The Activity Budget of Adult Chimpanzees (*Pan troglodytes troglodytes*) and Environmental Conditions in Mefou Primate Sanctuary, Centre Region, Cameroon

Melle Ekane Maurice¹*, Olle Ambe Flaubert Gildas², Bekarikoh Najembe Ekale² and Jeta James Fawoh²

¹Department of Forestry and Wildlife, Faculty of Agriculture and Veterinary Medicine, University of Buea, P.O. Box 63, Buea, Cameroon. ²Ape Action Africa, Yaounde, Cameroon.

Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Time is a limited parameter of various activities for most wild animals. The study of time budget allotment among various diurnal activities such as feeding, resting, grooming, travelling is essential for the characterization of living and working manner of a primate species, which lay the foundation for interrelating ecology and the behaviour of the species. The survey was focused on determining the activity budget of chimpanzees and their environmental needs in Mefou primate sanctuary. The research data collection was initiated after a brief pilot study of the study area and the animal group. A 4-month-data collection from April – July was carried out and was done the first 10 days of each month, from 8:00am – 6:00pm. The activities of the focal animal observed were recorded alongside the scan data obtained in a 15-minute-interval period. Additionally, observations were recorded on environmental changes. The research data was analyzed by the use of chi-square

*Corresponding author: Email: melleekane@gmail.com;
statistical model. The focal animal revealed a significant relationship on activity budget, \( X_2 = 23.818 \) df=6, \( p=0.001 \). Resting (30%), movement (28%) and feeding (22%) dominated the activity budget profile, while grooming (9%), aggression (6%), play (3%) and climbing (2%) were the least activities observed. The Adult chimpanzees’ behavior showed an association on weather type, \( X_2 = 15.801 \) df=3, \( p=0.001 \) and \( X_2 = 28.975 \) df=18, \( p=0.049 \), respectively. Seasonality witnessed a weak association on the adult animals, \( X_2 = 2.492 \) df=6, \( p<0.05 \). Also, a weak significance was recorded on social activity and seasonality, \( X_2 = 1.379 \) df=6, \( p<0.05 \). This survey discovered that the activities of the adult chimpanzees witnessed alterations due to the changes of environmental conditions.

**Keywords:** Chimpanzees; activity budget; environmental changes; focal animal; animal group; sanctuary.

### 1. INTRODUCTION

Primates attract the attention of many researchers because they are closely related to human in terms of human social behavior. According to Chalmers [1], primates are social animals and most of them interact with each other in their species. Social behavior means any behavior that involves another individual [2]. Studies have shown that primate social behavior is more or less similar to human behavior such as eating, playing, fighting, keeping the baby and others [3,4]. Activity budgets for primates in disturbed areas such as human settlements are different from those in their natural habitat [5]. Many serious ecological changes had occurred due to the increasing human population and development of agricultural areas [6]. Primates have to change their daily behavior according to the environmental conditions to ensure their survival. Many studies have shown that the activity budgets vary by several environmental factors including diet, distribution and food sources [7,8]. Long-tailed macaques are one of the primate species that is affected by human activities in exploiting their habitat. This is because the monkey is one of the most geographically widespread and abundant non-human primate species in the world. This primate is widely distributed in the Southeast Asian region (Thailand, Indonesia, Singapore, Brunel, Malaysia, Philippines, Vietnam and Laos) [9]. Long-tailed macaques have also been introduced to humans in the island of Mauritius [10], Ngeuar Islands, Republic of Palau [11] and Hong Kong [12]. Because they are so widely distributed, their behavior, social organization, habitat usage, morphology and genetics are different [13]. There are many past studies focused on the behavior of *Macaca fascicularis* in Malaysia such as on their aggressive behavior [14,15] aspects of social behaviour [16] and studies on the behavior of pests [17,18].

Social-living is complicated on one hand, and on the one hand, living in large groups can provide important benefits. Residing near others can reduce the likelihood of predation and the amount of time needed to scan for predators [19]. Furthermore, it can increase the likelihood of finding and acquiring food [20,21] and defending territories of higher quality resources [22]. Also, it can improve access to mates and promote cooperative breeding [23]. On the other hand, living with others can be highly costly. Large groups of individuals may be targeted more by predators [24] or be more susceptible to pathogens [25]. Furthermore, more individuals in the vicinity means increased competition for both resources and mates [26]. Because of these trade-offs, social systems can display high levels of variation [27]. Based on the relative costs and benefits of group-living, individuals can trade-off in their current social environment for a solitary existence or find another social group where they might be more successful. For these reasons, group size is often found to vary according to the trade-off between predation pressure and feeding competition.

Furthermore, the distribution and abundance of resources and potential mates may influence both the social and mating system displayed by the population [28]. This variation can occur both on an evolutionary time-scale and in response to short-term changes in environmental and social factors [29]. Understanding how individuals respond to the costs and benefits of social-living can promote a greater understanding of how and why these societies function the way they do. Organisms do not simply respond to their surroundings, they are also capable of changing them. A key way in which individuals can influence their social environment is through the production of signals [30]. A signal is a specific form of behavior that evolved to influence the behavior of others, typically by providing...
information regarding the signaler's motivational or physiological state [31,32]. For instance, rather than physically challenging a competitor, animals can produce signals that advertise their aggressive intent. If receivers heed this signal, this communicative behaviour saves both parties from a physically costly fight. Signals can be used to attract mates to oneself [33], to establish and maintain territory boundaries [34], to facilitate social interactions and even share valuable information about the environment with group members, such as the presence of a predator [35]. Thus, signals can be considered as tools for influencing one's social surroundings. While signaling behavior can provide many benefits to both signalers and receivers, it can also result in many costs. Signal production and reception typically require developmental specializations and the use of time and energy. Furthermore, signals can often be highly conspicuous, making individuals more susceptible to predators or competitors [36].

Group-living in wildlife is important to facilitate feeding, protection, learning and recreation. However, the role played by adult chimpanzees in Mefou primate sanctuary prompted for the assessment of environmental conditions affecting the animal social system. Chimpanzees, like other primate species, are homed by the wild environment, but their organizational structure leading to group leadership has little understanding among primatologists. The anthropogenic behaviour in wild habitat transformation to cultivation landscape has witnessed social behavioural changes within the wildlife communities in the rainforest zone in Cameroon. Habitat loss due to deforestation and land conversion are major causes of the decline of nonhuman primate species [37,38]. The continued degradation of forested areas, together with ongoing human population growth across most primate range countries, means that many primate populations now occur in forest-agricultural mosaics [38]. Primates inhabiting these landscapes face multiple challenges including habitat degradation and fragmentation, human infrastructures such as roads or settlements, and increased encounters with people [39].

2. MATERIALS AND METHODS

2.1 Description of the Study Area

Mefou primate sanctuary is located at the outskirt of Yaounde city between latitude 3°37'74 N and longitude 11°34'47 E. The study area is surrounded by four villages, Metet, Ndifidi, Oveng, and Ejsanna. The primate sanctuary covers a land-surface area of 1,044 hectares (Fig. 1). However, due to its primate population richness and species diversity, it hosts a lot of wildlife tourists and primate researchers. Ecologically, this area is characterized with a rainforest vegetation [40]. Additionally, the rainy season has a seven months (April-October) period while the dry season has five months (November-March). The average annual temperature and rainfall is 23.1°C and 2188 mm, respectively [40].

2.2 Research Data Collection

The research data collection for this study constituted an intensive one month pilot study. The pilot study was aimed at testing the wildlife behavioural ecological methods designed for the research. During this period, a chimpanzee group of 22 individuals was chosen for the study. Brief habituation was done and it ended when the chimpanzee group became acquainted with the student researcher, and research data could be recorded at close proximity without the animals fleeing from the researcher. After this survey, adjustments were made on some variables, such as landscape, since the study area was not really undulating as expected.

The launching of a full-scale research data collection was considered at the end of the pilot study and lasted for four months. The habituated chimpanzee group consisting of 22 animals was observed for 10 hours each day and this was done for 10 days each month. Data collection on check-sheets started 8:00am and ended 6:00pm each day. During this period the animal group was followed, targeting either an adult male or adult female for focal data collection for the day. The focal data collection was done within an interval period of 5 minutes, and during the period, observations were recorded on this adult on feeding, moving, resting, grooming, aggression, and climbing. Secondly, the scan data collection, based on the entire animal group activity was done within 15 minutes [41,42]. The ad-libitum and ecological data, such as weather type, food type, seasonality, photo-period, animal height from ground and sex-class of animal were recorded simultaneously alongside the animal activity.

2.3 Research Data Analysis

The research data analysis was done by the use of SPSS and excel. The chimpanzee behavioural
activity like feeding, moving, grooming, aggression, resting and climbing was tested upon ecological variables like weather, photoperiod and seasonality. The purpose of this was to know whether these environmental factors affect the behavioral activity of the adult chimpanzee or focal animal. Chi-square ($X^2$) was the main statistical model used for inferential analysis, while the assessment of activity and ecological frequency was done on exploratory statistical models.

3. RESULTS

The focal animals in this study revealed a significant relationship on activity budget, $X^2 = 23.818$ df=6, p=0.001 (Fig. 2). The focal animals in the chimpanzee group were the adult males and females chosen each day for data collection. In most wildlife species, group activities are determined by the adults, the reason which this study recorded data on adult males and females. Secondly, comprehensive knowledge on adult males and females is important, and understanding their relationship is applauded. Resting (30%), movement (28%) and feeding (22%) dominated the activity budget profile, while grooming (9%), aggression (6%), play (3%) and climbing (2%) were the least activities observed (Fig. 3). The study discovered that adult males were leading in all the activities, justifying their inherent dominance. In chimpanzees (Pan troglodytes troglodytes), the alpha male suppresses every other individual in the group in all social activities. The study observed that movement to food locations were initiated by this adult male, displaying its leadership ability.

The Adult chimpanzees’ behavior showed an association on weather type, $X^2 = 15.801$ df=3, p=0.001 (Fig. 4) and $X^2 = 28.975$ df=18, p=0.049 (Fig. 5), respectively. The determination of
weather on wildlife activity is well known in chimpanzees. Moderate sunny weather was highly associated to the adults’ activity, while rain and wind recorded the least. During a moderate sunny atmosphere, adults were observed leading the animal group to other food locations, especially after long-heavy rains. The rain and wind suppressed feeding, playing, movement, and grooming behaviours within the animal group but advantaged resting. The sunny weather also favored other activities except for play, groom, aggression and climbing.

**Fig. 2.** Focal animal and animal activity during study period

**Fig. 3.** Focal activity frequency
Fig. 4. Focal animal and weather type

Fig. 5. Focal animal activity and weather type

Seasonality witnessed a weak association on the adult animals, $X^2 = 2.492$ df=6, $p<0.05$ (Fig. 6). Seasonality on chimpanzees in Mefou Primate Sanctuary showed little or no associated as compared to other ecological variables. A comprehensive understanding on this association would require another socio-ecological study on these chimpanzees.

Adult animals recorded a significance on photo-period, $X^2 = 87.741$ df=12, $p=0.000$ (Fig. 7). The adult-animal activity in the morning period was characterized by movement and feeding, while the afternoon period witnessed more resting and the evening period was observed with feeding, movement and resting.

Leaves are the most prominent diet of chimpanzees in this area, though chimpanzees are not really folivorous per se, but the adaptation of resorting to leaf-feeding might be due to abundant fresh vegetation in the sanctuary. Nonetheless, a 50% leaf-feeding diet recorded on chimpanzee in this study is unprecedented to an animal that is not folivorous. Moreover, fresh fruits (32%), seeds (17%), and ants (1%) supplemented the feeding program of these adult animals (Fig. 8). Fruits and seeds were harvested from the trees and some were picked on the ground.

4. DISCUSSION

Time is a limited parameter of various activities for most wild animals [43,44]. The study of time budget allotment among various diurnal activities such as feeding, resting, grooming, travelling,
etc. is essential for the characterization of living and working manner of a primate species, which lay the foundation for interrelating ecology and the behavior of the species [45]. The proportion of time spent in each category of behavior is referred to as activity budget. How primates divide their activities daily and yearly, and how they interact with their environment, invest their energy and time for survival, and reproduction is an important indicator of their life styles [44,46]. Activity budgets of primates are commonly associated with strategies of energy conservation [47,48] which is influenced by a variety of factors such as age, sex, social rank, individual’s own physiological state, reproductive condition, demographic pattern and environmental conditions of habitat, distribution and quality of food resources, abundance, season, predation and the degree of human disturbance in the habitats [44,49,50]. The factors which influence

![Fig. 6. Adult-animal activity and season](image)

![Fig. 7. Focal animal activity and photo period](image)
primate activity budgets in natural habitats are linked to the challenges of acquiring food energy [51]. For example, primates often increase the amount of time spent on foraging when food resources are either limited or scattered in the habitat [52]. In many species, time spent feeding on fruits was found to be negatively correlated with the total feeding time and positively related to travel time [53,54]. In addition, sex-differences can also influence the activity budgets. Generally, females spent more time feeding than males in some colobines in folivore and frugivore primates [55,56]. These differences in activity budgets are usually credited to the different nutritional and energy requirements of both sexes and social involvements with group members [57,58].

In addition, climatic factor like temperature or thermoregulation also affects activity budgets [59]. For instance, when temperature is low and the thermoregulatory cost is severe, macaques used to decrease feeding and traveling time to save energy [44,59]. Researchers proved that resting time is influenced by three main factors: the percentage of leaves in the animals’ diet, temperature variation and mean annual temperature [60]. Thus, allocating time to different activities carried out throughout the day is important to understand the time adjustment in different habitats in order to optimize utilization of resources for survival and reproduction [61]. Changes in the activity budget and feeding ecology are usually the first responses of animals to habitat fragmentation and disturbance [62]. Therefore, it is very important in primates to document the proportion of time spent in different behavioral categories especially when the distribution and population of the species is highly threatened due to habitat fragmentation and disturbances. The activity budget of Hoolock hoolock has been studied by many workers in its distribution range in India [63,64], China and Indonesia [65] and Thailand [66]. Most of these studies are conducted in continuous forest. But a few studies have recorded activity budget differences in primate species between fragments and continuous forest [67,68]. However, no behavioral studies have been conducted particularly on assessment of time budget and activity pattern of Hoolock hoolock in highly isolated and fragmented forest patches.

Primate species show variable and multiple responses to environmental disturbances. Human-induced modifications in habitat quality can cause changes in primate feeding behavior, dietary diversity and resource use [69,70,71,72]. Primate responses to the availability of wild and anthropogenic food sources are often species and context specific [73]. Some primates predominantly use areas of their home range in locations where important wild resources still remain [74,75,76]. However, highly clumped and predictable food resources, such as exotic vegetation, cultivars, and human food waste, can also attract primates [77,78,79,80]. Changes in primate habitat use, ranging, and activity budgets are often associated with anthropogenically disturbed environments. In locations where habitat quality and food resource availability are diminished, primates tend to exhibit larger home ranges and daily path lengths and spend more time traveling and less time resting and feeding.

**Fig. 8. Food type frequency**
e.g., white-faced capuchins (*Cebus capucinus*) McKinney [80] and long-tailed macaques (*Macaca fascicularis*) Sha and Hanya [81]. Conversely, primates that have access to, and use spatially and temporally abundant human food sources tend to have smaller home ranges, spend less time traveling and foraging, and more time resting, e.g., yellow baboons (*Papio cynocephalus*) Allmann and Muruthi [82], ring-tailed lemurs (*Lemur catta*) Gabriel [83] and vervets (*Chlorocebus pygerythrus*) Saj et al. [84]. Most studies to date have focused on how habitat quality affects general patterns of primate activity budget allocation [83,70,80] while only a few have examined non-foraging activities across available habitat types within a landscape and within a single group [75]. The preferences primates show for allocating activities to different habitats can provide insights into the relative value of these habitats, as well as species’ ability to adapt to habitat change [85].

5. CONCLUSION

The natural environment is very important to the existence of wildlife and its population growth. However, human population growth and efforts to sustain it through hunting, farming, construction, fishing, and gathering behaviors has emerged species extirpation and wildlife population decline in most parts of the world. Primate species show variable and multiple responses to environmental disturbances. Human-induced modifications in habitat quality can cause changes in primate feeding behavior, dietary diversity and resource use. Changes in primate habitat use, ranging and activity budgets are often associated with anthropogenically disturbed environments. In locations where habitat quality and food resource availability are diminished, primates tend to exhibit larger home ranges and daily path lengths and spend more time traveling and less time resting and feeding. Primates such as chimpanzees that largely depend on the natural environmental resources are affected in many ways. This study revealed that the social organization of a chimpanzee group in Mefou primate sanctuary is witnessing activity budget pressure at the level of adult males and females due to the adverse environmental conditions caused by anthropogenic activity and the inability of the conservation stakeholders to get the phenomenon under control. The ecological role of primates and other wildlife species in rainforest regeneration and sustainability is predominantly neglected in research programs in Cameroon.

**ETHICAL APPROVAL**

The animal ethics committee approval has been taken before conducting the study.

**COMPETING INTERESTS**

Authors have declared that no competing interests exist.

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