kielland (Butterflies of Tanzania, 1990) provides the distribution of many species. Congdon and Collins from the African Butterfly Research Institute (ABRI) in Nairobi, where the Kielland collection is preserved, have published a Supplement to Butterflies of Tanzania in 1998. Liseki and Vane-Wrigth, between 2011-2019, have initiated a series devoted to the butterflies of Mt Kilimanjaro.

A total of almost 1400 species are recorded from the country (Liseki & Vane-Wright, 2011). The record in number of species is in the Minziro Forest on the West shore of Lake Victoria close to the border of Uganda where Kielland collected in 1992 more than 510 species of Butterflies!

Exhibition of butterflies in the TAWIRI collections

Moths of Tanzania are not so well collected and studied as butterflies. Only large species like Hawkmooths or Emperor mooths are relatively well documented. The Hawkmooths (Sphingidae) of Tanzania are illustrated in a catalogue of 164 species published by Darge in 2012. He has also published in 2008 a provisional checklist of 175 species of Saturnidae (Emperor Moths) recorded from Tanzania. The author says the country is probably the richest in Africa for its moth fauna.

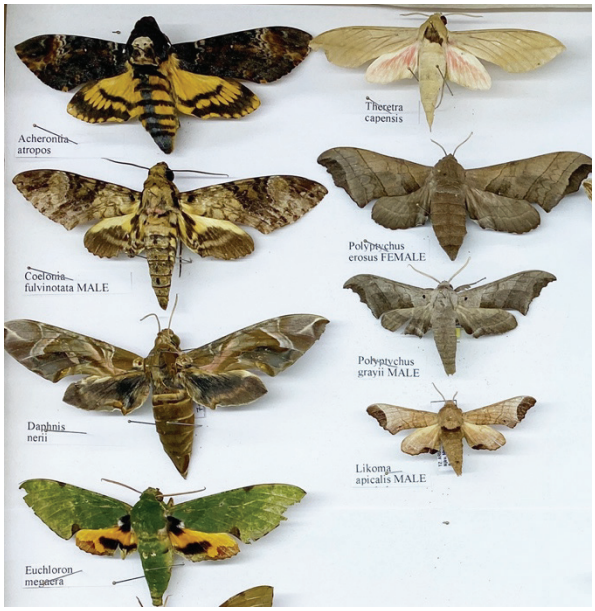
The JRS Biodiversity Foundation has supported since 2017 two projects devoted to the study of butterflies from the Uluguru Mountains and the Usambara Mountains.

A large number of moths have been collected with light traps in the Njiro Forest close to TAWIRI Headquarters. Light traps are used to collect specimens. A model of traditional light trap, the "senene trap" used around the Lake Victoria, can be adapted and constructed locally to collect moths and nocturnal beetles. These traps use a Mercury lamp very attractive for nocturnal insects. A network of light traps should be managed at a national level to know what insects occur in protected areas.

A "traditional" senene trap adapted to collect moths and coleoptera (Kagera, Karagwe district)

A "modern" light trap with windows and mercury lamp

Moth and beetles falling in the bucked of the senene trap filled with water and soap



Lepidoptera Sphingidae (Hawkmoths) collected in Njiro Forest.

TAWIRI entomological lab,
where further analysis after field collection is performed

Othman Akyoo is a technician laboratory in charge of mounting, labelling and digitising data in the collections. He is also sorting by families the collections of Hymenoptera (wasps and bees). He explains us some quotidian tasks in the lab:

"TAWIRI has set a place for entomological lab enriched with beautiful collection of insects and all other entomological facilities. The laboratory is now popular as it is receiving large numbers of university students, researchers, tourists and political leaders who are decision makers in our country.

Most specimens collected in the field are kept in ethanol for preservation before further analyses. After the specimens have arrived from the field, the technicians receive the sample for laboratory processes that will ultimately ending with identification of specimens. The activities in the laboratory include sorting, mounting, labelling, identification, digitization and long term preservation."

Sorting. Upon arrival from the field, insect collection bottles are checked to make sure they have labels with important information about collected specimens. Insect traps can catch different groups of insects, so the contents of collection bottles are poured into the sorting dish and then sorted by putting each group of insects in a different bottle. Insects are normally

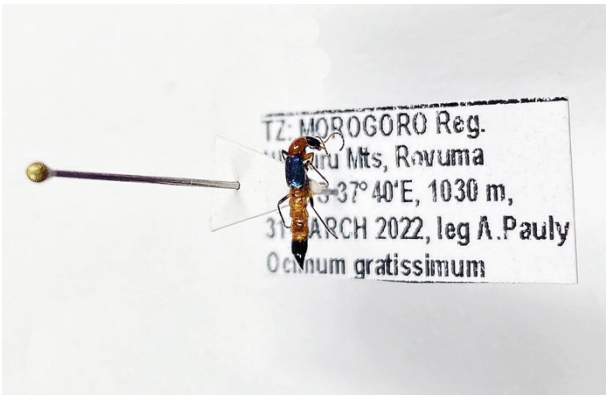
sorted into their orders such as Hymenoptera, Coleoptera, Hemiptera, Diptera, Lepidoptera, Millipedes and Araneae. Labels are included with the specimens inside the bottles.

Preservation. Three types of preservation are used: (a) Freezing and refrigeration: specimens can be placed in tight closed bottles for some days in a refrigerator before further treatment. Tissue paper is placed between the bottle and insects to keep them dry. (b) 70% ethanol is normally used as the best preservative of insects, especially those to be remaining in ethanol like Araneae, Millipedes and the majority of unsorted Diptera (only some families are systematically mounted on pins when a specialist is interested). Insects can be placed in ethanol for years before to be pinned or otherwise treated. Containers with ethanol are checked regularly because the liquid can evaporate and left the specimens dry and destroyed, when the top of the container can be damaged. Specimens for DNA study are stored in microtubes with absolute (93 %) ethanol. (c) Dry preservation involves the use of envelopes for the groups of insects that are not well preserved in Ethanol because they are covered by scales like Lepidoptera (butterflies and moths) or have fragile hairs like bees. Lepidoptera (moths and butterflies) collected in traps are however well preserved in ethanol for future DNA processing.

Mounting. Careful insect preparation is important, for it allows easier examination of the specimens and interpretation of differences between species. Insects stored in freezer are thawed until they are soft enough to be pinned without damaging them. Also specimens preserved in ethanol are pinned and dried. Two ways are applied during mounting which are direct pinning and gluing on the top of small triangular cardboards. We use pins n°1 or n°3.

Direct pinning. A lot of adult insects must be pinned through the thorax, others like Coleoptera are pinned on the top of the right elytra. Pin number 1 is usually used when pinning an insect directly. Around 10 mm is left between the top of the pin and the body of the insect for the pinned insect to be handled easily. Legs, antennae and wings are positioned according to the way you want the insect to look like and to keep as few spaces as possible in the entomological box. Specimens are pinned on a styrofoam board in the required position and remains there for some days until they are dry enough to be placed in the entomological boxes.

Gluing. Insects that are too small to pinned directly are glued on the point of the triangular small pieces of hard "visit card" paper that has already been stuck through with a pin number 3 (more strong than pin n°1). A drop of glue is placed on the tip of the point and each specimen is glued on to the tip of the point. Amount of glue should not be large to avoid covering parts of insect with glue and not too few for insect is falling. This technic with tiny insects require some skills and good "chirurgical" capacities.



Labeling. The information about specimens is just as valuable as the specimens in collection. A specimen without labels is often useless for scientific purposes. All specimens are labelled location where they were captured which may include coordinates and elevation, the date of collection, the method of collection, eventually the name of the plant visited by the insect, and in any case the name of the collector. Labels are printed on special heavy paper (style visit card or Laser inkjet copy paper 160 gr). Labels are pinned below each specimen at the same level using a pinning block. Specimens are arranged inside the boxes in clear rows with all labels facing the same direction to make them easily readable from the same side of the box.

Identification. Many different characters are used to classify and identify insects. Identification keys are tools commonly used to determine an insect, to the order, family, genus or species level. For a student, identification to the family level is already a good challenge. Identification to species level requires most of the time examination of the specimen by a specialist. This is particularly due to the lack of recent and good illustrated keys in many groups of African insects.

Digitization. Information from labels is copied into a data base that can later be free accessed by different people. Microsoft Excel or other specific software are normally used for data digitization. This process allow to generate automatically geographic distribution maps, seasonal graphics of abundance, correlations between insects and visited plants, etc.

Production of insect pictures. Pictures of insects are taken at different focal lengths in order to get a picture of the whole body in good quality and high resolution. These pictures are then combined by the computer program into a single image that have a sharp focus of the entire insect. Pictures of different parts of the part of the insect are also taken because it is difficult

to focus on the entire insect at once. Taking photos of the specimens in collections allows in some case identification without sending the specimen to a specialist outside the country. The virtual collection can be used at distance by any person interested when pictures are shared on a website or in pdf.

Desinfection. The main dangers that threaten an insect collection are humidity and… insects. Excess moisture manifests itself in moldy specimens and rusty pins. To prevent this damage, the collection must be stored in a relatively dry or air-conditioned place. Fortunately, the climate of Arusha, located at altitude, is sufficiently dry. The other danger is caused by insects that feed on dead insects and can cause significant damage to collections.

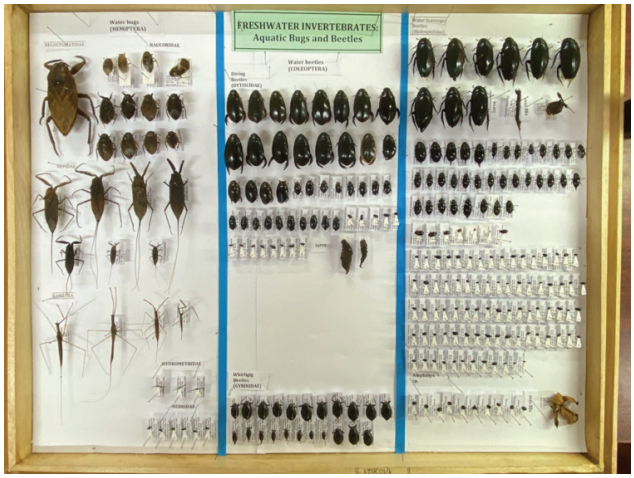
Among the main pests are dermestids and beetles (beetles), as well as tiny book lice (psocoptera). Sometimes we also find silverfish that slip into the boxes.The best way to protect a collection from unwanted insects is to keep it in a waterproof box. However, you must be careful that certain beetles such as Lyctidae perforate the wood of collection boxes. If live insects are found in the collection, they are eliminated by placing the boxes in the freezer for three days, tightly wrapped in a plastic bag. The best way to ensure the protection of a collection is to inspect the boxes regularly or to rotate them in the cold every six months. When taking out the box, do not open it until it is at room temperature, otherwise condensation will form on the specimens.

Question: What equipment can you find locally for the lab and what material must be imported for managing professionally this collection ?

"Entomological specific equipment like pins must be imported from Czech Republic. Chemical products like Thymol (preservative against fungi or pest in the collections) or stationary material like Laser inkjet copy paper 160 gr for labels must be imported from Belgium. Entomological boxes, cabinets, traps or nets are constructed locally after giving some good prototypes and instructions. Ethanol for chemical laboratory is very expensive but fortunately we received a gift of 250 liters pure bioethanol from the Kevan Company. Ground in polystyrene (styrofoam) for the bottom of entomological boxes are found in Arusha with Benson Company (they use it for protecting fridges during transport) but much better quality material like plastazote foam must be imported from the Netherlands". Microscopes and photographic equipment are imported. A pulsfog for fumigation of trees was imported from Kenya.

Extension and exhibitions

An exhibition of the butterfly and insect collections and aquatic invertebrates is managed at the entrance of the entomological laboratory for visitors. Vivarium with living insects could also be managed in the future if the new laboratory is visited by schools or groups of tourists.

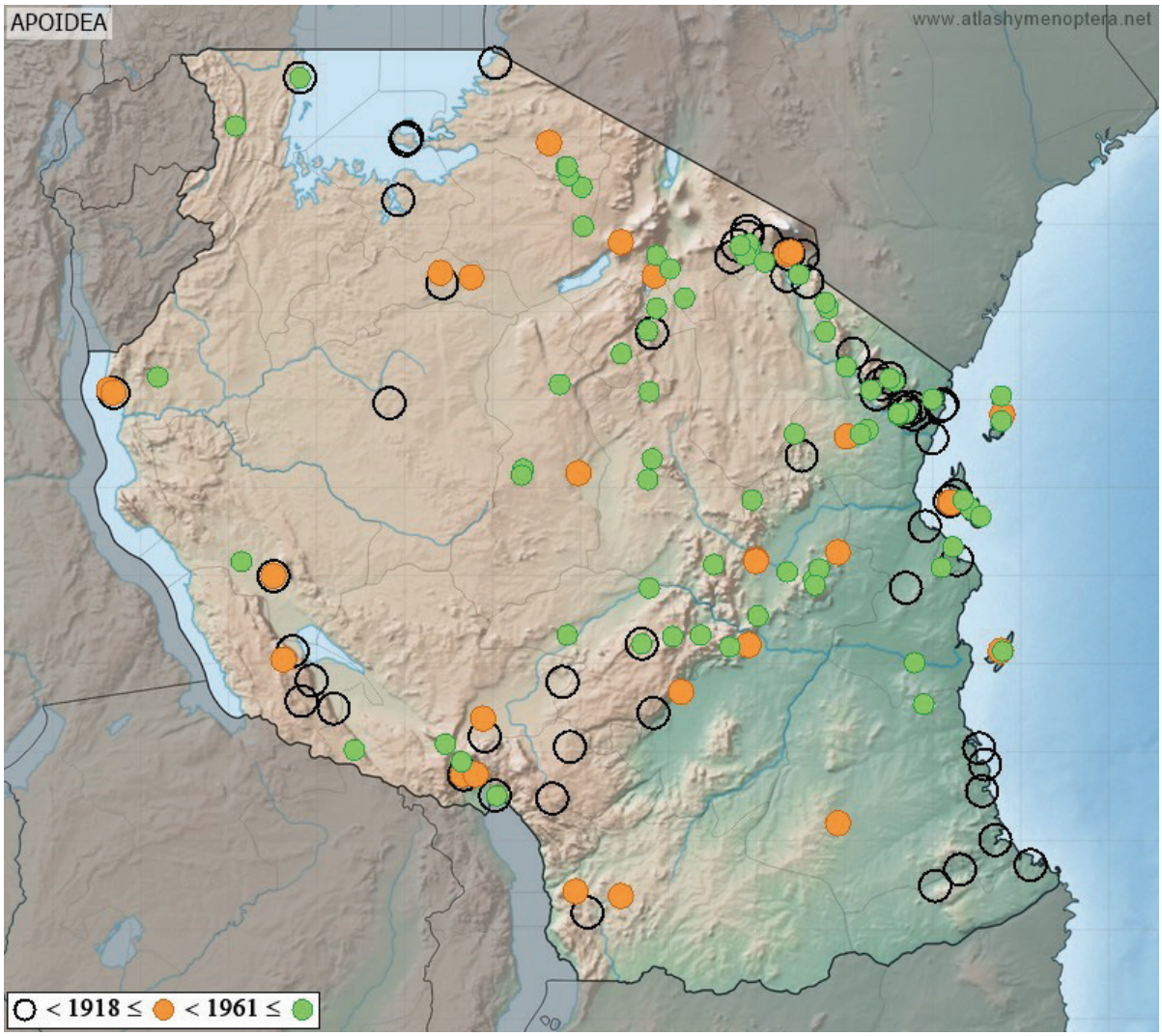


Developing a mobile collection with insects stored in demonstration boxes is one of the objectives of the project (Singida, Bee Day, May 2023)

What are the anticipated milestones for the project

We are expecting to contribute to a better knowledge of the insects and other invertebrates from Tanzania

- Developing a database of Insects and other Invertebrates
- Publishing a series of atlas of Insects from Tanzania
- Contribute to the taxonomy of different groups when specialists are available
- Capacity building to young researchers to conduct invertebrate surveys and training of parataxonomists
- Encourage amateurs, students, young scientists, and volunteers to join the team and collaborate to collecting insects in different regions of Tanzania



Map showing localities with data digitized for Apoidea
(symbols represent different historical periods)

TAWIRI New Laboratory

We must fill the museum with new specimens before it is too late so that future scientists continue to perfect our knowledge of evolution. We are the last generation to be able to observe the result of 3 billion years of evolution and natural selection.

Publications coming soon

Atlas of Invertebrates from Tanzania
A Virtual National Collection

Atlas of Invertebrates from Tanzania:
A Virtual National Collection

Volume 1
Bees (Hymenoptera: Apoidea)
Part 1: Historical data

Tanzania Wildlife Research Institute (TAWIRI)
Arusha, August 2023
Edited by Alain PAULY, Neema KILIMBA, Janemary NTALWILA & Edward KOHI

Atlas of Invertebrates from Tanzania:
A Virtual National Collection

Volume 2:
Dung Beetles (Coleoptera: Scarabeoidea)

Tanzania Wildlife Research Institute (TAWIRI)
Arusha, XX 2023
Edited by Alain PAULY, Neema KILIMBA, Janemary NTALWILA & Edward KOHI

Atlas of Invertebrates from Tanzania
A Virtual National Collection

Volume 3
Aquatic Invertebrates
A Guide for collecting invertebrates in freshwater environment

Tanzania Wildlife Research Institute (TAWIRI)
Arusha, August 2023
Edited by Alain PAULY, Neema KILIMBA, Janemary NTALWILA & Edward KOHI

Atlas of Invertebrates from Tanzania:
A Virtual National Collection

Volume 4:
Coleoptera: Carabidae

Tanzania Wildlife Research Institute (TAWIRI)
Arusha, April 2023
Edited by Alain PAULY, Neema KILIMBA, Janemary NTALWILA & Edward KOHI

Some books to know more on Tanzanian Insects

Forest Insects

Schabel H.G., 2006. Forest Entomology in East Africa: Forest Insects of Tanzania. Springer. 328 pp.

Pollinators

Martins D.J., 2014. Our Friends the pollinators. A handbook of pollinators diversity and conservation in East Africa. National Museum of Kenya. 102 pp.

Eardley C., Kuhlmann M. & Pauly A., 2010. The Bee Genera and Subgenera of sub-Saharan Africa. *Abc Taxa*, 7: vi + 138 pp.

Kiellan J., 1990. Butterflies of Tanzania. Melbourne: Hill House. 363 pp.

Larsen TB., 1996. The butterflies of Kenya and their natural history (2nd edn). Oxford (UK): Oxford University Press. 490 pp.

Darge P., 2012. An illustrated Catalogue of the Hawkmoths of Tanzania (Lepidoptera, Sphingidae). Tanzania, an exceptional Biodiversity in Africa. 63 pp. 15 col plates.

Kirk-Spriggs A.H. & Sinclair B.J. Eds. 2017-2021. Manual of Afrotropical Diptera. Volumes 1-3. Suricata. Pretoria, South Africa.

Dung Beetles

Davis A.L.V., Frolov A.V. & Scholtz C.H., 2008. The African dung beetles genera. Protea Book House, Pretoria. 272 pp.

Davis A.L.V., Deschodt C.M. & Scholtz C.H., 2020. Conservation assessment of Scarabaeine dung beetles in South Africa, Botswana and Namibia: IUCN red List categories, atlas and ecological notes. Suricata 6, Sanbi, Pretoria. 799 pp.

Aquatic Invertebrates

Dijkstra K-D & Clausnitzer V., 2014. The Dragonflies and Damseflies of Eastern Africa. Studies in Afrotropical Zoology, Royal Museum for Central Africa, 298: 264 pp, 360 colour photos.

Miller K.B., Bergsten J., 2016. Diving Beetles of the World. Systematics and Biology of the Dytiscidae. Johns Hopkins University Press, Baltimore. 320 pp.

Reed S.K. & Cumberlidge N., 2006. Taxonomy and biogeography of the freshwater crabs of Tanzania, East Africa (Brachyura: Potamoidea: Potamonautidae, Platythelphusidae, Deckeniidae). Zootaxa, 1262, 139 pp.

Schuh R.T. & Weirauch C., 2020. True bugs of the World (Hemiptera: Heteroptera). Classification and natural history (second edition). Siri Scientific Press, vol. 8, 767 pp, 32 plates.

Orthoptera:

Hemp C., 2021. A Field Guide to the Bushcrickets, Wetas and Raspy Crickets of Tanzania and Kenya. Senckenberg-Buch, 86: 451 pp.

Rowell H. & Hemp C. 2017-2021. Jago's Grasshoppers of East and North East Africa. 5 Volumes.

Catalogues and Checklists

Haas F. & Klass K.-D., 2003. The Dermaptera of Tanzania: checklist, faunal aspects, and fogging canopies (Insecta: Dermaptera). Entomologische Abhandlungen, 60: 45-67.

Enghoff H., Hoffman R.L. & Howell K.M., 2016. Checklist of the Millipedes (Diplopoda) of Tanzania. Journal of East African Natural History, 105(1): 51-113.

Acknowledgements to our sponsors

The JRS Biodiversity Foundation is an independent grantmaking foundation based in the United States with an endowment that awards grants to increase the access to and use of biodiversity information in sub-Saharan Africa.
The JRS Biodiversity Foundation is a major sponsor for our project to make surveys of invertebrates on Mt Kilimanjaro and Mt Meru and has provided funding to cover production costs of this newsletter.

The Belgian GTI-NFP is housed at the Royal Belgian Institute of natural Sciences, it runs under the CEBioS (Capacities for Biodiversity and Sustainable Development) programme, is funded by the Belgian Development Cooperation, and supports the implementation of the Convention on Biological Diversity.
The GTI (through grant CBD:GTI/JV/2021.16) and the Institute (RBINS) are helping our project in building capacities in taxonomy and collection management.

Pepperstreet Capital BVBA is a private company located in Belgium. Bart Rossel (Director) is thanked to have supported financially expeditions to make surveys of pollinators in natural montane vegetation of Northern Tanzania and providing equipment for the laboratory.

Large quantity of chemical products like ethanol are used to preserve insects collected in traps and are necessary for long term preservation of groups of invertebrates like flies (Diptera) and spiders (Araneae). Chemical products are very expensive. K-Van is a Tanzanian private company producing spirits. The director has generously provided bio-ethanol for our laboratory.