Effect of habitat fragmentation on food habits and gastrointestinal tract of *Praomys delectorum* sub-populations in the Taita and Kyulu hills, Kenya

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Abstract

Due to their short life histories, small mammals are useful indicators of environmental health. Despite this, little or no investigations on the effects of habitat modification on small mammals' diets in Kenya has been done. Response of the forest dependant Praomys *delectorum* to anthropogenic disturbance in different forest patches of the Taita Hills suggests that it is an opportunistic omnivore as its population increases with increase in vegetation intergiditation. This study investigated the effect of habitat fragmentation on food habits of *P. delectorum* in three sub-populations of the Taita Hills and the Kyulu Hills population. Food habits variation was assessed by comparing morphometry of the gastrointestinal tract in different forest patches. Total intestinal length was significantly correlated with body mass (r=0.624, P<0.001) and head plus body length (r=0.722, P<0.001), respectively. The linear response of total intestine length to head plus body length was greater $(S = 0.642, t = 5.951, P < 0.001)$ than that of body mass ($S = 0.214$ t=1.983, P=0.053) suggesting it is a better covariate in removing size effect. A significant difference (F=2.883*, P= 0.043) in the relative length of large intestine was noted which suggested variation in food quality. *Praomys delectorum* display a digestive tract adaptation suggestive of an opportunistic feeder. This may have been due to change in food habits which could be associated with transformation of natural habitat into fragments.

Keywords: *Praomys delectorum*, fragmentation. Intestinal length, head body length.

Introduction

Habitat fragmentation is among the most serious threats to biological diversity, as determined by a consensus of conservation biologists (Cameron, 1994). Effects of habitat fragmentation on biodiversity are very diverse with different authors measuring fragmentation in different ways and as a consequence drawing different conclusions regarding both the magnitude and direction of its effects (Lenore, 2003). Fragmentation is usually defined as a landscape scale process involving habitat loss and division of the natural habitat into progressively smaller patches of the total area isolated from each other by a matrix of habitat unlike the original (Lenore, 2003; Cameron, 1994). Habitat fragmentation not only reduces the area of habitat but also can isolate populations and increase edge effect.

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Understanding the possible consequences of habitat fragmentation has become a great concern to conservation biologists, since almost all natural habitats have become fragmented to some extent (Laurence, 1991).

Small mammals, especially rodents, are opportunistic feeders capable of changing their feeding habits depending on availability of food. This is an evolutionary adaptation to regulate their density during post-disturbances and to restrict competition with others (Bekele and Leirs, 1997). Due to their sensitivity to change in the environment such as ground cover and food resource base, rodents are potentially useful indicators to changes in the local environmental conditions such as habitat modifications caused by man (Kuhnelt, 1976). Researches on habitat fragmentation have identified several indicators as predictors of response of animals to habitat disturbances. Traits like population size, population fluctuation and storage, dispersal power, reproduction potential, annual survival, sociality, body size, trophic position, ecological specialization, microhabitat and matrix use, disturbance and competition sensitivity traits have been identified (Henle*et al.,* 2004). *Praomys delectorum* (Rodentia, Muridae) is a soft-furred small rodent belonging to the murid group. It has a head and body length of 8 -14 cm and a body mass of 21-57 grams (Kingdon, 1974). *Praomys delectorum* is one of the eight species in the genus *Praomys. P. delectorum* is endemic in Kenya, Tanzania, Malawi and North Eastern Zambia (Ronald, 1997). In Kenya it is found in the rain forests of the montane habitat in southeast Kenya (Oguge *et al.,* 2004) and is one of the most common rodents in the Eastern Arc forests. *Praomys deletorum* is distinguished by its soft brown fur, long tail and dirty white under belly. It is found mainly on the ground and is very rarely arboreal. The rodent feeds on seeds, vegetation and insects and nest in short burrows where they make concealed runways (Ronald, 1997).

Anthropogenic disturbance has resulted in isolation of the *P.delectorum* into different sub-populations in forest habitats of the Taita Hills. *Praomys delectorum* population densities vary positively with forest disturbance. It is generally assumed that opportunistic species, particularly pest, would increase with deteriorating habitat conditions while specialized non-pest species decrease (Primark, 1993). The local extinction of individual species starting with the most vulnerable ones changes the composition of trophic levels and that of the functional relations within ecosystems. Removal of particular key species can have cascade effects (Frankham *et al.,* 2002). Habitat fragmentation is known to cause such extinction. This study focuses on variation on morphometry of the GIT in the isolated *P. delectorum sub-*populations. Of particular interest are variations which could have resulted due to change in feeding habits in the different sub- populations in the Taita Hills and Kyulu population. A correlation between the total intestine length and body size was also quantified.

Materials and Methods

Study Area

Taita Hills and the Kyulu Ranges are among the rain forests of the montane habitat in South East Kenya . The Taita Hills, like other montane rain forests, have been subjected to heavy human activities leading to fragmentations into different forest patches (Rogoand Oguge, 2000). These hills rise abruptly from the Tsavo Plains to a series of ranges. Dry bush-land runs up into the lower slopes of the hills, grading into moist forest, farmlands or plantations. The forests of Taita Hills are experiencing different levels of habitat alterations with the indigenous trees being selectively harvested or cleared to give way to plantations and other forms of land use. The Taita Hills are divided into three distinct isolates: Mount Sagala, Mbololo and Dawida Massif. The main body of the hills known as Dawida Massif is made up of eight forest patches, among them is: Ngangao, Chawia, Yale and Macha forest patches (Oguge*et al.,* 2004). Ngangao is one of the two larger patches with the least anthropogenic disturbance but with the lowest *P. delectorum* population density of an average of 20 animals per hectare. Yale and Macha are smaller forest patches with an average density of about 30 animals per hectare and Chawia with an average density of 50 animals per hectare. The Kyulu Ranges are recent volcanoes of perhaps over 1000 years old (Bally, 1939). The high ranges of velvety green cones rising to an altitude of 2170 m creates a verdant mountainous contrast to the surrounding arid African Savanna (Beentje, 1990). The ranges run 64 Km in length and 16 Km in width and are geographically equidistance from Mt. Kilimanjaro to the (South-east) Taita Hills (East) and highlands of Machakos (North-west) (Oguge*et al.,* 2004). The forest vegetation here is presumed to be pioneer; standing at 1450-1750m above sea level. The southern portion comprises mist forests while the northeast has a much drier vegetation type (Beentje, 1990). The Kyulu Forest population assumed to be from an area that is ecologically stable was compared with sub-populations from Taita Hills. The forest patches of the Taita Hills are found between 03^0 20'S and 30^0 15 `E. These forests patches are:

Yale (2100 m: 03^0`$38^028^0$E), Chawia (1600 m; $03^028$`S, 38^020`E) and Ngangao (2150 m; $03^022$`S,38^020`E) (Oguge *et al.,*2004). The animals from Kyulu Forest were collected in the mist forest at $2^047.1$`S $37^052.14$`E at an altitude of 1700 m (Oguge *et al.*, 2004).

Collection and Preservation of Animals

The animals were collected from the study areas using standard smaller Sherman's mammal live traps (foldable aluminium trap of 5.5x 7x 18 cm) by line transect. Upon capture, the animals were weighed (using Pesola balance in grams) and the live weight recorded. Euthansia was performed on the animals and the head plus body (HB) length; the distance between the tip of the snout and mid anus measured and reproductive status (RS) noted Females with vagina open and males with testes scrotum are regarded to be in active reproductive phase, while females with vagina closed and males with testes abdominal as either juvenile or reproductive inactive. Body mass was also considered as a criteria in categorizing the animals as mature or immature. Some of the females with a body mass of 17.5 grams were found to be VO hence animals with a body mass of 17.5 grams were regarded as mature. Animals that had a body mass of 17.5 grams or more were selected for this study and their digestive tract was assumed to have been fully developed. The number of the captured animals from different patches was determined and sexes separated on the basis of their external genitalia. The animals were then fixed in formal saline buffered with Borax salt for 72 hours. They were then washed in water and preserved in 70% ethanol before being transported to the laboratory at Kenyatta University.

Data collection on the gastrointestinal measurements

The animals were dissected and from each, the digestive tract (stomach, small intestine, caecum, and large intestine) was removed and put in water for 1 hour to reduce brittleness. The digestive tract was then cleaned of the mesenteries through stripping the connective tissue and lipids. The Brambell method was employed in which the entire gastrointestinal tract (GIT) was laid in a trough filled with water and the pyloric sphincter end was pinned on paraffin wax adjacent to the zero mark of the fixed measuring tape. The other end (the anus) was pulled horizontally by a tensiometer (7 gm weight). The intestine was moved gently to ensure that it was not stuck at any point. The total intestine length (TI) small and large intestine with the caecum in place was measured. The length of the small intestine (SI) and that of the large intestines (LI) were also determined and recorded before removing the caecum for measurement. The stomach length was measured by laying it on a tape without stretching it. The stomach outer curve from the cardiac sphincter to the pyloric sphincter was measured with the the aid of a string. Caecum (C) curve measurement was taken from the ileocaecal valve to the spiral valve with the aid of a string

Data Analyses

The raw data obtained was first analyzed for correlation using Pearson Correlation. The mean length of the digestive tract components relative to head plus body (HB) and relative body mass (BM) were compared using one way ANOVA. Where there was a statistically significant difference, multiple comparison of means was performed (Tukey HSD P=0.05). Head plus body length and body mass as independent variables were regressed against total intestine length to assess the linear response of total intestines on BM and HB. The significance of S regression coefficient was tested using t- test for separate linear response of total intestine length to BM and HB and against both BM and HB.

Results

Morphometry of the GIT comparison between males and females

The total number of animals used in the study was 73. The Chawia sample comprised 20 animals: 12 were females and 8 males. The Yale sample had 18 animals, 10 female and 8 males. From the Kyulu group 19 animals were used of which 9 were females and 10 were males while Ngangao sample consisted of 16 animals with 6 females and 10 males. The gastrointestinal measurements were of individual rodents with a body mass $\geq$ 17.5 grams of the overall sample. Since the number of males and females was not balanced by sampling the animals in the four study groups, statistical analyses to assess whether there was any variation of the GIT due to sex was necessary. There was no significant difference in the total length of intestines (df =1, F=.0.021^{ns}, P = 0.884) between males and females. No significant difference was noted in

the sex interaction between forests (df =3, F= 0.042^{ns} P = 0.988) (Table 1). Similar results were obtained for small intestine (sex $F_{1,65}$ <0.001^{ns}; forest $*$sex $F_{3,65}$ = 0.69^{ns0}) and large intestine as the dependent variable (sex $F_{1.65}$ = 0.993^{ns}; Forest $*$sex $F_{3.65}$ = 0.166^{ns}).

Comparison between Sub-populations

The mean length of total intestine, small intestine and large intestine (colon) were compared among the Taita Hills sub-populations i.e. Ngangao, Chawia, Yale and Kyulu population (Table 2). The F value was highly significant for all sections of the digestive tract components:- TI F= 7.467, df=3, P≤ 0.05; SI F=6.009, df = 3, P=0.001;

LI F=9.430, df=3, P<0.001.

Multiple comparison of the means (Tukey HSD P<0.05) showed that the Kyulu population had a longer total intestine length (TI), which was statistically different from Ngangao and Yale. The same trend was observed for the small intestine. Large intestines of the Kyulu group were statistically longer than for the other groups (Table 2). The stomach length had a high positive correlation to the stomach curve (Pearson Correlation r=0.851 P<0.001) as both parameters increase with increase of digesta but caecum length (the outer curve) did not show any significant difference among the groups (N=72, df=3, F=1.141^{ns}, P = 0.339).

Relationship between Body Size and the Intestine Length

Both the body mass (BM) and head plus body (HB) length had a significant correlation to the intestine length. A positive correlation of HB and BM to all components of the intestines was recorded (Table 3). All sections of the gastro-intestinal tract were then assessed against the

two aspects of body size (BM and HB) to determine which related more to their variations. Fig.1 shows that only 38.89% of the total intestine length variation can be explained or accounted for by the fitted regression. When the significance of the slope S of the best-fit line was tested for significance using ANOVA with the total intestine length as the dependent variable and HB and BM as the independent variable, the t value at the subscribed P value of 0.05 was more for the HB than BM. The t value for test of significance of S regression coefficient using t-test was greater for HB (S =0.722, t=8.205, P<0.001) than for BM (S =0.624, t=5.862, P<0.001). The linear response of total intestine against both body mass and head body length showed that the S value was not significant (S =0.268, t=1.983, P>0.05) for the body mass but that of head body was significant (S =0.642, t = 5.951, P<0.001). Figure 2 shows that 52.06% of the total variation of the total length can be explained or accounted for by the fitted regression.

Digestive Tract Relative to Head plus Body Length

The differences in the GIT length could be due to overall size (body mass and head plus body length) as well as the difference in shape. Since the head plus body length appears to contribute more to variation in the digestive tract components, the GIT length was worked out relative to head plus body length. There was no statistically significant difference in the GIT sections relative to body mass. Comparison of large intestine length relative to head plus body length had statistically significant differences between groups ($F_{3,60}$=2.883*, P<0.05). Yale had the longest relative large intestine (0.9772) and Chawia the shortest (0.9089) while Kyulu (0.9321) and Ngangao (0.9436) had intermediate means (Table 4).

Table 1
The mean (±SE) length (cm) of different regions of the GIT in *Praomys delectorum* from Chawia, Yale, Kyulu, and Ngangao forest patches comparing males and females within and between habitats

GIT sections	Sex	Chawia	Yale	Kyulu	Ngangao
TI	**Female**	56.63±1.44	53.60±1.58	60.39±1.66	55.17±2.03
	Male	57.19±1.76	54.19±1.76	60.40±1.58	53.70±1.58
SI	**Female**	47.56±1.33	44.62± 1.46	50.33±1.53	45.10±1.88
	Male	48.25±1.63	44.90±1.63	49.85±1.46	44.68±1.46
LI	**Female**	8.77±0.25	8.60±0.27	9.67±0.28	8.57±0.35
	Male	8.75±0.30	8.84±0.30	10.10±0.27	8.72±0.27

SE- Standard error
All values expressed in centimeters (cm)

Table 2

Means (±SE) for the different components of the digestive tract in centimeters from different forest patches compared

Forest	N	TL±SE	SI±SE	LI±SE
Chawia	20	56.9±1.2[AB]	47.84±1.14[AB]	8.76±0.19[A]
Yale	18	53.9±1.22[A]	44.74±1.07[A]	8.71±0.21[A]
Kyulu	19	60.40±0.71[B]	50.08±0.70[B]	9,90±0.17[B]
Ngangao	16	53.88±1.32[A]	44.84±1.24[A]	8.66±0.22[A]

SE-Standard Deviation
Within a category means followed by different letters are significantly different (Tukey HSD, P<0.05).

Table 3

Pearson correlation between body mass and head body length against components of digestive tract (P<0.001)

Aspects of body size	Total Intestine	Small Intestine	Large Intestine	Caecum	Stomach length	Stomach curve
Body mass N = 56	0.624**	0.586**	0.579**	3.80**	0.289**	0.182
Head body length N = 64	0.722**	0.657**	0.749**	0.331**	0.286*	0.206

** highly significant at P < 0.001

Table 4

Multiple Comparison of relative large intestine means in centimeters (Tukey HSD P=0.05)

Forest Patch	N	Relative LI means
Chawia	15	0.9089[A]
Kyulu	19	0.9321[AB]
Ngangao	14	0.9436[AB]
Yale	16	0.9772[B]

Means followed by different letters are significantly different

Figure 1

Scatter gram showing relationship between total intestine lengths against body mass
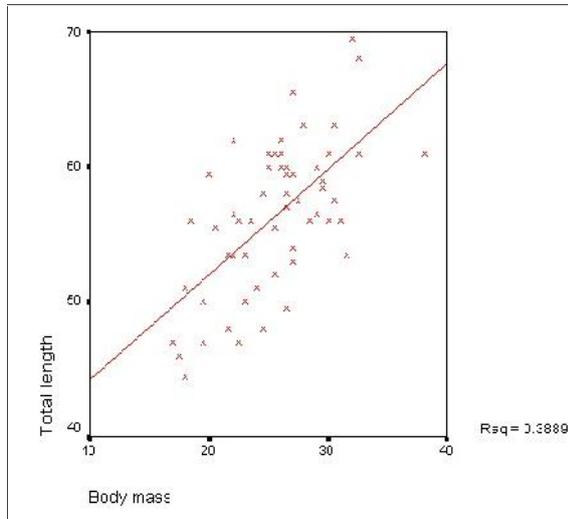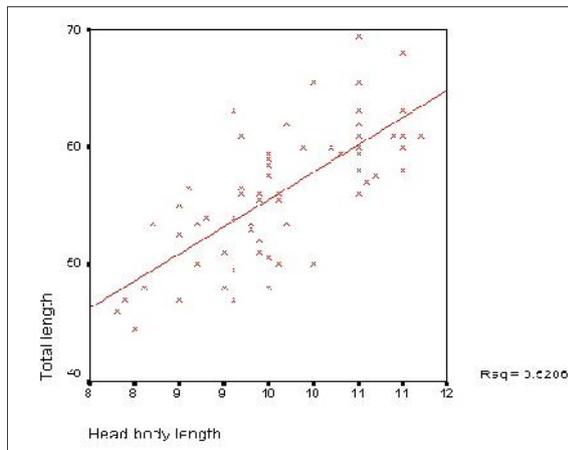

Figure 2
Scatter gram showing relationship between total intestine length against head plus body length

Discussion

Anthropogenic disturbance on natural habitat may disrupt food habits of animals. For an omnivore rodent, the change in feeding habits may result in the animal tending to be more carnivorous or more herbivorous. Analysis of the GIT morphometry in *Praomys delectorum* sub-populations suggests such an alteration in feeding habits. The head plus body length was found to be a better aspect of body size in removing the effect of the body size. The Chawia sub-population with shorter relative length of the large intestines suggest a diet with less fibre compared to that of Yale sub-population with longer relative large intestines.

GIT Morphometry and its Correlation to Body Size

The findings from this study show that there are intraspecific variations in the morphometry of the GIT in *Praomys delectorum* sub-populations. There was statistically significant longer total intestine and small intestine of the Kyulu sub-population as compared to Yale and Ngangao sub-populations. The large intestine of the Kyulu sub-population was also longer than that of Yale, Chawia and Ngangao sub-populations. While there was no significant difference in the body mass between the groups, there was a significant difference in head plus body length of the Kyulu population as compared to Yale, Chawia and Ngangao (Table 2). Although the body mass did not show significant difference, body mass mean trends were the same as those of head plus body length in which the Kyulu sample varied significantly from the other three samples (Yale, Chawia, Ngangao). The Kyulu sample had a longer head plus body length followed by Chawia, then Ngangao with Yale having the shortest. The same was observed for total intestine and small intestine with the Kyulu sample having the longest followed by Chawia and Yale recorded the shortest. The means for large intestines differed slightly from the observed trends with the Kyulu sample having a significantly longer large intestine followed by Chawia and Ngangao with the shortest (Table 2). As the body size increases the constituent organ sizes also seem to increase. Food affects body growth in terms of body mass as well as the head plus body length. Once an animal has reached its sexual maturity the head plus body length tends to remain constant. The body mass may however, show seasonal variation due to accumulation of fat, reproductive status or short-term environmental factors like the amount of water or digesta in the body. The body mass did not significantly vary among the samples and accounted less to variation of the digestive tract components. Studies on *Elephantulus myurus* show that they had remarkably constant body mass throughout the year. This indicated that body mass was, unlikely, the determining factor in the variations of the digestive tract and there was no significant correlation between the adults' body mass and any digestive tract parameter (Woodall, 1987). When the total intestine was regressed against both the body mass and head plus body length the

S value for the body mass was not significant. The scatter gram for total intestine length against body mass and head plus body length revealed that the percentage of the total variation of the total length of intestine that is accounted for by the fitted regression coefficient of determination (R^2) is greater for the head plus body length (R^2=0.5206) than for the body mass (R^2=0.3889). The digestive tract measurement of *P. delectorum* varied more as a function of head plus body length than with body mass. As change of organ size relates to change in body size, functional interpretation of differences in size of organs should be based on size-adjusted ratios. Since the strength of correlation between head plus body length to sections of the GIT was higher than that of body mass in this study the HB length was used to remove the effect of body size. This approach was used by Korn, (1991) although the rationale for using the HB was not given. While Korn used Leopold's method in measuring the GIT length, Brambell method was used in this study.

Effects of Food Habits on the GIT Morphometry

When the component of the digestive tract were size adjusted, it is only the large intestine that showed statistically significant difference between the sub-populations (Table 4). *Praomys delectorum* being an omnivore, its food consumption is likely to vary due to temporal change in abundance and availability of types of food. This means that the analysis of digesta may yield an incomplete and biased picture on the fibre content of the food. It may not be possible to associate the gross digestive tract morphology to crude trophic classes but variation in morphometry of the digestive tract is likely to be associated with food quality in *P. delectorum.* The prediction that with a decline in food quality animals should have larger digestive chambers was supported by the response of the prairie vole to change in food quality (Sibly, 1981). *Praomys delectorum* are small herbivore, granivore, insectivore rodents and quality and quantity of their food may vary tremendously with availability. With such variation of food habits digestive modifications may be necessary to most efficient use of the available food resources. It is well established that with an increased passage rate there is a corresponding decrease in digestibility (Moe, 1981; Van Soest *et al.,* 1983). Therefore gut capacity is critical in determining how much of the potentially digestible materials in the forage will be assimilated and how much will be excreted (Demment and Van Soest, 1985). This plasticity in the GIT is an important adaptation to compensate for greater food intake resulting from increased energy needs or reduced diet quality (Gross *et al.,* 1985).

The large intestine increases in size earlier than the small intestine. This may be due to the large intestine being more responsive to changes in metabolic requirements and dietary changes than small intestines (Woodall, 1987). Tissue especially that of small intestines, is metabolically expensive to maintain in comparison to other body tissues (Webster, 1981). Thus the animals may be expected to maintain a minimum amount of gut tissues necessary to meet daily energy needs. In mammals, intestinal flexibility is based on a balance of cell proliferation and cellulose, a process assumed to be energetically expensive (Starck, 2003). Response to variation in diet of the *Praomys delectorum* therefore is expected to start with a tissue that is more responsive to metabolic requirement and less expensive to maintain. Modification of the digestive tract due to energy demand must be hinged on a "trade off" in which the animal uses comparatively less energy in the adjustment than it gains. As the Yale sub-population adapt to the assumed less nutritious available food the physiological adjustment should normally start with less metabolically expensive tissue to maintain the large intestine. Hence the Yale sub-population was found to have longer large intestine as an adaptation to more fibrous, less nutritive food. Conclusion inferred from the comparison of the GIT morphometry can only generalize on the types of food in terms of the amount of fibre content. The results therefore compare the sub-populations with the significant difference, the Yale and Chawia sub-populations. The intermediate means in the large intestine length of Ngangao and Kyulu samples could therefore suggest that the sub-populations in the comparatively least disturbed Ngangao forest and more stable Kyulu ecosystem were feeding on intermediate fibre content.Intestinal length variation in small mammals due to changes in food quality was reported for *Abrothrix andinus* by Bozinovic *et al. (*1988) from South America, for *Microtus agrestis* by Hasson and Jaarola (1989) from Europe, by Gross *et al.* (1985) for *Microtus ochrogaster* and Green & Millar (1987) for *Peromyscus maniculatus.* Fragmentation of natural forest habitat creates an ecotonal area

between the forest inclusion and the clear–cut areas. Forest edges are transition zones between the wide climatic fluctuations of the external (usually defforested) environment and the relatively stable environment of the forest interior. The areas around the forest patches form the edges with vegetation intergidition. Different forest dependent species of animals may be affected differently by these edge vegetations hence the edge effect. The response of forest-dependant species like *Praomys delectorum* to these ecotonal areas exhibits an edge effect which seems to be positive. The edge to interior ratio increase with decrease in the size of habitat fragment. The forests of Taita Hills are experiencing different levels of habitat alterations with the indigenous trees being selectively harvested or cleared to give way to plantations and other forms of land uses (Oguge *et al.*, 2004). This has led to random fragmentation of the original continuous forest into forest patches of varying sizes. Yale Forest is smaller in size compared to Chawia and "edge effect" could be more significant in the Yale group. This implies that other than the anthropogenic effect in their natural habitats, more animals are most likely to extend their home range into the surrounding edge areas compared to those in Chawia. A positive "edge effect" for species like *Microtus* that clearly prefer high to low-cover habitat (Birney *et al.*, 1976) suggest that forest-dependent rodents like *Praomysdelectorum* could also be affected positively.

The Yale sub-population was most likely favoured by the availability of vegetative food which supported breeding throughout the year. Yale population density was second to that of Chawia. The Chawia sub-population was deduced from the GIT comparative analysis to be feeding on less fibre. Such food is assumed to be more nutritive and is likely to support a higher population. This study reveals that there was no significant difference in caecum length between the groups. Caecum and large intestine are better indicators of fibre content of food hence its quality. Variation in diet is expected to significantly affect the caecum size since most of the microbial digestion of cellulose takes place in the caecum (McBee, 1970, Cranford *et al.*, 2000). The variation in the diet of the *P. delectorum* may not have been so significant to cause variation in the caecum morphometry. The stomach length of the *P. delectorum* sampled correlated positively to the stomach curve (Pearson correlation r=0.851

$P<0.001$) as expected. Research by McPherson *et al.* (1988) which explored seasonal and habitat variations in the diet of pine voles (*Microtuspinetorum)* suggested that decline in stomach content in winter related to decline in food availability. However, Hammond (1993) suggested that the stomach content mass reflects forage quality. The Yale population, though smaller in body size (BM and HB) as compared to the other three sub-populations, had stomach length and outer curve only second to Kyulu sample for the unadjusted measurements. It seems plausible to infer that longer large intestine relative to body length in the Yale sample suggest a more herbivorous mode of feeding comparative to other sub-populations.

Change of Food Habits and Litter Size

In this study there was no significant difference between sex ($F_{1.65} = 0.021^{ns}$) and interaction of sex among the forests patches ($F_{3.65} = 0.042^{ns}$) for the total intestine length as well as for the different components of the intestines. Therefore, any variation in the intestine length could not be associated with compensatory gut changes due to reproduction energy demand. Many studies of mammalian reproductive energy have confirmed the traditional view that reproduction is energetically the most demanding activity of the life for a female mammal (Bronson, 1989). Females use various compensatory mechanisms to cope with reproductive demands. For example *Musmusculus* increases uptake of intestinal nutrients by increasing the mass of the intestinal mucosa during lactation (Hammond and Diamond, 1992). Intraspecific variation in relative intestine length in *Aethomys chrysophilus* was associated mainly due to the presence of reproductively active females in the sample (Korn, 1991).Pregnant or lactating females also accounted for the significant difference between the sexes in *Aethomys chrysophilus* and*A. namaquesis* since breeding females also tend to have longer intestines (Korn, 1991).Although the effects of food quality and quantity, water stress, temperature and breeding condition can be separated easily in the laboratory, they may function synergistically or antagonistically in the natural environment. A comparison of the *Praomysdelectorum* females and male intestine length within the population and mean difference between sexes among the forests was carried out to elucidate that variation did not occur as a result of the breeding females.

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Conclusions

The statistical difference in the large intestines of the *P. delectorum* from the various forest patches suggests that Yale group was foraging on food with more fibre compared to Chawia sub-population. This variation in the length of the large intestine may serve as an indicatorto show that habitat fragmentation can alter food habits in rodents. The shorter large intestine of Yale group compared to Chawia sub-population indicates that Chawia animals were feeding on less fibrous food, most likely, seeds and animal material. This assumed more nutritious food could be among other factors that contributed to the high population density in Chawia. The Yale sub-population deduced to be feeding on comparatively more fibrous food could be favoured by the greater 'edge effect' of the smaller forest patch that allows more animal to move to the surrounding areas. Ngangao sub-population from a comparative least disturbed forest patch compares well with Kyulu population from a stable ecosystem with respect to food habits. The head plus body length accounts more to the variation of the digestive tract morphometry. This makes it a better covariate in removing the effect of body size.

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References

Bally P.R.O. (1939). Corydon Museum Expedition to Chyulu Hills. Part V. Some vegetational and Botanical Notes. *J.East Africa Uganda Nat. Hist. Soc.* 14 161 – 166.

Beentje H.J. (1990). The forest of Kenya: Proceedings of the twelfth plenary meeting of Aetfat symposium II. *Mitt. Inst. Aug. Bot.* 239. 265 – 286.

Bekele A. and H. Leirs (1997). Population ecology of rodents of maize fields and grass lands in Central Ethiopia. *Belg. J. Zool.* 127: 39-48.

Birney E.C., W.E. Grant and D.D. Baird (1976). Importance of vegetative cover to cycles of *Microtus* population. *Ecol. 57:10 43-1051.*

Bozinovic F., C. Veloso and M. Rosenmann (1988). Termoregulation cinductual en *Phyllotis darwini* (Rodentia: Cricetidae): Effecto de la temperature ambiente, uso denido y agrupamiento social sobre el gasto de energia. *Rev. Chil. Hist. Nat.* 61: 81-86

Bronson F.H. (1989). Mammalian reproductive biology.Cambios del tracto digestico de *Abrothrix andinus (Cricetidae):* efecto de la calidad de dietay requerementos de energia. *Revta Chil. His. Nat.* 61:245-251

Bronson F.H. (1989). Mammalian reproductive biology. The university of Chicago press, Chicago Illinois.

Cameron G.N. (1994). Effects of habitat fragmentation on biodiversity: Implications for management of West Texas. *Environl Inst. Houston 10-11*

Cranford J.A., F.M. McNabb and J.K. Webb (2000). The nutritional Ecology of meadow voles *(Microtus pennysylvanicus)* under differing Environmental condition. Abstract and page 32 of M. Sc. Thesis

Demment M.W. and P.J. Van-Soest (1985). A nutritional explanation for body size patterns of ruminant and non-ruminant herbivores. *(Am. Nat.)* 125:641-672

Frankham R.J. D. Barllog and D.A. Briscoe (2002). Assumed and observed effects of habitat fragmentation on population of wild animals and plants. Introduction to conservation Genetics Cambridge University Press 640 pp.

Green D.A. and J.S. Millar (1987). Changes in gut dimension and capacity of*Peromyscusmaniculatus* relative to diet quality and energy needs. *Can. J. Zool.* 65:2159-2162

Gross J.E. Z. Wang and B.A. Wunder (1985). Effects of food quality and energy needs: Changes in gut morphology and capacity of microtus ochrogaster. *J. Mammal.* 66: 661 – 668.

Hammond K.A. and J.M. Diamond (1992). An experimental test for calling on sustained metabolic rate in lactating mice. *Physiol. Zool.* 65: 952 – 977

Hammond K.A. (1993). Seasonal changes in gut size of the wild prairie vole (*Microtus ochrogaster*). *Physiol. Zool.* 64:541 – 567

Hansson L. and M. Jaarola (1989). Body size related to cyclicity in Microtines: dominance behaviour or digestive effeiciency? *Oikos* 55:356-364

Henle K., K.F. Davies, M. Kleye, C. Margules and L. Setteles (2004). Predictors of species sensitivity to fragmentation. *Biodiv. Conserv.* 1:13

Kingdon J. (1974). East African Mammals: *An Atlas of Evolution* Vol II part B. Academic Press, London.

Korn, H. (1991). Intestine lengths of Southern African Savanna rodents and insectivores intra- and inter-specific comparisons. Journal of Zoology, London. 288: 455-460. *J. Exper. Zool. Part A: Comp Exp Biol*, 301A: 97 – 108.

Kuhnelt L. (1976**).** Books of the southwest Animals and Soils in Arizona.

Laurence W.F. (1991). Edge effect in tropical forest fragments-application of a model for the design of nature reserves. *Biol. ConserC* 57:205-219

Lenore F. (2003). Effect of habitat fragmentation on Biodiversity. *Annu Rev. Ecol. Evol. Syst.* 34: 487-515.

MacPherson S.L., F.A. Servello and R.K. Kirkpatrick (1988). Seasonal variation in diet digestibility of pine voles. *Canad. J. Zool.* 66:1484 – 1487

McBee R.H. (1970). Metabolic contribution of the caecalflora. *Amer. J. Clinc. Nutr.* 23:1514-1518

Moe P.W. (1981). Energy metabolism of dairy cattle. *J. Dairy Sci.,* 64:1120-1139

Oguge N., R. Hutterer, R. Odhiambo and W. Verheyen (2004). Diversity andstructure of shrew communities in Montane forests of South East Kenya. *Mammal. Biol.* pP 290 – 291

Primack R.B. (1993). Essentials of conservation Biology*. Sinauer associate Inc. Sunder land U.S.A.*

Rogo L. and N. Oguge (2000). Taita Hills forest remnants; A disappearing worldheritage. *J. Human Environ.* 29 522 – 523

Ronald M. N. (1997). Walker's Mammals of the world. The Johns Hopkins University Press.

Sibly R.M. (1981). Strategies in digestion and defecation Pp 109-139 in physiology ecology (.C.R. Townsend and P. Calow, eds) *Sinauer Association.* Sunderland Massachussets.

Starck J.M. (2003). Shaping up: how vertebrates adjust their digestive systems to changing environmental conditions. *Anim. Biol.* 53:245-256

Van Soest P.J., T. Foose and J.B. Robertson (1983). Comparative digestive capacities of herbivorous animals. Proc*. Cornell Nutr. Conf,* Pp 51-59.

Webster A.J. (1981). The energetics efficiency of metabolism. *Proceedings of the Nutrition Society.* 40:121-128

Woodall P.F. (1987). Digestive tract dimensions and body mass of elephant shrews(Macroscelididae) and the effect of season and habitat. *Mammalia.* 51:537-645.