UDZUNGWA ECOLOGICAL MONITORING CENTRE

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MUSE

HIFADHI ZA TAIFA TANZANIA NATIONAL PARKS

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CONTENTS

BACKGROUND 4

MISSION 5

MANAGEMENT & RESOURCES 5

FACILITIES 6

ACTIVITIES & ACHIEVEMENTS 8

Accommodating researchers and students 8

Ecological monitoring 9

Promoting and facilitating research and conservation programmes 21

Environmental education and community-based conservation 23

Construction of the Visitor Information Centre 25

Technical advisory and training to local staff (and communities?) 27

UEMC promotion and communication activities 30

PERSPECTIVES 32

ACKNOWLEDGEMENTS 34

REFERENCES 36

BACKGROUND

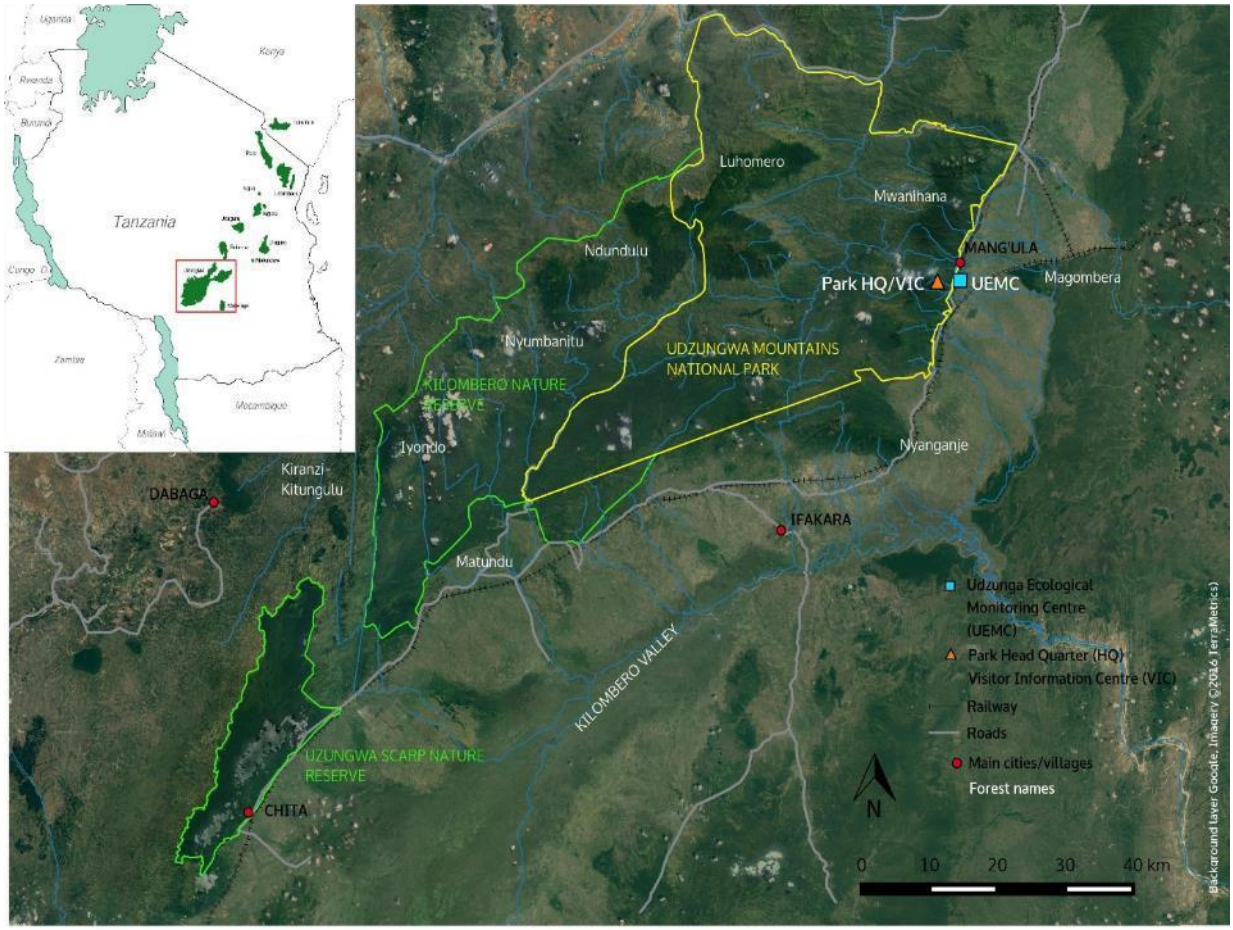
The Udzungwa Ecological Monitoring Centre (UEMC) is a field station of the Udzungwa Mountains National Park (UMNP), Tanzania, established by Italy's MUSE – Science Museum in 2006 in partnership with Tanzanian National Parks (TANAPA). Following two consecutive management phases regulated by 5-year MoUs, in 2017 the Natural History Museum of Denmark (NHMD) entered the partnership for a third management phase (2017-2021) which is the focus of this report. Moreover, in 2019 the Department of Biology of the University of Florence (Italy), Francesco Rovero's current affiliation, formally joined MUSE in the efforts to co-manage UEMC with NHMD and TANAPA.

Beyond providing accommodation and research facilities to local and visiting scientists and students, UEMC aims to provide technical advisory to the National Park and more generally to facilitate research, conservation planning and community outreach programmes in the area. Among the strategic activities, UEMC contributes to the implementation of biodiversity monitoring programmes, the organization of training courses for rangers, park ecologists and university students, and the promotion of school education programmes for scholars.

Located in south-central Tanzania, the Udzungwa Mountains (hereafter also called 'Udzungwas') occupy an area of approximately 19,000 km^2, comprising the largest remaining forests blocks in the Eastern Arc Mountains, a renowned region ranging from southern Kenya to Tanzania within the *Eastern Afromontane Biodiversity Hotspot*. Covering an altitudinal gradient of 300 m in the Kilombero valley to 2,576 m at Luhomero peak, the Udzungwas include tropical lowland and montane rainforest, as well as *miombo* woodland, dense dry forest, and grassland. This region holds outstanding levels of biological diversity and endemism comprising **more than 400 bird species, over 120 mammals, 2,500 species of plants and thousands of new invertebrate species, many still awaiting description**. Owing to a combination of natural (i.e., geology, climate) and human-induced factors (i.e., subsistence and commercial logging, pole cutting agriculture, bushfires), the habitats in Udzungwas are highly fragmented, making a mosaic of intact and modified closed-canopy forests interspersed with drier habitats, settlements, and agricultural areas. In particular, the conversion of surrounding lands in the Kilombero valley into intensive agriculture for sugar cane and rice, and the associated infrastructural and human population increases, pose the highest threats to biodiversity in the Udzungwa landscape.

This report describes the activities and achievements of UEMC during 2017-2020, and it refers to the 10-year report (2006-2016) for detailed description of the institutional arrangements and background activities related to the first decade of operations. It is available for download at this link.

The current, third management phase is regulated by an MoU lasting from 2017 till 2021 between TANAPA and MUSE/NHMD that extended the two previous ones.



The Udzungwa Mountains are a mosaic of forest blocks interspersed with drier and settled or farmed areas, with most of the natural habitat protected under different reserve categories. The Udzungwa Mountains National Park protects 1,990 km^2 in the north-eastern portion of the range, while Kilombero and Uzungwa Scarp Nature Reserves protect other important chunks of natural habitat.

UEMC MISSION

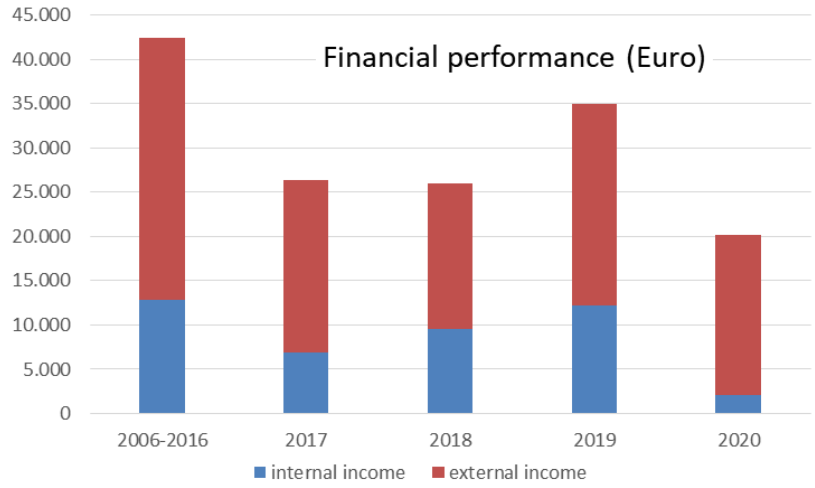
The mission of UEMC remains to increase the understanding of the biological importance of the Udzungwa Mountains by promoting and facilitating research and monitoring of biological diversity. UEMC aims to make use of the long-term data collected within this area for developing more effective conservation management and community education plans for the preservation of the whole mountain range, including the Forest and Nature Reserves.

MANAGEMENT & RESOURCES

In the first decade (2006-2016), UEMC staff had increased in number of staff from 8 to a maximum of 22 people depending on different projects that have been active at the time, with this count that included staff involved in projects ran directly by MUSE and partners. More specifically, a minimum of 7 staff dedicated to core management routines (security, gardening, house-cleaning and maintenance) have been employed under the umbrella of the MoU with TANAPA, while the more technical staff (coordinators, field technicians) had contracts through locally-registered NGOs such as TFCG and Association Mazingira. During the current

management phase, from 2017, the core UEMC staff has been composed by 1 coordinator, 1 financial officer, 4 field technicians, 2 drivers, 1 gardener, 2 house keepers and 4 security guards. A variable number of temporarily employed field technicians has also been involved on specific projects.

In the first decade, UEMC financial movements - related to routine management funded through MUSE and NHMD institutional funding (thus not including research and monitoring projects ran through dedicated funding) - increased from a budget of around 12,000 € in 2007 to around 60,000 € in 2016. While the institutional funds from MUSE have covered the bulk of funding in the first years, during the ten years of activity UEMC was able to raise more than 30% of the total income from accommodation fees. **In the period 2017-2020, the budget per year for routine management of the station has ranged from 20,000 to 35,0000 €, with an internal income that averaged 26%**. The low figures for 2020 are due to COVID-19-related drop in visiting researchers and students. Apart from the anomaly represented by 2020, the figures for the reporting phase are comparable to previous years in terms of core UEMC functions when considering that some of the summer schools held in the first decade did not continue every year in this phase (hence causing a slight decrease, from 30 to 27%, in the internal income). It is also important to remark that we worked to attain a sustainable and cost-effective management model for UEMC for its long-term persistence.



Annual financial budget of UEMC in Euro during 2017-2020 and the average values for the previous decade (2006-2016), divided by institutional funding and internal income, which averaged 27%.

FACILITIES

The basic function of UEMC is to provide accommodation and facilities to visiting researchers, national students and international students staying in Udzungwa for training and research. Over the 14 years of activity, UEMC diversified its offer. UEMC provides accommodation for short and long-term students and researchers, it also organizes summer schools and training courses, and it provides logistic support and lodging facilities for independently-organized courses and summer camps. In addition, UEMC facilitated research and conservation programmes led by external agencies.

During the reporting period the structures have remained the same as in the first decade, consisting of an office with research facilities (Internet, computers, printers, maps etc.), a large (150 m^2) seminar room that can accommodate over 50 people, three more buildings as researchers' houses, a large dormitory block with four rooms that can host up to 24 students, a dining hall with annexed kitchen and stores and a storage building next to the office.

Aerial photo taken from a drone showing a landscape view of the Mwanihana forest escarpment in the National Park and the location of the UEMC buildings (left). Seminar room of the UEMC with students attending a lecture during a summer school (right). Photo credits: Nikolaj Scharff (left) and Francesco Rovero (right).

Moreover, discussions among partners of the need for an additional building to be used as a laboratory for sorting and storing biological samples and other analyses that need dedicated space and equipment have been initiated during the current phase. Funding for such premise have been secured by the partners through a donation from the Aage V. Jensen Charity Foundation in 2021, and **realizing a laboratory building will be one of the objectives of a proposed future management phase**.

We also mention here the construction of the Visitor Information Centre at the park HQs that was promoted by UEMC through its partners, as reported in the next session.

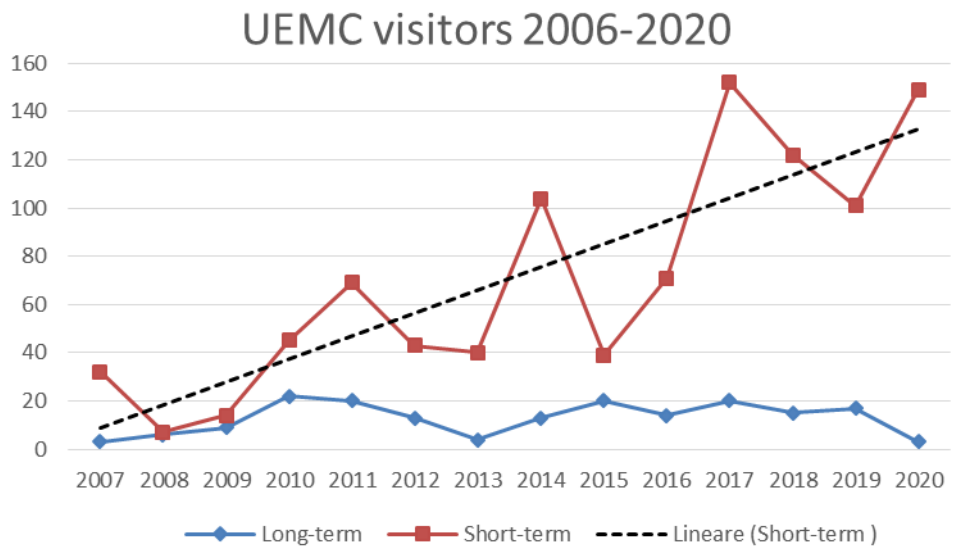
ACTIVITIES & ACHIEVEMENTS

Main activities and related achievements are grouped as follows:

i. Accommodating researchers and students
ii. Ecological monitoring
iii. Promoting and facilitating research and conservation programmes
iv. Environmental education and community-based conservation
v. Construction of the Visitor Information Centre
vi. Technical advisory and training to local staff and communities
vii. UEMC promotion and communication activities

(i) ACCOMMODATING RESEARCHERS AND STUDENTS

UEMC continued to host national and international researchers and students that lodged for short- to long-term periods. The **overall number of visitors since UEMC establishment reached over 2,000 people with 1,167 that lodged at UEMC and the remaining number relates to daily visits**. More specifically, of the 1,167 lodged visitors, 988 stayed for less than a month (short-term in the chart below) and 179 spent over a month. Importantly, the short-term visitors have increased while the long-term remained stable, with the exception of the drop in 2020 due to COVID-19 travel restrictions.



The number of UEMC visitors by year (histogram above) divided as lodging for short-term periods, less than one month (red line) and long-term periods, more than one month (blue line). Long-term guests dropped in 2020 due to COVID-related travel restrictions.

During the period 2017-2020, 62% of the visitors were Tanzanian and the remaining 38% were foreigners, with the share of Tanzanian visitors reversed relative to the first 10 year period (2006-2016) where 63% of the visitors were foreigners. Overall, the vast majority of the guests staying at UEMC for short or long periods were researchers and students, whereas the figure

for daily visits by researchers and students were slightly over 50%, with the remaining visitors being of other categories such as tourists and Government officials.

(ii) ECOLOGICAL MONITORING

Non-human primates

Non-human primates are an iconic faunal group across the tropics: our closest relatives are among the most threatened animals on the planet, facing constant reduction across their range due to hunting and habitat loss. Yet, non-human primates are an essential component of tropical forest ecosystems. They are, therefore, a priority group for monitoring and conservation efforts. With 13 species, including range-restricted and endemic ones, **the Udzungwas are an outstanding hotspot in Africa for primate conservation**, and a recent assessment indicates that it is also ***the*** **top-ranking site in Tanzania for presence of globally rare, red-listed and range-restricted primate species and subspecies**. Thus, it is not surprising that a Primate Monitoring Programme has been in place for two decades now, indeed representing the longest-term monitoring scheme, and yielding among the most important datasets on any biological component of the Udzungwa forests.

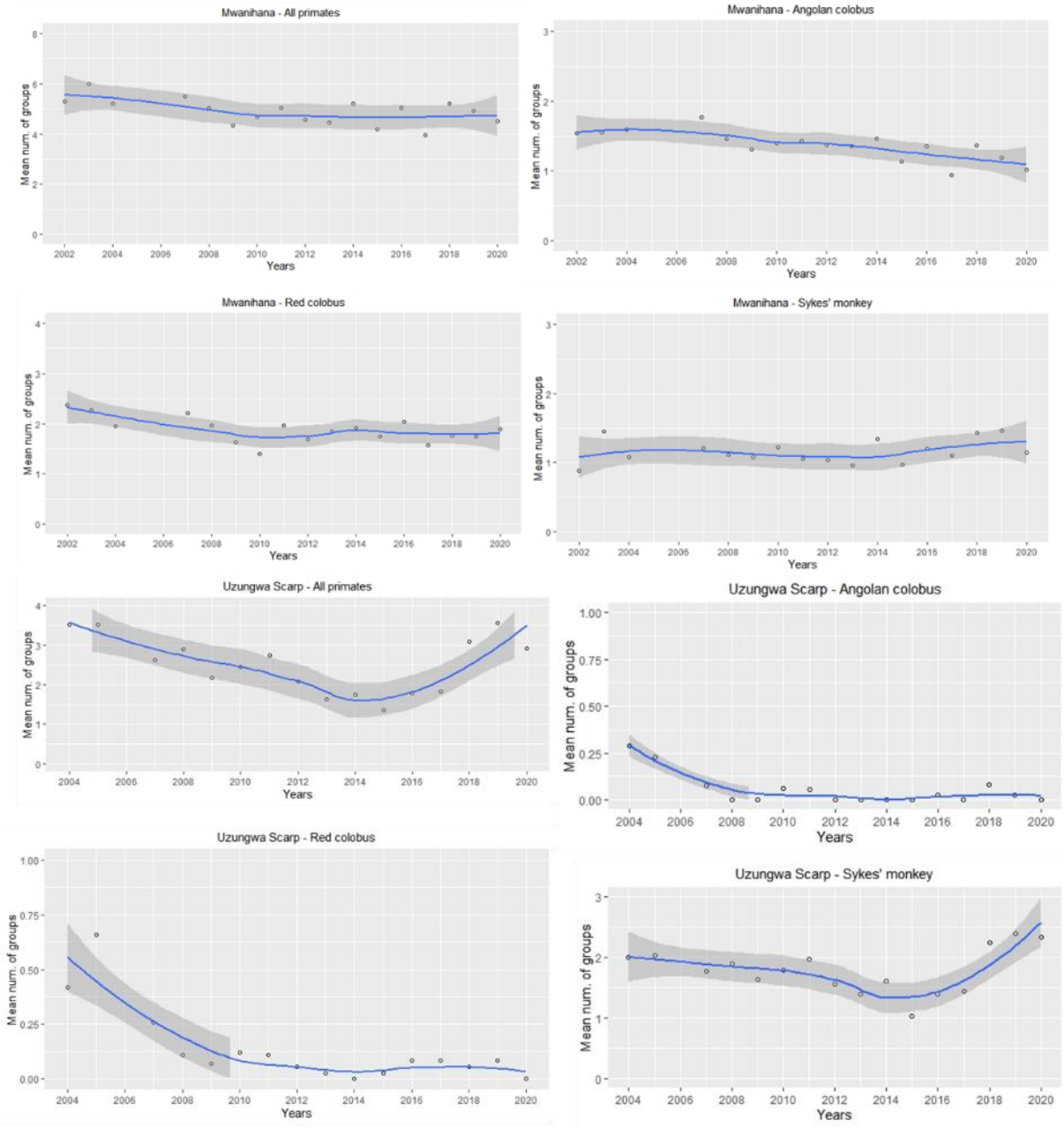
Sanje mangabeys (*Cercocebus sanjei*), the Udzungwa' endemic and iconic species, occurring only in Mwanihana and Uzungwa Scarp forests. This species is not properly sighted from line transects but has been monitored through camera trapping. Photo credits: Francesco Rovero.

The **Primate Monitoring Programme was set up in the late 1990s** by Thomas Struhsaker from Duke University (USA) as part of a broader primate research programme. The transect-based protocol for monitoring diurnal primates was placed in the east-facing Mwanihana forest, one

of the largest forest blocks, easily accessible from the eastern edge of the National Park. Researchers identified four trails of 4 km in length as 'line transects', regularly maintained, that entered the forest from its edge leading west, and walked regularly by trained local technicians and students. Line transect counts are the most common method to monitor primate abundance: observers slowly walk the trail and record all sightings of primate social groups with their position along the trail (as indicated by tags placed on trees every 50 m), as well as the number of individuals and any other useful information. Due to a relatively long phase of fine-tuning the programme, it was only from 2002 that data collection became standardized. Moreover, from 2004, the programme was extended by Francesco Rovero to another important forest, Uzungwa Scarp (now a Nature Reserve; USNR), 150 km to the southwest.

In 2006, UEMC took over this programme and continued the data collection in agreement with both the park's Ecology Department for Mwanihana forest and the Tanzania Forest Service for USNR. **By the end of 2020, an important sampling effort has been completed: 1,356 census walks of the four transects in Mwanihana, and 401 of the three transects in USNR, which translates into 7,250 km of transects surveyed overall**. Among the diurnal primates occurring in Udzungwas, five species were regularly monitored, including the endangered and endemic Udzungwa red colobus monkey (*Procolobus gordonorum*), the Peters' Angola colobus (*Colobus angolensis*), the Tanzania Sykes' monkey (*Cercopithecus mitis monoides*), the endangered and endemic Sanje mangabey (*Cercocebus sanjei*) and the yellow baboon (*Papio cynocephalus*). However, the latter two species could not be properly monitored, as they are mainly terrestrial and notably shy; therefore, they are not easily sighted from transects. However, Sanje mangabey is Udzungwa's most iconic species, and fortunately it has been targeted by other research efforts, including monitoring through camera trapping.

It is not the purpose of this report to present the scientific results in great details, also given that the most recent datasets (2020) have yet to be properly analysed, and analyses are often complex and time-consuming. Thus for scientific results the reader is referred to existing or upcoming scientific publications, particularly Rovero et al. (2015), downloadable here. A second publication that presents robust analyses of temporal trends for all data and extends the 2015 one is currently in preparation and foreseen for 2022. However, here the key results in terms of variation of population abundance in time, as simply quantified by the mean number of primate groups counted per transect, which can be considered an index of relative abundance. Charts also show a polynomial smooth line with 95% confidence intervals which is only merely pointing to possible trends, although it is important to remark that only a robust statistical analysis that considers imperfect detection can discern real trends from natural fluctuations and other biases.



Results of the Primate Monitoring Programme in two of the Udzungwa forests: Mwanihana included in the National Park (charts above) and Uzungwa Scarp Nature Reserve (USNR; below). Dots indicate the mean number of groups seen per year during each transect repetition. For each forest, results are shown clockwise for all primates combined (i.e., including Sanje mangabey and yellow baboon) and for the three best sighted ones (Udzungwa red colobus, Peters' Angola colobus and Sykes' monkey). Regression lines indicate a smoothed regression function, pointing to a rather stable trend in the National Park (with the slightly decreasing trend for Angolan colobus that will deserve further attention) and to a more complex trend in USNR, with an initial decline that was marked especially for the two colobus and relative stability afterwards, while Sykes' monkey show a clear increase in recent years (data by F. Rovero and UEMC).

For Mwanihana forest, results point to an essentially stable trend of relative abundance with time, with the apparent decline for Angolan colobus that will need statistical verification but does not seem to be particularly worrying. Results also show a possible increase in the Sykes' monkey, an opportunistic species that is also showing a marked increase in Uzungwa Scarp. The

comparison of results between Mwanihana and USNR (charts above) generally continues to highlight a key contrast in population dynamics between the two study forests: first, the relative abundance is generally lower in USNR than in the National Park, with the only exception of the Sykes's monkey. Second, and most alarmingly, **in USNR the trend continues to be of concern for the two colobine monkeys, which are a known target of local bushmeat hunting**. Importantly however, the declining trend for all primates and colobines seems to be switching from 2015-2016 towards an increase in Sykes' and a relative stability (although at very low abundance levels) for the colobines. This may be related to a release in the pressure of hunting and other human disturbances in this forest, where, from 2017, a new protection programme by TFS and partners has been put in force (details in the Conservation outcomes session).

Once again, these results not only show the importance of consistent and long-term ecological monitoring and how efficient a relatively simple protocol is at detecting trends, but they also call for urgent action, pointing to the imperative need for maintaining and where possible increasing protection of primate habitats.

Camera trapping to monitor ground-dwelling mammals

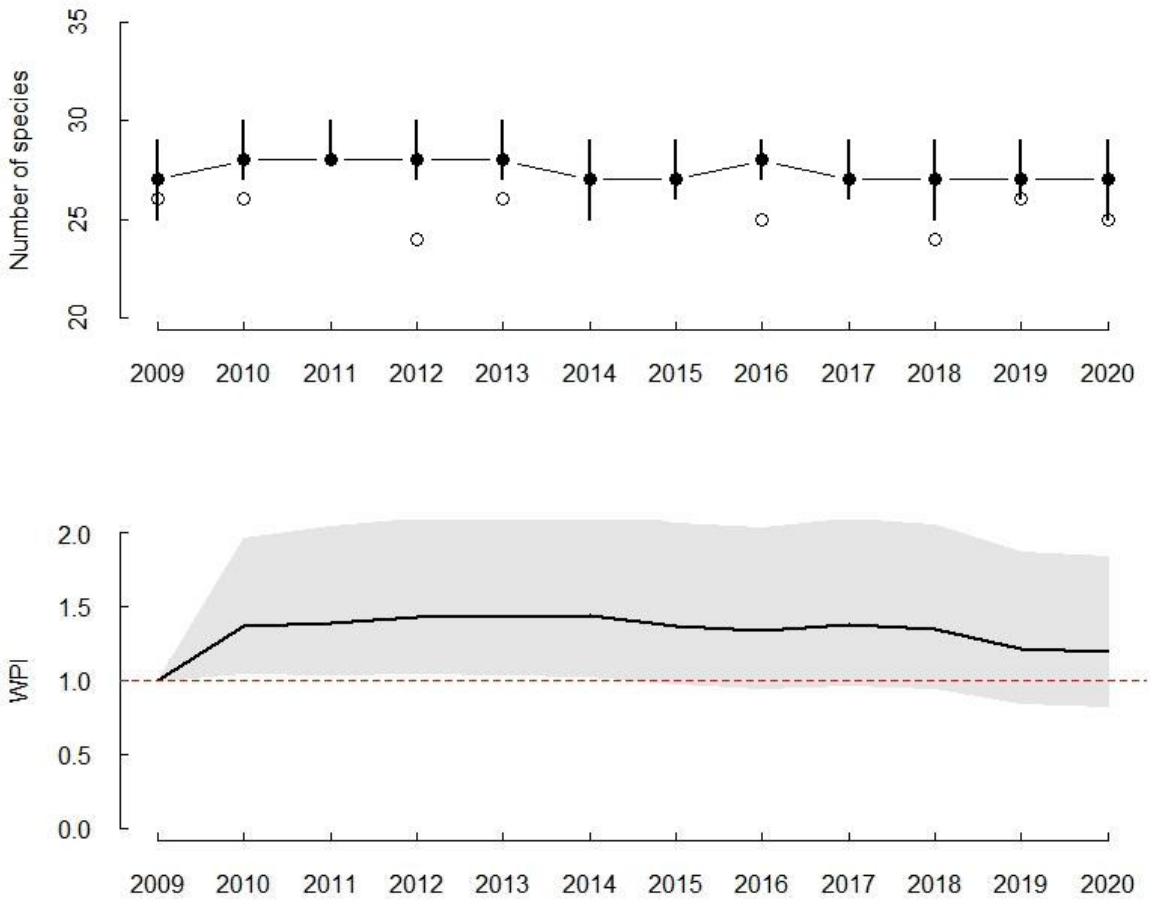
A second important monitoring programme at UEMC is carried out by means of camera traps, which are a powerful tool to detect medium-to-large, ground-dwelling mammals. Therefore, this programme is highly complementary to the monitoring of arboreal primates and includes a larger pool of species. The programme started in 2009 through UEMC's participation in a pantropical network of field stations, called the *Tropical Ecology, Assessment and Monitoring* (TEAM) network. The network, that reached 17 stations across the global tropics, was originally set up and funded by Conservation International.

Camera trap photos of mammals in Mwanihana forest obtained during the TEAM Network monitoring. Clockwise: elephant, grey-faced sengi, leopard and bushpigs (piglets). Photo credits: Francesco Rovero.

Since 2017, TEAM transitioned to a voluntary network of projects that falls under a new, global initiative called Wildlife Insights (see here for more information). Wildlife Insights is a platform to store, manage and facilitate analytics of camera trapping data around the world, and has been joined by several of the larger international agencies, including Smithsonian Institution, World Wide Fund (WWF), Wildlife Conservation Society (WCS), Zoological Society of London (ZSL) and others. However, the actual data collection past 2017 rests on the funding and initiative of dedicated institutions such as MUSE/UNIFI in the case of Udzungwa.

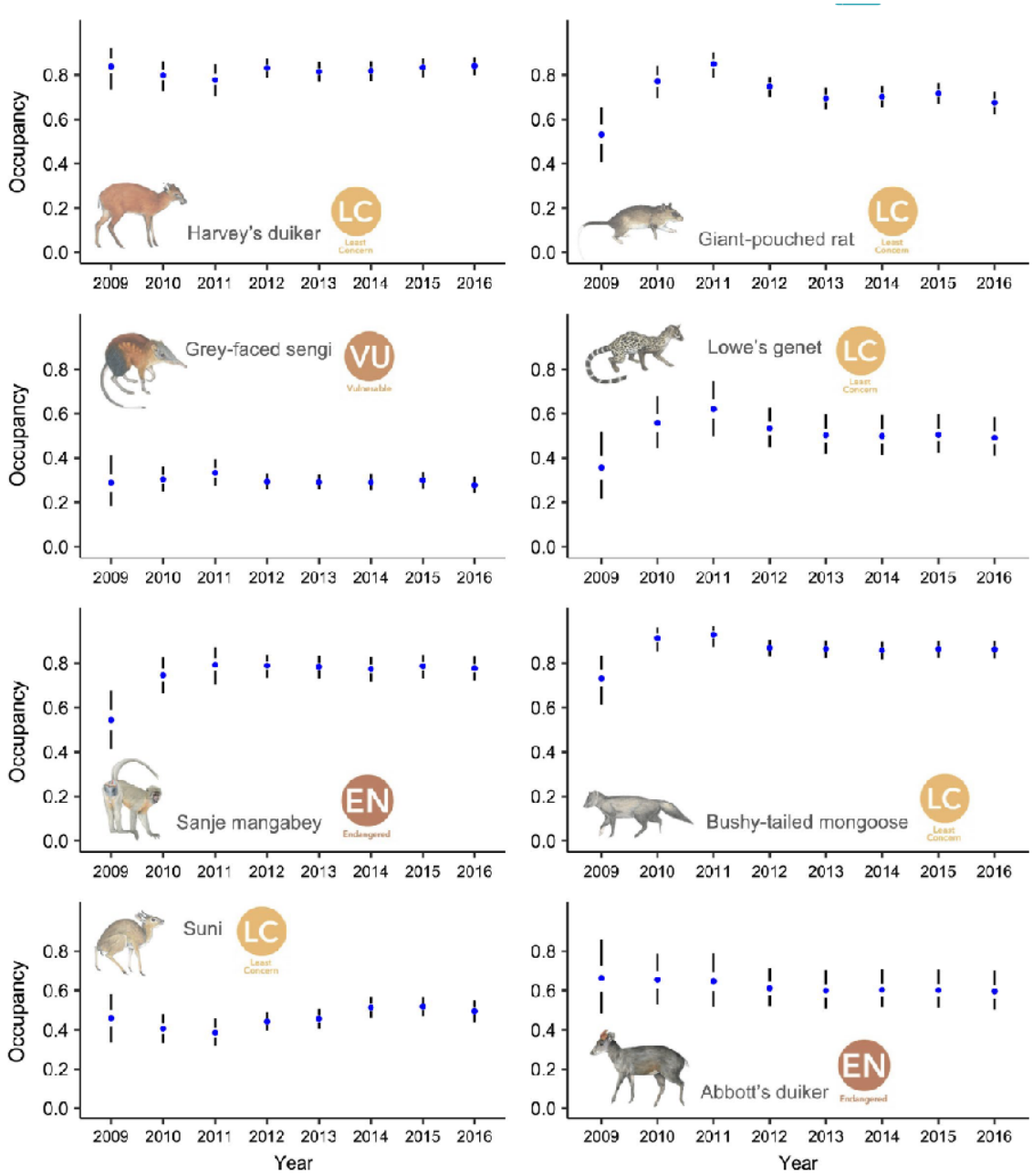
TEAM's 'terrestrial vertebrate' protocol consists of a grid of 60 locations in Mwanihana forest (one every 2 km^2) which have been sampled every year since 2009, with camera traps set for 30 days. Over the 12 years (2009-2020), **a remarkable dataset of over 240,000 camera trap images of wild mammals (on average 20,020 per year) has been accumulated**, with as many as 31 species of mammals photographed (range of 24 to 28 per year). In addition to building a species inventory, such data allowed researchers to study population and community occupancy and changes over space and time. *Occupancy* is a popular and statistically-robust metric that estimates the probability of presence, or the proportion of area used, of each species across the forest. The summary hereafter exemplifies the results and type of analyses that can be done based on this approach. Analyses until 2020 are only preliminary and have not yet been done in great details, while more detailed analyses and publications are available for data collected until 2016.

The most comprehensive and relevant results from the camera trapping data that meet the objective of a standardized monitoring programme are those on temporal changes in the status of the entire mammal community, in terms of both estimated species richness (see chart below) and population occupancies. In particular, the ***Wildlife Picture Index*** **(WPI)** specifically quantifies such temporal changes of the community status. This index is sensitive to both species richness (a species that goes extinct or are new colonizers) and their occupancies at each particular year. Below is the WPI computed on the data from 2009-2020 showing that the community of ground-dwelling mammals has been relatively stable in the National Park both in species richness and occupancies. As observed for the data on primates, this result continues to confirm the adequate protection efforts ensured by the National Park over this period.



Temporal profiles of the community of medium-to-large mammals detected from camera trapping over 12 years in Mwanihana forest, part of the TEAM's network project. Results indicate overall that the community has not changed significantly in the number of species and abundances. The chart above shows the variation in estimated species richness (full dots and confidence interval bars) and observed species richness (open dots). The chart below profiles the *Wildlife Picture Index* (WPI), an index that signals changes in the number of species available and the abundance of such populations within the community (source: TEAM Network and F. Rovero unpublished data).

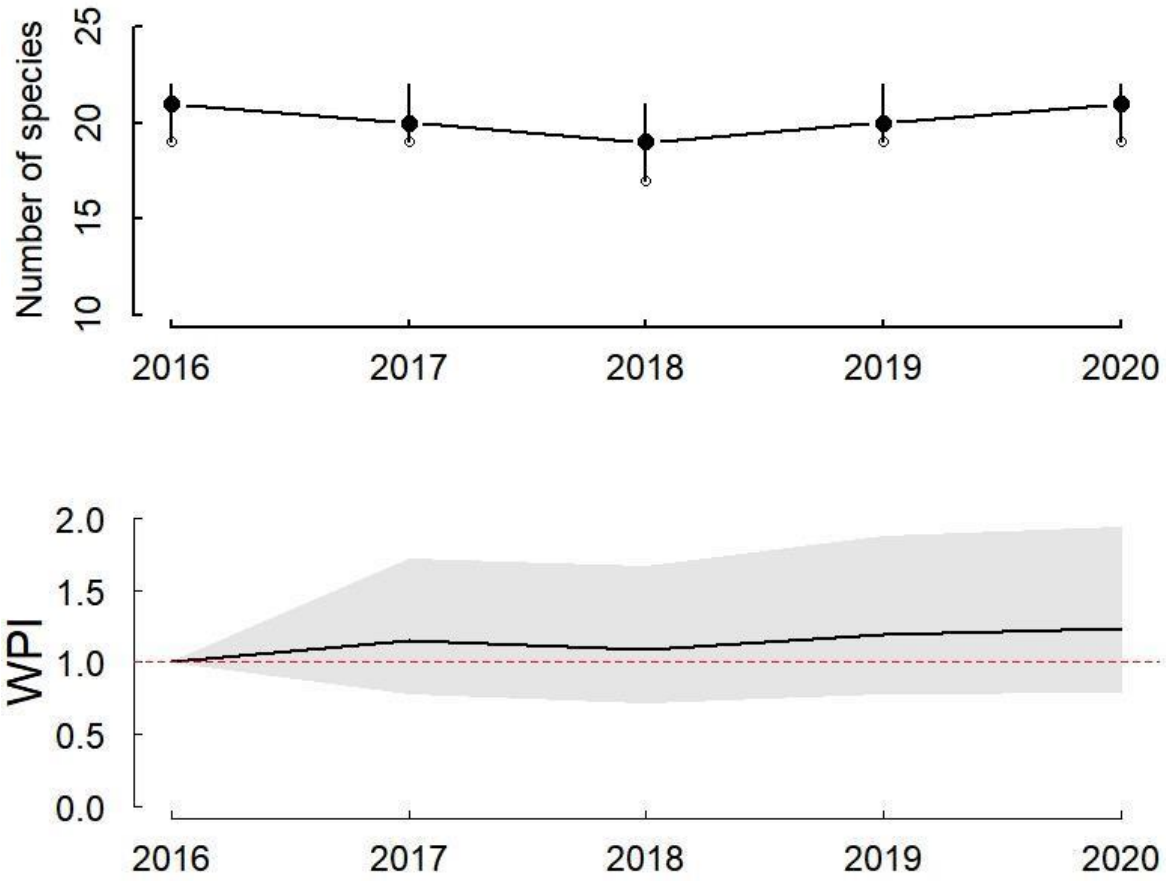
As mentioned, a range of analyses on focal species have been so far conducted on data till 2016, and for a number of details the reader is referred to the decade report (2006-2016; downloadable here). A relevant analysis among these has targeted temporal changes and factors associated for the pool of most detected species. These results are summarized in the chart below from Oberosler et al. (2020a) that confirms the relative stability for all species targeted. We used the number of snares illegally set by poachers in the forest as an index of potential poaching pressure, and found that only for Harvey's duiker, a relatively widespread forest antelope, this index negatively affected the occurrence probability. This result highlights the vulnerability of some species and hence the importance of continued monitoring.



Profiles of estimated occupancy for target species of mammals during 2009-2016. From Oberosler et al. (2020a).

Importantly, **TEAM's sampling protocol since 2016 was replicated in the southern Uzungwa Scarp Nature Reserve**, so to match the complementary efforts of primate monitoring. Therefore, the same design and spacing of 60 sampling sites was repeated in the same period by a second team of qualified technicians, and under specific permission from the Tanzania Forest Services. In this forest, the species found across the 5 years of sampling (2016-2020) were 22 (range 17-19 per year), relative to as many as 31 in Mwanihana. The mean number of images of wild mammals retrieved per year was nearly 8,300, relative to 20,000 in Mwanihana. Equivalently to Mwanihana, we used the data from this forest to first assess the temporal variation in species richness and WPI, reported in the following charts. Interestingly, despite the clearly higher anthropogenic disturbance that this forest has suffered especially in the past, the trends over these five years of data collection appear stable, which may provide indication

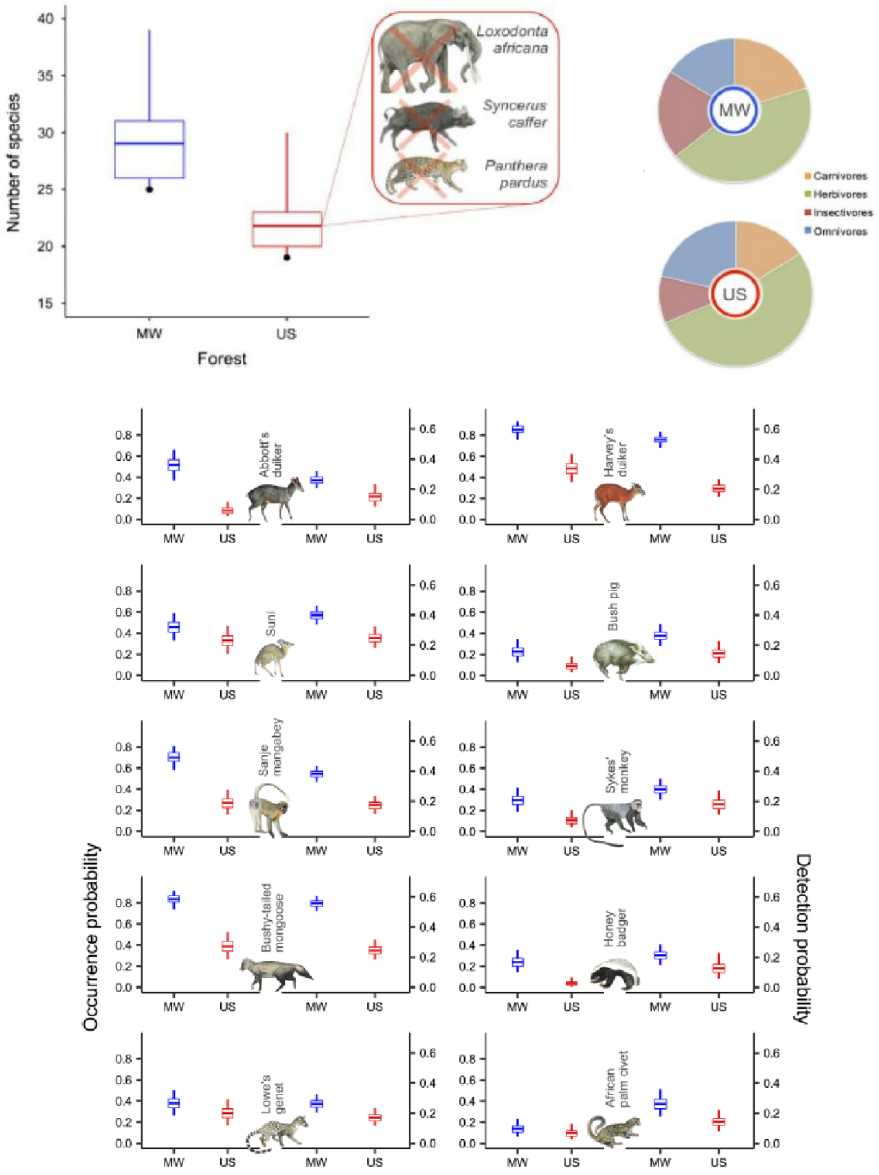
of the relatively efficient protection recently allocated and may anticipate a potential recovery of the mammalian community. Indeed, a preliminary assessment of focal species' trends in occupancy shows that trends are stable over the five years targeted, with signs of a slight tendency to an increase shown for the Sykes' monkey (matching data from line transects). Continued monitoring will be required to better assess the vulnerability of wildlife in this area, where, importantly, regular laws enforcement are in place and have been boosted since 2017 thanks to the support to TFS of the *Uzungwa Scarp Protection Programme* mentioned earlier and described in the Conservation outcomes session of this report.



Temporal profiles of the community of medium-to-large mammals detected from camera trapping over 5 years in Uzungwa Scarp Nature Reserve. Results indicate overall that the community has not changed significantly in the number of species and abundances despite an apparent, slight decrease centered on 2018. The chart above shows the variation in estimated species richness (full dots and confidence interval bars) and observed species richness (open dots). The chart below profiles the *Wildlife Picture Index* (WPI), an index that signals changes in the number of species available and the abundance of such populations within the community (source: F. Rovero unpublished data).

By combining the data from both Mwanihana and Uzungwa Scarp, we could also carry out comparative analyses. Thus, we have used data from 2016 from both forests to assess differences in various metrics, such as species richness, community structure in trophic guilds, and variation in species occupancies. A summary of results from this study are reported below,

showing that: (1) estimated species richness is significantly lower in Uzungwa Scarp then Mwanihana, for the absence of large species such elephants, buffalos and leopards; (2) the structure in terms of estimated proportions of dietary guild appeared altered in Uzungwa Scarp mainly with an increase in omnivores and a decrease in insectivores; and (3) for nearly all species that occur in both forests, occupancy and detectability is lower in Uzungwa Scarp. These results once again raise the importance of increased and continued protection to the recently established Nature Reserve. Detailed results are reported in Oberosler et al. (2020b).



Results of the comparison in community structure (pie chart above) and population parameters: *Occupancy* and *Detectability* (charts below). Results show differences in community and populations between Mwanihana (MW) and Uzungwa Scarp (US). From Oberosler et al. (2020b).

A fundamental value of the former TEAM's programme is the availability of standardized data from several sites across the tropics, which has allowed for unprecedented regional and global-

level analyses, to which the Udzungwas contributed. These global or pantropical studies are not described here but are available as publications in high impact journals (e.g., Rovero et al. 2020; Kays et al. 2020; Gorczynski et al. 2021). Due the paucity of standardized data from the tropics, these studies could not be possibly performed before TEAM.

Monitoring and documenting invertebrate fauna of Udzungwa

A new programme was initiated in 2012 under the title "Eastern Arc Biodiversity Programme: Discovering, Documenting and Explaining the 'Smaller Majority' of the Udzungwa Mountains". The programme focuses on the invertebrate fauna (the smaller majority) of Udzungwa. The original objectives of the programme were:

- to explore the taxonomy of selected invertebrate taxa of the Udzungwa Mountains, in particular spiders, millipedes, beetles, and flies;
- to further develop and promote standards, techniques and methodologies for state of the art and cost-efficient biodiversity inventories and assessments;
- to make a substantial amount of primary occurrence data available from the Udzungwa Mountains, thereby providing essential data for conservation planning and natural resource management;
- to investigate faunal turnover along both altitudinal and longitudinal transects.

<u>Development of inventory techniques</u>

The long-term aim of the programme is to document the fauna and develop methods that can be used to monitor the invertebrate fauna of the Udzungwa Mountains, thereby complementing the on-going monitoring programmes for mammals and plants. Many arthropods have much narrower distribution ranges than vertebrates and can therefore provide answers to conservation and management issues on a more fine-grained scale than vertebrates. However, the cheer number of species and individuals of invertebrates in Udzungwa raise several challenges that we have tried to address in the first project period (2012-2017). We estimate that the number of invertebrate species in the Udzungwa's could easily be as much as 100,000 different species, and each hectare could hold millions of individuals. With such high numbers of species and individuals, we need to develop and promote standards, new inventory techniques and methodologies for state of the art and cost-efficient inventories and assessment, before we can initiate monitoring of the invertebrate fauna.

Up to 2017, the invertebrate program has focussed on the development of inventory protocols for fast and cheap assessment of the arthropod's fauna (insects, spiders, myriapods etc.) thereby providing methods for future monitoring of arthropods. The protocol developed is named COBRA-TF (Conservation Oriented Biodiversity Rapid Assessment for Tropical Forest; Malumbres-Olarte et al. 2017) and the new protocol was subsequently tested on spiders (Malumbres-Olarte et al. 2018) and provided important information about spider diversity and species composition (guilds) along altitudinal gradients on the Eastern scarp of the Udzungwa Mountains.

The COBRA-TF protocol was developed for spiders but could be used for many other invertebrates. It relies on a combination of manual collecting by human collectors and automatic trapping (pitfall traps). Even though the protocol only provides subsamples of the biodiversity, from which diversity is estimated, it still requires substantial sorting and

identification by taxonomical specialists, to provide reliable list of observed species. Sorting and identification therefore constitute a major bottleneck for the general use of such protocols on a broader scale. To overcome this, a master project was carried out on extra samples carried out in 2014. Catches from Malaise traps and pitfall traps were barcoded through a metabarcoding approach (Nielsen et al 2019; here) providing information about the invertebrate biodiversity in the samples. Traditionally, bulk samples are grinded and sequences for DNA analyses, thereby destroying the specimens in the samples. In this study (Nielsen et al. 2019) bulk samples that had been grinded and sequences was compared to bulk samples where DNA was extracted from the liquid (ethanol) in which specimens were sampled and stored, thereby saving specimens in the sample, and making them available for taxonomical studies. The study shows that sequencing the non-grinded samples works as well as sequencing the grinded samples (Nielsen et al. 2019) and thereby provide a promising avenue for future biodiversity assessments via barcodes. The material collected in 2014 was also used to test whether iDNA (Invertebrate Derived DNA) could be used to monitor vertebrates in Udzungwa (Lynggård et al 2019; here). Some of the invertebrates collected in Malaise traps and pitfall traps will feed on blood from vertebrates and the identity of these vertebrates can be revealed through metabarcoding of the vertebrate blood in the sampled insects. The method used is described in Lynggård et al. (2019) and a wide variety of vertebrates could be detected with this method, such as Hewitt's Bush Squeaker (Amphibia: *Arthroleptis xenodactyloides*), Honeyguide greenbul (Aves: *Baeopogon indicator*), Zanzibar bushbaby (Mammalia: *Paragalago zanzibaricus*), Suni (Mammalia: *Neotragas moschatus*), Red duiker (Mammalia: *Cephalophus natalensis*) and 12 other vertebrates. Vertebrates were detected in 19% of the analysed samples.

As can be seen from the metabarcoding studies mentioned above, modern molecular techniques can be used to help monitor invertebrates, as well as vertebrates in a given area, and can be done much faster than with traditional methods, relying on taxonomical expertise. However, there is a caveat in tropical settings, where species diversity is high and the proportion of new unknown species are high, or where barcode libraries have not yet been established for the local fauna. In such cases, names cannot be associated with sequences, and diversity will have to be described as a number. However, even though species lists cannot be provided for such areas, biodiversity can still be measured and compared.

Species diversity

A total of 15 plots, each 0.25 hectares in size, were sampled and revealed a total of 650 'species' of spiders, of which 85% turned out to be new to science. Since the protocol is both standardized and optimized, it can be used to estimate the total number of species, given the observed number of species, and this revealed an estimated total of 784-866 spider species in the 15 plots (3.75 hectares). This is thus an estimate of the number of spider species in the plots, had we been able to collect all species. It should also be emphasized, that the species number is based on the given size of the plot, the collecting period and the collecting methods available. The number would be substantially higher, had the plot been larger and the sampling period longer and the methods more diverse. For instance, we did not manage to include samples from the canopy of the forest in this study but know from a previous study carried out in the Udzungwa Scarp Nature Reserve in 1997 (Sørensen et al. 2002; Sørensen 2003, 2004), that the canopy may hold 30% unique species. We thus could have missed almost 1/3 of the diversity, by leaving out the canopy. The number of species found in this survey should be

compared to the current checklist of all Tanzanian spider species (Russell-Smith 2020) which currently list 901 species. This clearly shows that the diversity of spiders in Tanzania is much higher than the current checklist indicates.

Spider faunal turnover along gradients

The purpose of the spider survey mentioned above was not only to reveal the number of spider species in Udzungwa, but also to sample spiders along an altitudinal gradient in Udzungwa and thereby test two prevailing hypotheses about species diversity along altitudinal gradients. One hypothesis suggests that there is a monotonic decrease in species diversity along an altitudinal gradient, with more species at lower altitudes and fewer at the top (Rahbek, 1997). The other hypothesis suggests that there is a hump-shaped pattern of species diversity, with maximum diversity at mid-altitudes and lower diversity at lower as well as at higher altitudes (Rahbek, 1997). Sampling took place in three different altitudes – low (300-800 meters), middle (800-1400 meters) and high altitude (1200-1500 meters) at 5 altitudinal gradients along the eastern scarp of the Udzungwa Mountains. No differences were found in the spider diversity at the three different altitudes. Therefore, it could be concluded that the spider diversity did not match any of the hypotheses proposed. However, and perhaps not very surprising, the spider guilds at the three altitudes where very different. More surprising was the finding that the maximum number of adult specimens were found at the highest altitudes (Malumbres-Olarte 2018). The material collected will also allow us to analyse faunal turnover on horizontal gradients, but this have not yet been done.

Taxonomy and species discovery

As documented by two comprehensive spider surveys carried out in the Udzungwa Mountains in 1997 and 2014, very little is known about the invertebrate fauna. Nikolaj Scharff (1990, 1992) studied the spider family Linyphiidae in the Udzungwa Mountains. He found 31 forest species, of which 25 were endemic (81%). Such degree of endemism has not changed since then, even though new material has been collected and new species found. No less than 80% of the spiders' species were new to science in the study by Sørensen et al. (2002) in Masisiwe (Udzungwa) and 85% of the species collected in the 2014 survey was new to science. Only very few similar studies have been done for other groups of invertebrates, but the sampling done by our programme provides material that is currently worked upon by taxonomical specialists worldwide.

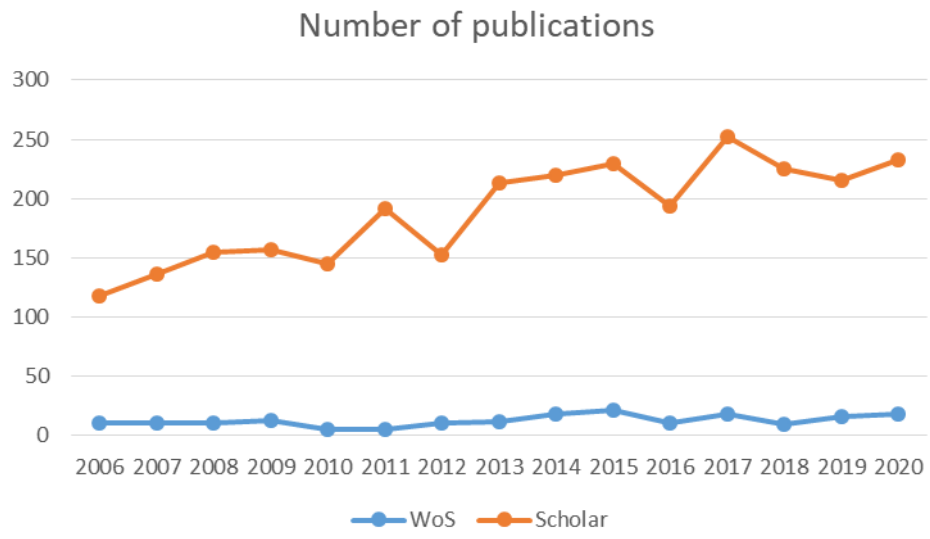
Similar diversity patterns are documented also for millipedes. Enghoff (2017, 2018a, 2018b, 2020) documented many new species based on material collected in the Udzungwa Mountains National Park, Uzungwa Scarp Nature Reserve and Kilombero Forest Nature Reserve. For instance, 39 species were recorded for the millipede family Odontopygidae (Enghoff, 2018a), 34 of which were new to science, and 90% were endemic to the Udzungwa Mountains. Most endemic species have rather limited distributions, being confined to one of the three protected areas. Even higher degree of endemism was observed for the millipede genus *Eviulisoma* (family Paradoxosomatidae) where Enghoff (2018b) found 22 species, all new to science and all endemic to Udzungwa Mountains. The families Paradoxosomatidae and Odontopygidae seems to be the most diverse families of millipedes in the Udzungwa Mountains. The few species shared with other mountain areas in the Eastern Arc Mountains and beyond are generally found at lower altitudes. Enghoff (2017) also described the new genus *Tropostreptus* (family

Spirostreptidae) with 6 new species endemic to Tanzania, and three of these endemic to the Udzungwa Mountains.

(iii) PROMOTING AND FACILITATING RESEARCH AND CONSERVATION PROGRAMMES

By facilitating individual researchers and agencies working in the area, UEMC continues to be instrumental to facilitate the expansion of research and conservation efforts in Udzungwas. A detailed analyses of research outputs as measured by the scientific production was presented in the first decade report and showed that 59% of 124 peer-review papers published during 2006-2016 (source: Web of Science using 'Udzungwa' as search word in title or abstract) related to projects facilitated by UEMC.

Here we update the overall publication score using the same two metrics as in previous report, namely the number of peer-reviewed publications per year according to the Web of Science and the number of all publication from Google Scholar engine. This includes also the so-called 'grey' literature (unpublished report or other non-peer reviewed publications). These are papers where the word 'Udzungwa' appears anywhere in the text, and is therefore a *maximum* count, as it may include papers where Udzungwa is not the focal study area. **There has been a marked increase in both the number of peer-reviewed papers from the Web of Science and the number of publications from Google Scholar**: the first metric yielded an average of 15.3 papers per year, higher than the 12.8 value for 2006-2016, and raising the overall number of peer-reviewed publications from 2006 to 185. The second metric yielded an average of 231.3 publications per year from Google Scholar, compared to the 173.8 value in 2006-2016 decade, raising the total number to 2,837. These trends are shown in the chart below.



The number of scientific publications yielded from research conducted in the Udzungwas. The chart above is based on a count of peer-reviewed papers in international, scientific journals (Source: ISI – Web of Science) and shows the share (averaging 59% in the decade) of papers that were facilitated by UEMC. The chart below is a more general count of all publications and reports of all sorts as found by the Google Scholar engine (see text for more details).

In terms of research and conservation projects, **we recently added to UEMC website a document with a comprehensive overview of ongoing projects** (here), as a potentially useful resource to facilitate coordination among project leaders and institutions. We intend to regularly update this document and use it as a base for organizing virtual or physical workshops that can facilitate coordination of research and conservation in the area. We anticipate that a **stakeholders' workshop will be organized within the new programme funded by the Aage V. Jensen Charity Foundation**.

Conservation outcomes of research and focal conservation projects

A large portion of research directly conducted or facilitated by UEMC continued to fall within the realms of applied ecology and biodiversity science, and as such it carried conservation relevance, with some studies that were primarily aimed at addressing conservation issues. For example, by revealing the dramatic decline of primates in Uzungwa Scarp Nature Reserve, the Primate Monitoring Programme has been instrumental to support increased protection of this important forest that in 2017 was upgraded from Forest Reserve to Nature Reserve. Concomitantly, a collaboration between MUSE, UNIFI, Association Mazingira, Bristol Zoo, and Wild Planet Trust, and implemented by the Southern Tanzania Elephant Program (STEP) started in 2017 the **Uzungwa Scarp Protection Programme**. This on-going effort provides **funding and capacity building to Tanzania Forest Service for enhancing protection of the forest**. This project represents an emblematic example of how applied research and long-term monitoring can trigger conservation action.

Photographs from the Uzungwa Scarp Protection Programme, showing the patrol team in action, composed of TFS, KDU and community members. Photo credits: STEP.

(iv) ENVIRONMENTAL EDUCATION AND COMMUNITY-BASED CONSERVATION

Environmental education activities conducted by UEMC begun at its establishment, as by then MUSE had been piloting them for a few years through community conservation initiatives around the Uzungwa Scarp area. MUSE is a Science Museum that works extensively with schools in Italy, the programme naturally fell among the primary objectives of MUSE's work in Tanzania.

From 2011, most of these activities were taken on by **Association Mazingira** to boost environmental education in local schools and to establish a long-term community conservation programme that complements UEMC's efforts. Association Mazingira ('environment' in Swahili) was founded in 2010 in Italy and registered as a Tanzanian NGO in 2019. Mazingira helps local communities establish tree nurseries, conduct tree planting and agro-forestry, and adopt energy efficient technologies to decrease the consumption of firewood from the forest. In the reporting period, Association Mazingira has begun to explore the potential of eco-tourism in the area by organizing visits to Udzungwa Mountains National Park and the surrounding villages by eco-tourists from Italy and by promoting income generating activities such as beekeeping, animal husbandry, tourism hospitality and handcraft works. In this context, Mazingira had a leading role in the establishment of the Visitor Information Centre (see below).

By 2017, **14 primary schools and 4 secondary schools were involved in environmental education for a total of 32 classes and an average of 3,000 students targeted each year in different initiatives**. The themes embraced relevant topics such as environmental-friendly sources of energy, agro-forestry and sustainable agriculture practices, climate change, soil conservation, waste management, biodiversity and eco-tourism. In addition to traditional lessons, workshops on energy-saving technologies, practical lessons on how to produce seedlings from seeds at local tree nurseries, and regular visits to the park, the rubber plantation and other places of interest were also introduced. Since 2018 the programme was integrated with activities at the newly established Visitor Information Centre. In addition, Association Mazingira established **7 school tree nurseries** with the help of environmental teachers and environmental clubs. Each nursery has **produced an average of 5,000 seedlings each year**. The 18 schools are also applying sustainable agriculture in their farms and planting trees. Some of them are using alley cropping technique in their fields and producing enough firewood for cooking daily breakfast for all students at the school.

In 2019 alone, Association **Mazingira produced 185,000 seedlings by 12 tree nurseries** that were planted in villages, schools, farms, churches and mosques, hospitals, and private houses. Agroforestry has also expanded: many farmers joined a pilot study to implement alley cropping in the area. In 2018, 48 farmers have made available 0.25 acres of their land for alley cropping implementation in a scaling-up project and planted 39,660 trees, of which 79% survived the first year. In 2019, 55 farmers, with the same scheme, planted in their lands 51,161 trees of which 74% survived the first year. Sixty farmers from the villages adjacent to the lowland forest of Magombera, subject to heavy deforestation, have been involved in woodlot establishment. Seedlings have been provided free of charge by the project tree nurseries. Fifty-two alley cropping acres (21 hectares) have been planted in 5 villages. The total amount of acres planted since the beginning of the programme is 237 (96 hectares).

To reduce greenhouse gas emissions and the consumption of wood and coal that threatens the environment and produces harmful fumes, Association Mazingira promotes and produces Energy Efficient and Sustainable Technologies (EEST). Thirteen women's groups produce and promote **insulated baskets and bags**, mud stoves, **Mayon turbo stove** and **briquette from carbonized waste biomass** produced with an electric machine. Each group disseminates and promotes the EEST in their village by cooking house by house and receives a monthly fee from the project and a variable share from EEST sale. Over 50 women have been selected, trained and sensitized since the beginning of the programme. In the village of Mang'ula B, AMNGO opened an EEST store for the production, promotion and sale of EEST. The revenues go to the group of women and young people who run the store. Over 10,000 mud stoves have been constructed in 14 villages and over 100,000 briquettes were produced with hand press and sold since the beginning of the programme. In mid-2019, an electric briquette machine was purchased and since then 6,040 kg of briquettes have been produced and sold.

Association Mazingira and MUSE, with the support of several Italian travel agencies, organize **eco-tours** of 15 days duration, 2-4 times a year in Tanzania. Tourists visited the forests of the Udzungwa Mountains, the ongoing international cooperation activities in the villages and other local places of interest. From 2013 to 2019 a total of 137 Italian tourists visited the area and the projects, during 14 eco-tours.

Association Mazingira has also involved women's groups, young people, and farmers in **income-generating activities**. The beneficiaries are trained and supported technically, economically, and logistically in the start-up of entrepreneurial activities (tailoring shops, poultry farming, technician expert in solar energy, local crafts, beekeeping, production of trees for the sale of firewood and timber, production and sale of EEST). Approximately 150 people have been involved in income-generating activities since the beginning of the programme. Twenty-four young women have been trained in a one-year course in tailoring and employed in local tailor shops; 4 sewing machines powered by photovoltaic panels were purchased and donated to 4 local tailors; 2 local groups, in the villages of Mang'ula A and Mwaya (one composed entirely by women and the other mixed), have been supported technically and economically for breeding chickens and hens. One group of solar technicians has been formed, trained and is active in the village of Mwaya with an established store. One group of 36 craftsmen has been trained and is active at the VIC craft market, at the entrance to the UMNP. Five beekeeping groups have been trained and are operative in the area.

Monthly night projections of self-produced promotional videos in Swahili have been showed in each village involving about 250-300 people per night. Association Mazingira has also realized and distributed thousands of manuals and brochures on tree nurseries, agroforestry and EEST in Swahili in villages and in schools. Additionally, it has designed, produced, and posted promotional posters on agroforestry and EEST in villages and schools. A radio campaign on sustainable agriculture, EEST and environmental conservation was recorded and aired. Eighteen village chiefs have been involved. Over 10 big sensitization events were realized, and 16 Village Community Banks (VICOBA) were involved in the promotion of solar energy.

(v) CONSTRUCTION OF THE VISITOR INFORMATION CENTRE

Following TANAPA's vision of establishing at the entrance of each National Park a visitor centre, we realize a small museum and interpretation centre to introduce visitors to the park and provide useful information for the visit. Funding from Trento Province was secured in 2015, through an alliance of institutions led by the non-profit Association 'Nadir' based in Trento, together with MUSE and Association Mazingira as partners to build the Udzungwa Mountains National Park's Visitor Information Centre (VIC). The Natural History Museum of Denmark later joined the partnership and provided funding for most of the exhibits through a grant from the Aage V. Jensen Charity Foundation.

VIC was constructed over 3 years and officially inaugurated on the 6th of March 2018 at the presence of the Italian Ambassador in Tanzania Mr. Roberto Mengoni, the Member of the Parliament and Deputy Minister for Natural Resources and Tourism Japhet Ngailonga Hasunga, the Provincial Councillor of the Trento Autonomous Province Sara Ferrari, the Director of MUSE – Museo delle Scienze Michele Lanzinger, and the TANAPA Conservation Commissioner Allan Kijazi.

Photographs of the inauguration day of the Visitor Information Centre (VIC). Top left: TANAPA's Conservation Commissioner addresses the opening speech in presence of the Deputy Minister for Natural Resources and Tourism and the Ambassador of Italy to the left. Students and village community members in the exhibition rooms. Photo credits: Francesco Rovero.

The architectural structure is made of two modular block buildings, one being a museum and interpretation centre, and one a seminar/video projection room. The structure was designed by the Italian architect Flavio Ridolfi and was mainly built by using eco-friendly construction materials. These include bricks made of pressed soil and sand with little use of cement.

External (left) and internal views of the VIC (right). Photo credits: Nikolaj Scharff.

Along with the VIC, a craft market was also inaugurated adjacent to the visitor centre. Twenty local craft groups of artisans from different villages were selected and given the opportunity to get in contact with the tourism of the National Park and establish a working collaboration between TANAPA and the representatives of the craft groups by signing a Memorandum of Understanding (MoU), valid for 5 years. Eventually, the groups joined and formed a consortium composed of over 35 local artisans who produce and sell their products at the 7 stands of the market. The artisans belong to three local Village Community Banks (VICOBAs).

School visits to VIC began in May 2018. The students of 30 classes of 14 primary and 4 secondary schools, where Association Mazingira works, have been welcomed at the VIC by qualified personnel who accompanied them on a guided tour in the exhibition area. Thanks to the Aage V. Jensen Charity Foundation, that funded part of the educational programme of Association Mazingira, these activities will be presented and implemented in the next 5 years. School students will visit VIC receiving training on conservation issues and local solutions. The VIC seminar room will be used for sensitization events such as video watching, twinning programmes with European students and workshops on sustainable practices and behaviours.

Visits by village representatives to the VIC organized by Association Mazingira (left) and tourists at the community-managed art crafts market outside the VIC (right). Photo credits: Silvia Ricci.

(vi) TECHNICAL ADVISORY AND TRAINING TO LOCAL STAFF AND COMMUNITIES

UEMC continued to work closely with the park's Ecology Department through sharing whenever requested the data from relevant monitoring efforts such as the Primate Monitoring Programme, assisting with planning and implementing park-driven monitoring efforts, providing routine advisory on technical issues pertinent to ecological monitoring and training UMNP staff.

UEMC also facilitated and collaborated to **training workshops** organized by the park. Specifically, UEMC facilitated a GIS training course organized by TANAPA on Anti-Poaching which conducted on the 30th – 31st August 2020. During the 16th – 18th of November 2020, UEMC hosted and supported, together with STEP and Reforest Africa, a major training on GIS techniques. The training was attended by 45 participants that included TANAPA Park Ecologists, Veterinary officers, Outreach officers and private organization staffs. The course took three days including practical sections. The training addressed various topics such as data collection, analysis, reporting and data exporting to centralized databases.

Photos of TANAPA staff trainings organized by UMNP at UEMC in November 2020 in conjunction with the GIS day. Photo credits: Steven Shinyambala.

Another relevant training course related to UEMC activities was conducted as part of the Uzungwa Scarp Protection Programme mentioned earlier. Specifically, Francesco Rovero with colleagues from partner institutions including Andrew Bowkett from the Wild Planet Trust participated as trainers at a training workshop for 20 TFS staff units and held at STEP offices in Iringa on the 9th of August 2019. Topics included monitoring schemes and the identification of forest mammals.

Group photo (left) and training session (right) from a workshop held at STEP offices in August 2019 on ecological monitoring in the context of the Uzungwa Scarp Protection Programme. Photo credits: STEP.

Also Association Mazingira organized various training sessions, in particular:

- training of local technicians on system sizing, maintenance, and in-house installation of solar energy system (27th to 31st August 2018).
- Training of VICOBAs for solar lantern business and household daily income and expenditure recording (19th of September 2018).
- Workshop with government leaders and other stakeholders for the establishment of a demonstrative tree nursery nearby the UEMC.

Related to training of local staff is the **provision or facilitation of scholarships for higher education**. As in previous period, UEMC did not have a dedicated budget for providing scholarships, and due to unexpected budget limitations, we could not support full scholarship for staff to enroll into higher education. The only exceptions have been the support to Steven Shinyambala to complete in 2018 his B.Sc. studies at the University of Dodoma that begun in 2015 and the facilitation by Natural History Museum of Denmark for Arafat Mtui to enroll into the EU-funded Erasmus Mundus Joint Master Degree Programme in Sustainable Forest and Nature Management during 2019-2021 at the University of Copenhagen, Denmark and at Bangor University, United Kingdom. Finally, we note that thanks to the forthcoming programme funded by the Aage V. Jensen Charity Foundation, to be rolled out from 2022, UEMC will be able to provide a limited number of scholarships to TANAPA and other local staff.

Summer schools & study abroad programmes

The 2009 inauguration of the student hostel block next to the UEMC offices and research houses, made it possible to host and organize training programmes for students. A major one has been the international summer school organized by MUSE in partnership with the University of Trento (Italy) and, for the later editions, the Natural History Museum of Denmark (University of Copenhagen). Starting in July 2011, **the international summer school entitled "Tropical rainforest biodiversity: field and GIS tools for assessing, monitoring and mapping" reached its fifth edition in 2016**. Through a combination of field trips in the rainforest, and lessons and exercises on a PC, the summer school aimed to provide field and GIS experience for assessing forest biodiversity, especially rainforest mammals, integrating state-of-the-art field techniques to assess key indicator species with GIS tools to map and model species distribution. During the five editions held, 70 international students enrolled in Masters programmes from

a range of countries participated, joined by staff from TANAPA (see above) and a number of students from Tanzanian Universities and conservation agencies. Based on student feedback solicited by questionnaire at each editions the school was a success, and students especially enjoyed the mix of field trips with lessons in classes and exercises on a PC using the data collected.

Since 2017, the Natural History Museum of Denmark have organized **a yearly field course (summer schools) with the title 'Field Course in Ecology and Evolution of East Africa'** for undergraduate students at the University of Copenhagen, Denmark, University of Dar es Salaam, Sokoine University of Agriculture and Mweka Wildlife College in Tanzania. Course content includes a general introduction to East African rainforest and savanna ecosystems, biodiversity surveys, monitoring and conservation issues. It also introduces the students to morphological and biological characteristics of the major 'key' groups of animals and plants in the East African rainforest and savanna ecosystems and tropical fieldwork and field techniques are demonstrated and practiced.

Group photo with students and lecturers that participated in the Summer school held in 2019 and organized by the Natural History Museum of Denmark at UEMC premises. Photo credits: Nikolaj Scharff.

A total of 67 students (49 Danish and 18 Tanzanians students – and the park ecologist from Udzungwa Mountains National Park, TANAPA), attended the training courses. However due to the eruption of the COVID pandemic at the beginning of 2020, the summer school was not conducted in the 2020 and will unfortunately also be cancelled for 2021 due to travel restrictions and other health restrictions. We hope to be able to resume summer schools from 2022. The course is evaluated by the students, as parts of the general evaluation of courses at the University of Copenhagen, and the ratings are very positive. The course can accommodate 24 students, but we currently get twice as many applications for participation, so the course is very popular. Students are particularly fund of the mixture of classroom lectures, practical

exercises and a 3 night camping in the national park where the students can get practical experience in the field and experience the forest. The course finish with a two-day excursion to Mikumi National Park where the students are introduced to savannah ecosystems and its megafauna.

In addition to the above mentioned schools, UEMC continued to offer independent courses and summer camps for any interested institution, by providing logistic support and lodging facilities. In 2017-2019, Penn State University, USA has continued to organize an integrated research-education study abroad programme for a class of 12 undergraduate students interested in landscape planning and park-community interactions. Co-directed by prof. Larry Gorenflo (Department of Landscape Architecture) the Tanzania Parks and People Programme focuses on community design and ecotourism in selected communities close to the park. The project aims to help local people meet resource demands without adversely affecting Udzungwa Mountains National Park or other reserves in the area. The programme was interrupted in 2020 due to COVID-19 but will resume in 2022.

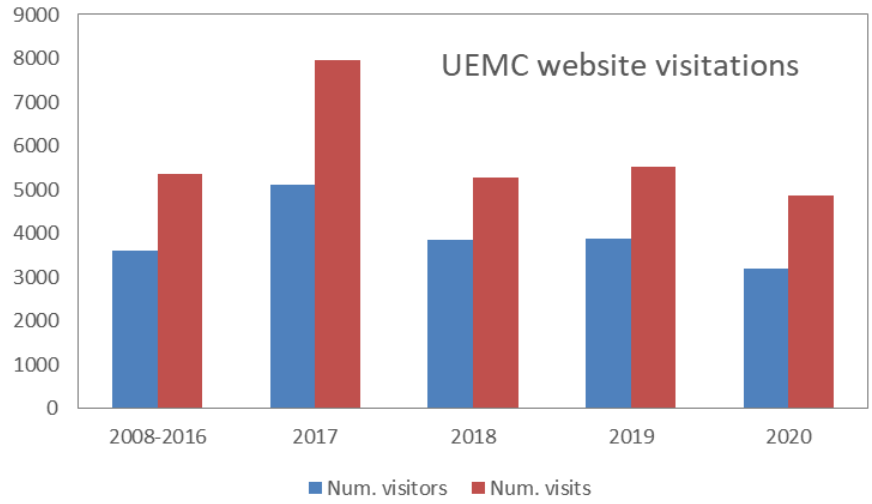
Finally, starting from 2022, UEMC will host students from three Tanzanian Universities (Mweka, SUA and UDSM) as part of the Erasmus+ European programme, under the CONTAN project, to implement state-of-the-art Higher Education training to boost capacity and curricula in monitoring and conservation biodiversity.

(vii) UEMC PROMOTION AND COMMUNICATION ACTIVITIES

UEMC work and achievements continue to be promoted in various ways. Francesco Rovero and Nikolaj Scharff participated in the 2017 TAWIRI conference held in Arusha where the former was invited to present UEMC achievement by then and the decade report, giving a speech titled: “When monitoring matters: 10 years of Udzungwa Ecological Monitoring Centre”.

All past UEMC coordinators and F. Rovero attending the TAWIRI conference. From left to right: Amani Kitegile, Philipo Jacob, Francesco Rovero, Emanuel Martin, Arafat Mtui. Photo credit: Arafat Mtui.

We kept the website (www.udzungwacentre.org) updated as the virtual 'door' to use the field station, learn about its activities and more generally get a wealth of information on the area, with the most recent update done in 2020. Both **the number of visits and the number of different visitors in the reporting period was steady and comparable relative to the earlier period** as show in the chart below.



The number of UEMC website visitations expressed as number of different visitors and number of visits (source: http://www.udzungwacentre.org/stats/).

PERSPECTIVES

THE NEW PERSPECTIVE MANAGEMENT PHASE (2022-2026)

In spite of delays and complications emerged due to the COVID-19 pandemic, a new management phase will be presented to TANAPA from the alliance of MUSE/UNIFI/NHMD by the end of 2021.

Besides renewed management procedures that to the intents of proposing institutions will continue to go in the direction of a progressive handing over to TANAPA of management responsibilities and the provision of resources for running UEMC, we list here the key foreseen elements of such renewal. These intents are solid and realistic in view of two major assets: (1) the continued willingness of both MUSE/UNIFI and NHMD to support UEMC for another phase and more generally to continue consolidate their long-term presence in the area, and (2) the donation to NHMD from the Aage V. Jensen Charity Foundation of a grant to support and enhance coordinated research, monitoring and conservation work for the next 5 years in the Udzungwas.

Such key lines of work are the following:

- **Continue and consolidate the long-term biodiversity inventorying and ecological monitoring** with priority to the Primate Monitoring Programme (in two forests), the TEAM Network programme (in two forests with possible extension to Kilombero Nature Reserve) and the invertebrate assessment and monitoring towards a progressively more timely and efficient use of data by the park for management decisions.
- Support financially and with capacity building **enhanced protection in Uzungwa Scarp** through the Uzungwa Scarp Protection Programme and **extend such programme to Kilombero Nature Reserve** through STEP; concomitantly, assess the scope for **support to UMNP Protection Department** to compensate to budget cuts incurred due to COVID-19.
- Construction of an **additional UEMC building to be used as a laboratory** for all research that needs screening, preparation, identification and storing of samples collected in the field, for example for the invertebrate assessment programme by NHMD or studies of population genetics. We believe such structure would address a significant gap in the current facilities and hence make UEMC attractive to a broader range of research projects.
- Continue the alliance with Association Mazingira to support **environmental education and other activities that engage communities**, with special focus on developing activities together with the park through the VIC.
- Continue to **provide formal and informal training to TANAPA staff and other professionals from protected areas and conservation agencies** for the use of standardized monitoring tools; this effort will also be contributed by a new EU-funded project (CONTAN) that runs 2021-2024 and includes e-learning and field training for Tanzanian University students and professionals.
- Organize, towards the end of the new phase, a **landscape-scale stakeholders' workshop** to bring together all stakeholders (Protected Areas managers, local Government,

communities, private sector, NGOs, researchers etc.) to discuss and agree on coordinated management activities for the long-term sustainability of conservation in the Udzungwas. Such workshop is deemed necessary given the rapid land use changes that have occurred in the landscape, particularly in the Kilombero valley.

In conclusion and using the same final words of the first decade report, we see UEMC to continue its primary and fundamental functions it was realized for: host researchers, facilitate research in the Udzungwas, support the capacity of the park and the other reserves in the area by monitoring their exceptional biological treasures, and use this knowledge to fine tune management. In a context of ever-increasing anthropogenic pressure on the forests, with rapidly escalating conflicts in land use between conservation and intensive agriculture at their surroundings, we must not overlook the importance of monitoring and protecting them. For it is precisely the very existence of these forests that provides the ecosystem services (water, hydropower, soil fertility, rainfall, etc.) on which thousands of people's livelihoods depend.

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