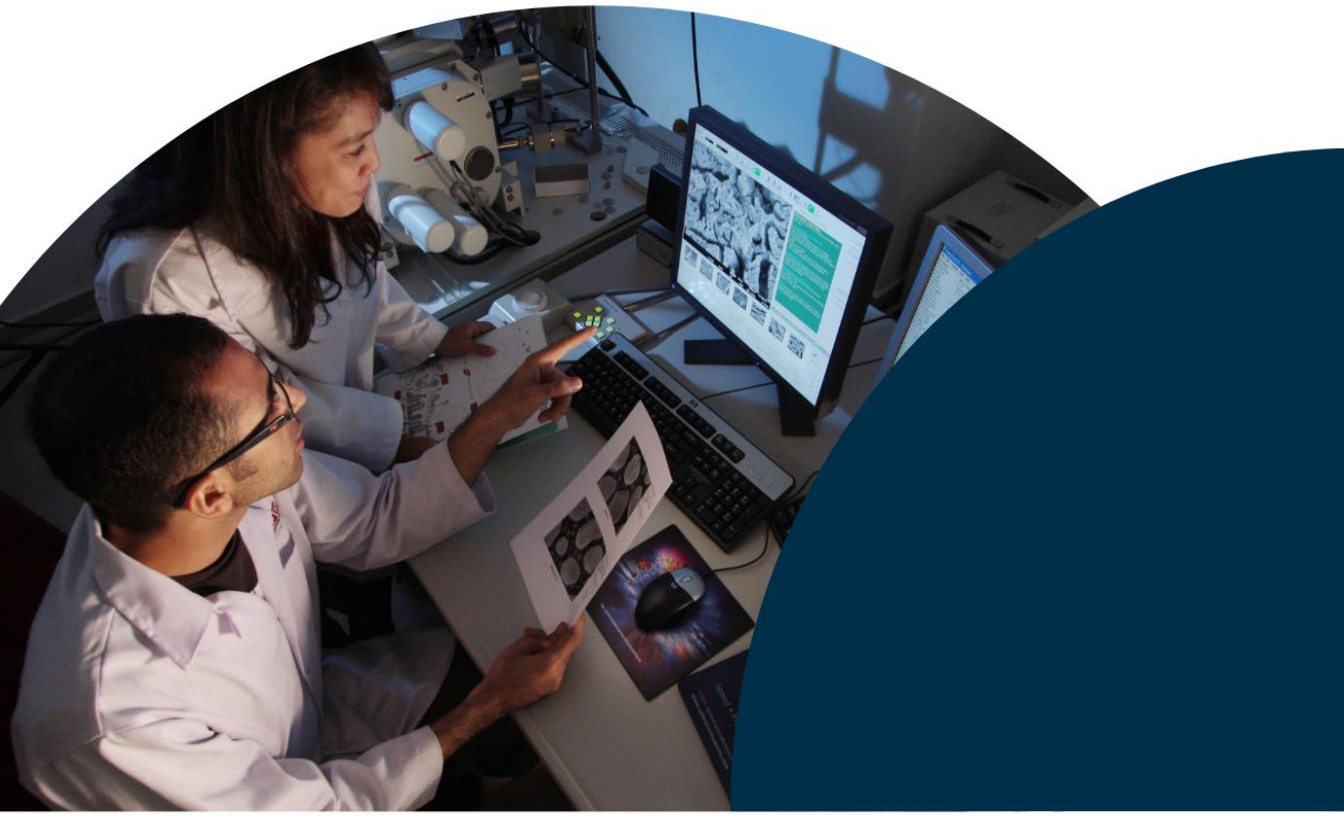
JUNE 2023

COMPILATION OF **RESEARCH PAPERS ON STEM**

SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS



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HAZLINA MOHD PADIL

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FOREWORD

It is with great pleasure that I introduce this compelling compilation of research papers on STEM (Science, Technology, Engineering, and Mathematics) in June 2023.

The field of STEM encompasses a vast range of disciplines, each playing a crucial role in shaping our present and future. This collection brings together a selection of research papers that explore few aspects of STEM, showcasing the remarkable breadth and depth of knowledge being generated across these domains.

This book serves as evidence to the collaborative spirit that defines the scientific community. It is a celebration of the collective achievements of researchers, scholars, and scientists who dedicate their lives to unravelling the mysteries of the natural world and advancing our understanding of the universe.

I extend my gratitude to the authors whose work graces these pages, as well as the publisher's team who have made this compilation possible. Their dedication and passion for advancing knowledge in STEM are truly commendable.

I hope that this compilation inspires readers to appreciate the wonders of STEM and encourages them to embark on their own journeys of discovery and inquiry. May this book serve as a source of inspiration and a catalyst for further exploration and innovation.

Editor

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Small Mammal Diversity at the Bukit Belata and Bukit Belata (Extension) Forest Reserves, Selangor

Muhammad Syaridzwan Baharudin*, Mohammad Shahfiz Azman, Nor Hazwani Ahmad Ruzman and Noor Faradiana Md Fauzi

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ABSTRACT

Selangor is the most developed state in Malaysia. Forest areas are pressured by development in their surroundings, affecting colonization and dispersal of small mammal communities. Therefore, this paper aims to document small mammal communities at two forest reserves identified in the CFS initiatives; Bukit Belata Forest Reserves (BBFR) and Bukit Belata (Extension) Forest Reserves (BBEFR). A total of 40 collapsible cage traps, 40 Sherman traps, 10 mist nets, and three harp traps were deployed at each study site to capture rodents and bats. As a result, 116 individuals were captured from 19 species and seven families from the two sites. Of these, the highest abundant species was *Cynopterus brachyotis* (n=42). Muridae recorded the highest number of species documented with 6spp and followed by Sciuridae (5spp). Among these two sites, BBEFR has the higher diversity index with H=2.289. Based on this information, continuous monitoring of small mammal communities must be carried out to ensure more knowledge can be produced, including hotspots, the interaction between forest resources availability, and forest edge effect on the communities. With this information, strategic actions can be formulated to maintain the ecosystem and preservation of habitats for fauna in Malaysia.

Key Words: Small mammal, diversity, forest reserve, species, fauna, diversity indices

1. INTRODUCTION

Fragmentation refers to the changes in the structure of the landscapes, which the functional attributes and ecological integrity are usually affected by this phenomenon (Groombridge, 1992). The results commonly can be associated with habitat fragmentation, which causes the isolation of the habitat, and accelerates the adverse effects on the ecosystem and its processes (Andren, 1994; Yahner, 1996).

Rapid economic development has caused significant pressure on biodiversity and forest landscapes due to the increasing human population. Demand for raw materials, food sources, and other necessities for human survival is rising, and the needs are met by procuring from biological resources.

Malaysia is a developing country that utilizes land use as part of its economic development. From the 1950s to the 1970s, forest areas were converted into agricultural land, mainly for rubber and oil palm plantation (Wong, 1974). The need for land use then progresses into the manufacturing sector to emphasize the economic development starting in the 1980s, which comprises housing, new urban areas, and industrial estates. This leads to forest fragmentation, which damages the ecosystems or ecoregion and lowers ecological integrity through landscape disintegration, species loss, and deterioration of habitat quality (Laurence, 2001; Gulinck & Wagendrop, 2002). Continuous breaking of large patches into numerous smaller patches leads to a net habitat loss, which decreases the number of resources and shelter areas available to the wildlife and reduces the number of individuals (Mullu, 2016).

Selangor has the highest gross domestic product per capita and is the wealthiest state in Malaysia. As the land use transition from the agricultural sector to the industrial industry occurred in this state, more of the forest has been cleared to provide space for further development. Moreover, the human population is the highest in the country, contributing about 23.7% to the KDNK Malaysia in 2018, which is the highest among all states.

The Central Forest Spine (CFS) project aims to maintain a cohesive forest complex by establishing ecological corridors connecting fragmented forests. It also aids in the conservation initiative. Introduced by the National Physical Plan (NPP), it focuses on a set of four environmentally sensitive forest complexes in Peninsular Malaysia that are crucial to life in this landscape. The issue is the CFS is degrading at an alarming rate due to rapid urbanization growth. Over the years, human intervention for commercial gains like the expansion of agricultural land (oil palm and rubber plantations) has been identified as one of the leading proximate causes of forest fragmentation (Abdullah & Nakagoshi, 2007).

The study sites were located at Bukit Belata Forest Reserve (BBFR) and Bukit Belata (Extension) Forest Reserve (BBEFR), Selangor. The objective of this paper is to demonstrate the small mammal diversity at these sites. The results from this study will be used to formulate an action plan for landscape management of this corridor.

2. LITERATURE REVIEW

The area of BBFR covering about 6,613 ha, while BBEFR covered 3,140 ha. This area mainly covers two types of land uses: settlement and agricultural. The main agricultural activity in the area is oil palm cultivation. This forest is densely covered with tall but little tree trunks and a scrubby and damp ecosystem. Bukit Belata FR is a lowland dipterocarp and peat swamp forest reserve. Two villages near BBFR, namely Felda Sg. Tengi (S) and Kampung Tawakkal. Bukit Belata (Extension) FR was operated in 1990 and 2007. The actual area of 420 ha was gazetted on 19 December 1990, followed by the exact size of 1,901.1 ha on 11 October 2007. Study by Lim et. al. (2009) has recorded 15 species of bats and 10 species of rats and rodents.

3. METHODOLOGY

Surveys were conducted between 2015 and 2016, covering the two forest reserves. At least two sampling sessions were carried out at respective forest reserves, and each site was surveyed twice, where each trapping session lasted for four consecutive nights. A total of 40 collapsible cages and 40 Sherman traps were deployed and baited with oil palm kernels along a transect line of 800 m. These traps were deployed alternately at 10 m intervals on the ground and used to capture non-volant small mammals. For chiropteran, 10 mist nets and three harp traps were randomly placed within the study site. Each small mammal caught was removed from the traps or nets and temporarily put into the cloth bag before the measurement was conducted. The live weight of each sample was recorded using spring balance, and five measures were documented, including body length, hind foot, ear size, forearm, and tail length. Moreover, the reproductive status of each individual was also examined. References (Francis, 2008; Francis, 2019) were used for identification purposes.

The species diversity indices that were indicated by Shannon-Wiener diversity (H), Evenness, Dominance, and estimator Chao-1 were obtained by calculation using the Paleontological Statistics (PAST) software (Hammer et al., 2001).

4. RESULTS AND DISCUSSION

This study documented a total of 116 individuals' small mammals in two study areas. The 19 species of small mammals recorded belongs to seven families. We managed to record a total of 12 species of non-volant small mammals, mainly rodents, and seven species of volant small mammals, which consisted of bats. Furthermore, between these two sites, the highest richness of small mammals documented was in BBEFR with 14 species and BBFR with 13 species. The Muridae family was recorded among the highest number of species with six species and followed by the Sciuridae family with five species (Table 1). In the Table 2, it can be seen that the evenness of the species for BBEFR is higher than BBFR, though the individuals recorded at BBFR is lower than BBEFR. Out of 19 species recorded, there are eight species present at both study sites. The dominance of species was also higher in BBFR, considering the high number of *C. brachyotis* captured.

Table 1 List of species and abundance of small mammal assemblages in two study sites

No	Family	Species Name	Study Sites	
			Bukit Belata FR	Bukit Belata (Extension) FR
1	Megadermatidae	*Megaderma spasma*	2	0
2	Muridae	*Leopoldamys sabanus*	2	6
3		*Maxomys rajah*	0	2
4		*Maxomys whiteheadi*	1	12
5		*Rattus rattus*	0	1
6		*Rattus tiomanicus*	1	6
7		*Sundamys muelleri*	1	0
8	Pteropodidae	*Balionycteris maculata*	3	2
9		*Cynopterus brachyotis*	40	2
10	Rhinolophidae	*Rhinolophus affinis*	2	0
11		*Rhinolophus sedulus*	0	1
12	Sciuridae	*Callosciurus notatus*	4	5
13		*Lariscus insignis*	0	1
14		*Rhinosciurus laticaudatus*	4	1
15		*Sundasciurus lowii*	0	2
16		*Sundasciurus tenuis*	3	0
17	Tupaiidae	*Tupaia glis*	3	7
18	Vespertilionidae	*Miniopterus medius*	0	1
19		*Murina suilla*	1	0
	Number of individuals		**67**	**49**
	Number of species		**13**	**14**
	Number of families		**7**	**6**

Table 2 List of species and abundance of small mammal assemblages in two study sites

Sites	Species	Individuals	Dominance (D)	Shannon (H)	Evenness	Chao-1
Bukit Belata FR	13	67	0.3731	1.627	0.3915	14.5
Bukit Belata (Extension) FR	14	49	0.1295	2.289	0.7047	16.0

The number of *C. brachyotis* captured in this study was very high compared to the survey conducted by Shukor et al. (2008) (n=2). This might be due to different trapping efforts between these two studies, as the survey by Shukor et al. (2008) only deployed six mist nets while we deployed 10 mist nets. *Cynopterus brachyotis* can be found in various environments, including orchards, gardens, and forest areas. Csorba et al. (2019) mentioned that in rural and urban landscapes and forested places, it nest in palms, particularly seed clusters of palms, either solitary or in small groups of a few individuals. It appears that this species was present at both sites, considering its behavior as frugivorous and phytophilic (plant-loving). It can also be found sleeping under modified palm leaves and orchid leaves in tropical rainforests (Crichton & Krutzsch, 2000; Richarz

& Limbrunner, 1993). The high number of individuals recorded at BBFR is probably linked to one of its behaviors to roost in groups (one male and about four females, and sometimes up to 20 females in a group) (Richarz & Limbrunner, 1993).

Muridae was the most diverse among the families recorded, consisting of six species. The high diversity of this family can be related to the fact that two-thirds of all rodent species of this family and genera belong to the Muridae. This species also has vast dietary choices, ranging from true omnivores to earthworms, subterranean fungi and even aquatic invertebrates. Not to mention that they have different habitation styles, as some of the species are semiaquatic, live underground, or live on the canopy of tropical forests for most of their time. Although Muridae was the most diverse among all families in this study, the relatively low numbers of individuals captured might be due to the species in this family being nocturnal and rather cryptic and rarely can be seen foraging in the wild (Ruppert et al., 2015).

5. CONCLUSION & RECOMMENDATION

In this study, it appears that the species composition can be quite different even among the adjacent forest. Apart from that, the species richness was observed to be low despite the large hectarage of both forest reserves. This study can be improved by covering other taxa of small vertebrates such as reptiles, amphibians, and avifauna. The effort of sampling also can be increased in terms of the number of traps per session, variety of trap placement, and using multiple trapping approaches.

6. ACKNOWLEDGEMENT

We want to express our gratitude to the Forest Department of Peninsular Malaysia and the Selangor Forestry Department for the permission provided to conduct the research in the stated area in this study. We are thankful for the continuous guidance and support from the Forest Biodiversity Research Division Director. Last but not least, we are grateful for the contribution in terms of human resources, time, and services provided by the staff of the Zoology Branch, FRIM.

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Fruit Bats (Pteropodidae) at Selected Forest Reserves in CFS C-PL2, Pahang, Peninsular Malaysia

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ABSTRACT

Surveys on fruit bats (Pteropodidae) were carried out in Ulu Jelai Forest Reserve (UJFR) and Bukit Bujang Forest Reserve (BBFR), Pahang. Central Forest Spine (CFS) initiative has identified these forest reserves as part of the C-PL2 ecological corridors, among nine corridors identified in Pahang state. This study mainly aims to document the occurrence of Pteropodidae in the selected forest reserves in C-PL2. The surveys were conducted in two phases from September to October 2019. A total of 10 mist nets were deployed in each forest reserve to capture the fruit bats. Overall, 38 individuals from seven species of fruit bats were recorded in the study areas. UJFR recorded the highest number of pteropodids compared to BBFR, with seven and four species, respectively. The Forest Short-nosed Fruit Bat (*Cynopterus* cf. *brachyotis* 'Forest') is the most abundant species recorded in this study, with 15 individuals from both forest reserves combined. The presence of pteropodids in the forest reserves might be associated with the availability of roosting sites and food sources. Therefore, this information generates a new distributional record of the pteropodids and provides an early insight into the potential seed dispersers and pollinators at the forest reserves in the C-PL2 ecological corridor landscapes.

Key Words: Bats, Pteropodidae, Central Forest Spine (CFS), C-PL2, Pahang

1. INTRODUCTION

Malaysia has recorded a total of 11 genera and 23 species of fruit bats from the family Pteropodidae (Senawi & Ahmad, 2021). Most pteropodid bats inhabit primary and secondary forests, including mangrove forests and peat swamp forests (Francis, 2019). There is only one bat family in Malaysia that feeds mainly on fruits and nectar (Francis, 2019). More than 50 plant species were recorded as important food sources for these bats (Lim *et al*., 2018). Based on their foraging activities, fruit bats play essential ecological roles as seed dispersers and pollinators (Kasso & Balakrishnan, 2013). There are more than 30 plant species recorded to depend on pteropodid bats as their seed dispersal or pollination agent in Peninsular Malaysia (Hodgkison *et al.*, 2003).

However, habitat loss is posed a significant threat to Malaysian bats (Kingston *et al*., 2006). As a result, the Central Forest Spine (CFS) initiative was established to protect biodiversity by re-establishing connectivity between fragmented forests through 39 identified ecological corridors across eight states in Peninsular Malaysia (PLANMalaysia, 2022). However, there is a lack of information on Pteropodidae from the forest reserves in the CFS ecological corridors, including the C-PL2.

Thus, the main aim of this study is to document the occurrence of Pteropodidae in the selected forest reserves in C-PL2. This data will aid stakeholders in developing a conservation plan to safeguard the essential seed dispersers and pollinators in order to sustain the ecosystem succession of forest reserves in the C-PL2 ecological corridor landscapes.

2. LITERATURE REVIEW

Based on the previous study done by Tenaga Nasional Berhad (2003), there are seven species of mammals recorded in Ulu Jelai Forest Reserve (UJFR), excluding Pteropodidae. Moreover, no records on mammals in Bukit Bujang Forest Reserve (BBFR).

3. METHODOLOGY

3.1. Study Area

This study was conducted at two forest reserves, namely, Ulu Jelai FR (04°25'10.4" N, 101°36'29.8" E) and Bukit Bujang FR (04°24'46.9" N, 101°36'16.4" E). Both forest reserves are secondary lowland forests. The study plot in each forest reserve has hilly areas, a closed canopy, and dense vegetation. In addition, UJFR has rock crevices along the nearby shallow stream, while BBFR has canopy openings.

3.2. Sampling Methods

The surveys were conducted in two sessions, from September to October 2019. A 1-ha plot (100 m x 100 m) was established in each forest reserve, and each plot was sampled twice. Ten transect lines of 100 m length with 10 m separations were prepared for each plot. A total of 10 mist nets were deployed at the forest understory in each plot to capture the pteropodid bats. Nets were left open for five consecutive nights and checked twice daily, as early as 6.30 a.m. up to 10.30 p.m. All captured individual morphological measurements were recorded during the survey. The species identifications were made following the descriptions in Kingston *et al*. (2006) and Francis, 2019.

4. RESULTS AND DISCUSSION

Overall, a total of 38 individuals from seven species of Pteropodidae were recorded at these forest reserves (Table 1). Most of the pteropodids captured in this study were species that can be found foraging in the forest understory (Kingston *et al*., 2006; Francis, 2019). This might be due to the placement of mist nets in the forest understory.

Comparatively, UJFR has the highest number of fruit bat species compared to BBFR, with seven and four species, respectively. This might be due to the presence of roosting sites in the study area. Rock crevices that were only found at the study area in UJFR might provide more roosting sites, especially for species such as the Black-capped Fruit Bat (*Chironax melanocephalus*) and Horsfield's Fruit Bat (*Cynopterus horsfieldii*) that use rock shelters as roosting sites (Kingston *et al*., 2006; Francis, 2019). Other than that, this finding might also be associated with the availability of food sources in the study area in UJFR. The presence of fruiting trees such as figs and wild bananas attracts more fruit bat species to forage in the study area to feed on the fruits (Francis, 2019).

Furthermore, the most abundant Pteropodidae captured in this study is the Forest Short-nosed Fruit Bat (*Cynopterus* cf. *brachyotis* 'Forest'), with 15 individuals from both forest reserves combined. This species is commonly found in primary and mature secondary forests and often forages in the forest understory as well as the canopy (Campbell *et al*., 2004; Kingston *et al*., 2016).

The pteropodid bats recorded in this study are classified as Least Concern (LC) by the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (Version 3.1). However, these species must not be neglected because their populations are still declining as a result of habitat loss (Kingston *et al*., 2006; Senawi & Ahmad, 2021).

Table 2 Checklist of Pteropodidae recorded in this study

No.	Common Name	Scientific Name	IUCN	UJFR	BBFR
1.	Black-capped Fruit Bat	*Chironax melanocephalus*	LC	1	
2.	Forest Short-nosed Fruit Bat	*Cynopterus* cf. *brachyotis* 'Forest'	LC	9	6
3.	Sunda Short-nosed Fruit Bat	*Cynopterus* cf. *brachyotis* 'Sunda'	LC	2	
4.	Horsfield's Fruit Bat	*Cynopterus horsfieldii*	LC	3	
5.	Lesser Long-tongued Nectar Bat	*Macroglossus minimus*	LC	3	1
6.	Greater Long-tongued Fruit Bat	*Macroglossus sobrinus*	LC	7	1
7.	Sunda Tailess Fruit Bat	*Megaerops ecaudatus*	LC	3	2
		Total No. of Individual		**28**	**10**
		Total No. of Species		**7**	**4**

5. CONCLUSION AND RECOMMENDATION

In conclusion, a total of 38 individuals from seven species of Pteropodidae were recorded in this study. UJFR has the highest number of fruit bat species compared to BBFR. The Forest Short-nosed Fruit Bat (*Cynopterus* cf. *brachyotis* 'Forest') is the most abundant species recorded during the study. The occurrence of Pteropodidae in this study might be related to the presence of roosting sites and food sources. This indicates that the CFS ecological corridor C-PL2 is an essential habitat for Pteropodidae. Besides contributing to the new distributional record of the pteropodids in Peninsular Malaysia, this study also provides an early insight on the potential seed dispersers and pollinators in the CFS C-PL2 ecological corridor landscapes. Despite that, more areas of forest reserves should be continuously monitored to better understand the population dynamics of Pteropodidae in the ecological corridor. Hence, this information is crucial in supporting stakeholders in formulating management plans to ensure the forest mosaics in the ecological corridor are able to provide habitat and pathways for the Pteropodidae.

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Brief Report on the Trapping of Non-volant Small Mammals in Tembat Forest Reserve, Terengganu

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ABSTRACT

Surveys on non-volant small mammals were conducted at Tembat Forest Reserve (TFR), Terengganu in April and June 2019. This forest reserve is identified as one of the Central Forest Spine (CFS) Primary Linkages named T-PL1. The aim of this study is to document non-volant small mammal species in TFR. Two plots were established in TFR referred to as TFR1 and TFR2. Each site was equipped with 10 transect lines. A total of 100 collapsible cage traps were deployed at each site. The traps were set for five consecutive nights per session, with two sampling sessions per site. The cumulative trap effort for each site was 1000 trap nights. As a result, a total of 36 individuals comprising nine species of non-volant small mammals from four families were recorded during the surveys. Of these, four species namely *Maxomys rajah*, *Maxomys surifer*, *Maxomys whiteheadi,* and *Lariscus insignis* were additional records for TFR. Despite the additional species reported, the capture rate of non-volant small mammals in TFR was still considered low. The capture rate of non-volant small mammals in TRF1 and TRF2 were 2.4% and 1.2%, respectively. Hence, continuous surveys with the application of multiple approaches to compare the efficacy of different trapping methodologies for the sampling of non-volant small mammals in this forest reserve is recommended. Through comprehensive studies, a better representation of the non-volant small mammal's population in TFR could be determined, thus, their diversity and ecological needs could be understood fully.

Key Words: Small mammals, diversity, capture rate, Central Forest Spine, Terengganu

1. INTRODUCTION

Forests are necessary for all living organisms including wildlife. It plays essential roles in providing a vast array of habitats, shelters, and foods, and conserving genetic resources for the survival of wildlife (Muhammad Nawaz, 2018). However, the ongoing habitat loss and enormous forest conversion for agriculture, settlements, industrial areas, and other developments in Malaysia have caused habitat degradation which then leads to forest fragmentation.

Forest fragmentation is seen as one of the major threats to wildlife conservation as it causes large forest areas to be broken into smaller parts. Smaller forest areas reflect reduced essential resources for wildlife such as space, food, and partner. This condition poses challenges such as an increase in inbreeding, speciation, predation, and rate of disease transmission for the wildlife population inhabits within that small, isolated forest patch (Damian, 2012).

The government has introduced an initiative called Central Forest Spine (CFS) to address forest fragmentation by creating wider forested areas through ecological corridors that connect fragmented forests in Peninsular Malaysia. There are 39 ecological corridors which consist of 20 primary linkages (PL) and 19 secondary linkages (SL). Tembat Forest Reserve (TFR) is also part of the Central Forest Spine (CFS) ecological corridor known as T-PL1: Kenyir State Park-Tembat FR-Petuang FR-Gunung Tebu FR (PLANMalaysia, 2022). The linkage between Tembat FR and the adjoining forest reserves under T-PL1 represents a large habitat to the north of Taman Negara, the largest national park in Peninsular Malaysia, which connects three states, namely Pahang, Kelantan and Terengganu.

Non-volant small mammals can be referred any mammal species excluding bats whose individual live weight does not exceeds 5kg as an adult (Hayward and Phillipson, 1979). Rats, treeshrews, shrews and porcupines are among the non-volant small mammals (Francis, 2019). Non-volant small mammals could support healthy trees and forests by serving in many ways include as seed dispersers, pollinators, biological controllers, forest decomposers, and sensitive indicators to environmental changes (Munian et al. 2020; García et al. 2005; Zwolak et al. 2010).

Previously, records of non-volant small mammals in TFR were reported through studies by Nurul Adyla et al. (2016); Nur Syuhada et al. (2016) and Meisery et al. (2020). According to the records, a total of six non-volant small mammal species were documented at TFR. Although information on non-volant small mammals from this area is available, more surveys are required to understand the dynamics of non-volant small mammal communities in these areas. Hence, this study aims to update the checklist of small mammals in TFR. This updated information may supply essential information to decision-makers, especially the state or local authorities, to undertake further action. Thus, to protect and preserve this forest reserve as a vital *in-situ* conservation site for non-volant small mammals in particular.

2. METHODOLOGY

2.1 Study sites

Tembat Forest Reserve (TFR) situated in Hulu Terengganu District of Negeri Terengganu. TFR is a permanent forest reserve with the highest point, is Gunung Tembat, possess an elevation approaching 965m. TFR also described as the largest forest reserve in the state of Terengganu with a total area of approximately 133,576.45 ha (Anon, 2014 and Nur Amalina et al. 2017).

In these surveys, two plots have been established in TFR, referred in these surveys as TFR1 and TFR2, which lies at 05°01'19.8" N; 102°32'00.1" E and 05°00' 51.9" N; 102°32'09.0" E, respectively. Both plots were located at least 500m away from the main road and composed of secondary forests with a combination of lowland and hill forests. The surveys were conducted twice for each site; the first sampling session for both plots was carried out on 22-27 April 2019, whilst the second sampling session was carried out on 17-22 June 2019.

2.2 Trapping

At each site, a 1ha (100m X 100m) plot comprising 10 transect lines (A-J) was established. The distance between each transect line was 10m at the interval. A total of 100 collapsible cage traps were set up. Each survey opened these traps for five consecutive nights. The cumulative trapping efforts for each plot were 1000-trap nights.

All the captured individuals were safely secured in cloth bags. Required morphological measurements for all individuals were taken for identification purposes before being tagged, photographed, and released back to nearby habitats.

3. RESULTS & DISCUSSION

A total of 36 individuals captured from nine species comprising four families were recorded in TFR namely Erinaceidae (one species), Muridae (five species), Sciuridae (two species) and Tupaiidae (one species). Among the study sites, the species and the individual number of non-volant small mammals captured from TFR1 were higher than TFR2 in both sampling sessions. The cumulative capture rate obtained from TFR1 is 2.4%, meanwhile for TFR2 is 1.2% (Table 1).

The high yield of non-volant small mammals in TFR1 could be correlated by the remains of low canopy openness and dense distribution of secondary in comparison to TFR2. This situation promotes better habitat structural complexity with favorable microhabitats and microclimatic conditions to support different species requirements (Hayward & Phillipson,1979; Chow & Lum, 2009; Carey & Johnson, 1995). Besides that, TFR1 fronting less human intrusion may be due to difficult terrains compared to TFR2.

Murids were the most abundant species captured from both sites. Respectively, a cumulative of 23 individuals and nine individuals were recorded from TFR1 and TFR2. According to Francis (2019), most of the rodent species (Family Muridae) are well-distributed and inhibit wide ranges of habitats, including primary forests, disturbed forests, mangroves, cultivated areas, orchards, gardens, and urban areas. Among the species documented, *Leopoldamys sabanus* was the most captured species from both sites with 11 and four individuals obtained from TFR1 and TFR2, respectively. According to Lim (1970), this giant-bodied and long-tailed rat is a common, generalist species in local assemblages of small mammals presented throughout the Sunda region of Southeast Asia. Moreover, this rat can also move in different matrix structures of logged and unlogged forests (Wells et al.2008).

For these surveys, the trapping success was considered low due to inadequate trapping efforts and placement of traps. During the surveys, the trapping efforts were focused on single habitat (terrestrial) as collapsible cage traps were deployed on the forest floor. Therefore, the traps were aimed to capture ground-dwelling small mammals, thus may not represent the actual species diversity of non-volant small mammals that inhabits the area, especially the arboreal species such as civets and giant squirrels.

From these surveys, there were four new records of non-volant small mammals species for TFR (Table 2), based on previous studies by Nurul Adyla et al. (2016); Nur Syuhada et al. (2016) and Meisery et al. (2020). The species include M*axomys rajah*, *M. surifer*, *M. whiteheadi* and *Lariscus insignis*. This finding may show the possibilities of more species of non-volant small mammals yet to be discovered in this area. Hence, more surveys encompassing wider areas, increased trapping effort, and multiple approaches may facilitate a more comprehensive representation of small mammals in this forest reserve (Jayaraj et al. 2013).

Furthermore, two of these additional species, namely *M. rajah and M. whiteheadi* were categorized as Vulnerable according to IUCN red list of Threatened Species. These results possibly indicate the significance of TFR as a vital area for the *in-situ* conservation of precious small mammals including the threatened and protected species.

Table 1. Number of individuals, species, families, trap-nights and capture rate [(number of individuals captured/total no. of trap-nights) x100] of non-volant small mammals at Tembat Forest Reserve (TFR), Terengganu

No	Family	Common Name	Scientific Name	IUCN	TFR1			TFR2		
					S1	S2	Total	S1	S2	Total
1	Erinaceidae	Moonrat	*Echinosorex gymnura*	LC					1	1
2	Muridae	Long-tailed Giant Rat	*Leopoldamys sabanus*	LC	6	5	11	3	1	4
3	Muridae	Brown Spiny Rat	*Maxomys rajah*	VU	1	2	3			
4	Muridae	Red Spiny Rat	*Maxomys surifer*	LC		1	1		3	3
5	Muridae	Whitehead's Spiny Rat	*Maxomys whiteheadi*	VU	1	1	2	1		1
6	Muridae	Dark-tailed Rat	*Niviventer cremoriventer*	VU	5	1	6		1	1
7	Sciuridae	Black-striped Squirrel	*Callosciurus nigrovittatus*	NT	1		1			
8	Sciuridae	Three-striped Ground Squirrel	*Lariscus insignis*	LC					1	1
9	Tupaiidae	Common Treeshrew	*Tupaia glis*	LC				1		1
Total no. indviduals					**14**	**10**	**24**	**5**	**7**	**12**
No. of species					**5**	**5**	**6**	**3**	**5**	**7**
No. of families					**2**	**1**	**2**	**2**	**3**	**4**
Trap-nights					**500**	**500**	**1000**	**500**	**500**	**1000**
Capture rate (%)					**2.8**	**2.0**	**2.4**	**1**	**1.4**	**1.2**

IUCN= International Union for Conservation of Nature; LC= Least Concern; NT=Near Threatened; VU=Vulnerable

Table 2. List of non-volant small species recorded in TFR,Terengganu

					Present data (2019)		Nurul Adyla et al. (2016)	Nur Syuhada et al. (2016)	Meisery et al. (2020)
No	**Family**	**Common Name**	**Scientific Name**	**IUCN**	**TFR1**	**TFR2**			
1	Erinaceidae	Moonrat	*Echinosorex gymnura*	LC		/			/
2	Muridae	Long-tailed Giant Rat	*Leopoldamys sabanus*	LC	/	/		/	
3	Muridae	Brown Spiny Rat	*Maxomys rajah*	VU	*				
4	Muridae	Red Spiny Rat	*Maxomys surifer*	LC	*	*			
5	Muridae	Whitehead's Spiny Rat	*Maxomys whiteheadi*	VU	*	*			
6	Muridae	Dark-tailed Rat	*Niviventer cremoriventer*	LC	/	/		/	
7	Sciuridae	Black-striped Squirrel	*Callosciurus nigrovittatus*	LC	/			/	
8	Sciuridae	Three-striped Ground Squirrel	*Lariscus insignis*	LC		*			
9	Sciuridae	Low's Squirrel	*Sundasciurus lowii*	LC			/	/	
10	Tupaiidae	Common Treeshrew	*Tupaia glis*	LC		/		/	

(*) = additional species recorded from present study

4. CONCLUSION & RECOMMENDATIONS

This study shows Tembat Forest Reserve houses a variety of non-volant small mammals. Therefore, protecting and preserving this forest reserve is crucial for their population. We also believe there are still many species to discover. Hence, we recommend (1) carrying out more studies covering different sites in diverse forest settings; (2) more sampling efforts by applying diverse techniques such as Sherman traps, pitfall traps, camera traps, variety of baits, and covering different seasons to identify best approaches to well documenting non-volant small mammal communities in this habitat.

5. ACKNOWLEDGEMENT

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Methodologies in Quantitative Research

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Abstract
This paper offers a thorough examination of methodologies utilized in quantitative research. The discussed methodologies include experimental designs, survey research, observational studies, secondary data analysis, meta-analysis, modelling and simulation, sampling techniques, data collection and instrumentation, and statistical analysis methods. Each methodology is explored, highlighting its purpose, applications, and important considerations. The objective is to equip researchers with a comprehensive understanding of these methodologies, enabling them to make well-informed decisions when designing and conducting quantitative studies. By emphasizing the strengths, limitations, and best practices associated with each methodology, this paper serves as a valuable resource for researchers across various disciplines.

Key Words: Quantitative research, experimental designs, survey research, observational studies

1. INTRODUCTION

Quantitative research relies on systematic and empirical approaches that employ numerical data to investigate phenomena and generate scientific knowledge. Methodology selection plays a critical role in the design and execution of quantitative studies. This paper provides a comprehensive exploration of various methodologies employed in quantitative research. The methodologies covered include experimental designs, survey research, observational studies, secondary data analysis, meta-analysis, modelling and simulation, sampling techniques, data collection and instrumentation, and statistical analysis methods. The goal is to present researchers with a comprehensive toolkit to inform their research endeavours.

Experimental designs provide researchers with a controlled environment to examine cause-and-effect relationships (Smith, 2010). Survey research is a valuable method for efficiently collecting data on attitudes, behaviours, and characteristics (Johnson & Brown, 2015). Meanwhile observational studies offer insights into real-world phenomena by systematically observing and recording behaviours, events, or

phenomena in their natural settings (Davis, 2018). On the other hand, the secondary data analysis allows researchers to utilize existing data for new research questions, saving time and resources (Thompson et al., 2012). Meta-analysis is a quantitative method that synthesizes findings from multiple studies to obtain an overall effect size and assess result consistency (Cooper et al., 2016). While modelling and simulation techniques are used to explore complex systems and simulate their behaviour (Chen & Wu, 2019). Lastly, the sampling techniques ensure the selection of representative samples from a larger population (Krejcie & Morgan, 1970). The following section explains the details of each methodology with examples.

2. METHODOLOGIES IN QUANTITATIVE RESEARCH

2.1 Experimental Designs

Experimental designs are frequently utilized in quantitative research to investigate causal relationships between variables. They involve manipulating independent variables while controlling extraneous factors to examine their impact on the dependent variable. Random assignment of participants to different conditions helps minimize bias and enhance internal validity. Experimental designs can be conducted in laboratory settings, field experiments, or through quasi-experimental designs without random assignment.

An illustrative example in Figure 1 showcasing the application of experimental designs in quantitative research involves investigating the influence of a novel educational intervention on student achievement. In this hypothetical study, researchers would randomly assign students from different classrooms to either an experimental group or a control group. The experimental group would receive the educational intervention, while the control group would follow the standard curriculum. The key independent variable in this context is the educational intervention, whereas the dependent variable is the measured student achievement, typically assessed through test scores. By carefully manipulating the independent variable while controlling for extraneous factors, such as maintaining similar classroom environments and ensuring teacher expertise consistency, researchers aim to assess the specific impact of the intervention on student achievement. The random assignment of participants to the two groups serves to minimize potential bias and enhance internal validity by enabling researchers to attribute any observed differences in student achievement to the intervention rather than other confounding variables. Notably, such experimental designs can be implemented across diverse educational settings, including classrooms, schools, or educational institutions, thereby facilitating the evaluation of intervention effectiveness and providing valuable insights to inform educational practices.

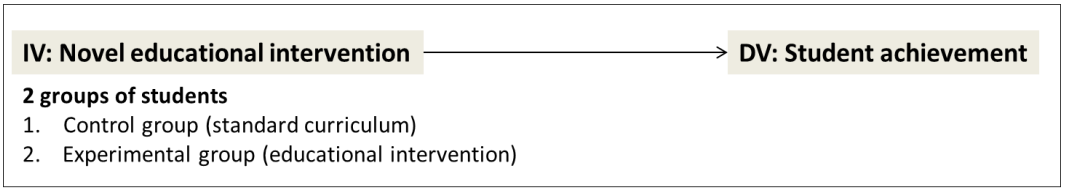

Figure 1: Experimental Design

2.2 Survey Research

Survey research involves collecting data through structured questionnaires or interviews administered to a representative sample. It enables researchers to efficiently gather extensive data, explore opinions, attitudes, behaviours, and characteristics of individuals or groups. Surveys can be conducted through various methods, such as face-to-face interviews, telephone interviews, online surveys, or mail surveys. Ensuring validity, reliability, and appropriate sampling techniques are crucial for survey research.

For example, investigate public perspectives on environmental conservation practices. Researchers might design a well-structured questionnaire to collect data from a representative sample of individuals, encompassing diverse demographic backgrounds. The questionnaire would encompass inquiries regarding attitudes towards recycling, energy conservation, and support for sustainable policies. To ensure the sample's diversity, researchers would employ random sampling techniques during participant selection. The survey could be administered through various methods, such as face-to-face interviews, telephone interviews, online surveys, or mail surveys, depending on logistical considerations and the target population. By adhering to established principles of survey research, such as formulating clear questions, employing reliable measurement scales, and safeguarding respondent confidentiality, researchers endeavour to obtain dependable and valid data concerning public opinions and behaviours pertaining to environmental conservation. The insights derived from the survey outcomes possess the potential to inform policymakers, organizations, and the wider public regarding prevalent attitudes, thus guiding the formulation of effective strategies for environmental conservation.

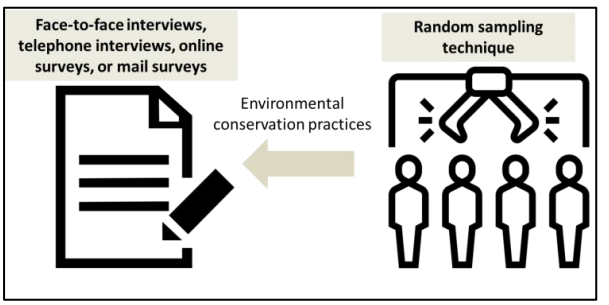

Figure 2: Survey Research

2.3 Observational Studies

Observational studies aim to systematically observe and record behaviours, phenomena, or events in natural settings without intervening or manipulating variables. They provide insights into relationships, patterns, and interactions among variables. Observational studies can be categorized as structured (with predefined behaviours) or unstructured (with more open-ended observations). While they offer valuable real-world insights, observer bias and limited control over confounding factors are potential challenges.

Example of this study is examining the social behaviours of children during recess in a school playground. Researchers would systematically observe and document the natural interactions, behaviours, and play patterns of children without intervening or manipulating variables. Employing structured observation methods, researchers could categorize behaviours, such as cooperative play, competitive play, or solitary play, to gather quantitative data on their prevalence and frequency. Additionally, unstructured observations would enable researchers to explore social interactions and emergent behaviours in a more open-ended manner. The findings derived from such observational studies offer valuable insights into the social dynamics, peer relationships, and play preferences among children during recess. It is important to acknowledge potential biases, including observer bias, and the limitations associated with controlling confounding factors in natural settings. Nevertheless, observational studies serve as a valuable tool to deepen our understanding of real-world phenomena and contribute to the field of social and developmental psychology.

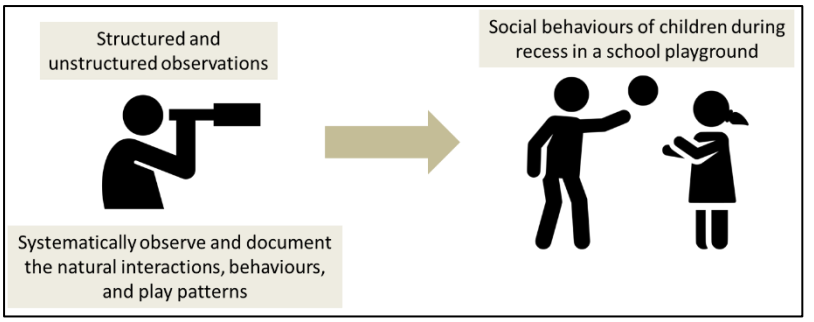

Figure 3: Observational Studies

2.4 Secondary Data Analysis

Secondary data analysis involves utilizing existing data collected by other researchers or organizations for different research purposes. It offers time and resource efficiency, allowing researchers to analyse large datasets and explore research questions that require extensive resources. Secondary data can include survey data, administrative records, public datasets, or archival data. Assessing data quality, relevance, and limitations is vital to ensure suitability for the research objectives.

For instance, a study of the association between socioeconomic status and academic achievement in student population. Researchers may access an existing dataset, made publicly available by a national education agency, which contains comprehensive information on students' socioeconomic backgrounds and academic performance. By leveraging this pre-existing dataset, researchers can efficiently conduct in-depth analyses without the need for collecting new data, thereby conserving time and resources. This approach allows researchers to explore various research inquiries, such as examining the influence of parental income on educational outcomes or investigating the impact of neighbourhood characteristics on student achievement. Nonetheless, it is imperative for researchers to exercise critical evaluation of the secondary data's quality, relevance, and limitations, ensuring its appropriateness for their specific research objectives. Factors such as data accuracy, representativeness of the sample, and potential limitations related to missing variables should be thoroughly assessed. By conducting meticulous secondary data analysis, researchers can uncover valuable insights, contribute to the existing body of knowledge, and inform educational policies and practices.

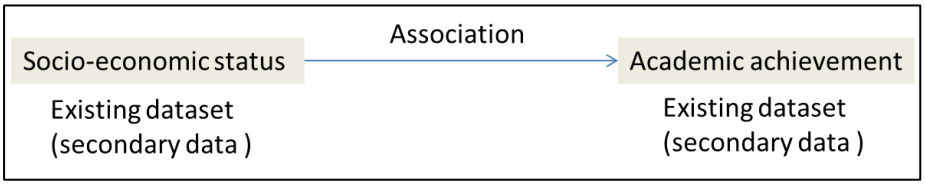

Figure 4: Secondary Data Analysis

2.5 Meta-analysis

Meta-analysis is a quantitative method used to synthesize and analyse findings from multiple individual studies on a specific research question or topic. It involves systematically collecting, evaluating, and statistically combining data to obtain an overall effect size and assess result consistency across studies. Meta-analysis enhances conclusions by increasing sample size and providing a comprehensive overview of existing evidence.

Demonstration of the use of meta-analysis involves examining the effectiveness of a specific psychotherapy treatment for anxiety disorders. Researchers would systematically gather a collection of individual studies that have explored the same treatment approach, encompassing various research designs such as randomized controlled trials or quasi-experimental designs. By rigorously analysing the data from each study, researchers can calculate effect sizes and evaluate the consistency of results across the studies. Meta-analysis offers the advantage of combining findings from multiple studies, which not only increases the overall sample size but also provides a comprehensive overview of the existing evidence regarding the treatment's effectiveness. By employing this method, researchers can draw more robust conclusions that are

informed by a larger body of evidence, enhancing our understanding of the efficacy of the psychotherapy treatment for anxiety disorders. The insights derived from the meta-analysis hold the potential to inform clinical practices, aid in treatment decision-making, and contribute to the development of evidence-based interventions for individuals with anxiety disorders.

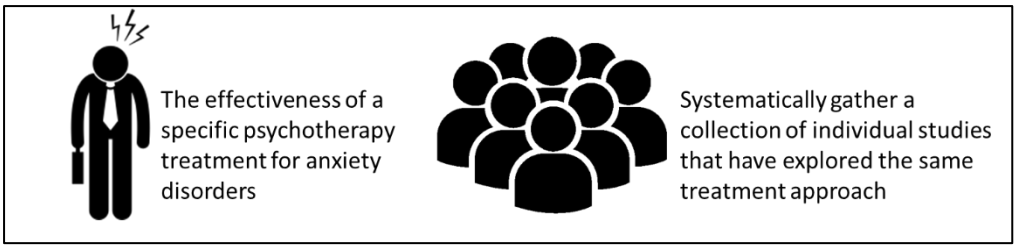

Figure 5: Meta-analysis

2.6 Modelling and Simulation

Modelling and simulation employ mathematical and computational models to represent complex systems and simulate their behaviour. They allow researchers to explore hypothetical scenarios, test theories, and make predictions. Modelling is applicable in economics, biology, physics, social sciences, and other fields to understand complex phenomena and study variable effects. Validity and reliability depend on accurately representing real-world processes and employing appropriate calibration and validation techniques.

The utilization of modelling and simulation can be observed in the field of ecology, particularly in the study of population dynamics. Researchers develop mathematical models that depict the intricate interactions among different species within an ecosystem and simulate their behaviours over time. By considering variables such as birth rates, death rates, and migration patterns, the model enables the exploration of how changes in one species can impact the entire ecosystem. Through simulations, researchers can assess various scenarios, such as the introduction of a new predator or alterations in environmental conditions, thereby predicting the potential outcomes on population sizes and species interactions. Modelling and simulation serve as valuable tools in comprehending complex ecological phenomena and facilitating predictions concerning the consequences of human activities on biodiversity and ecosystems. To ensure the validity and reliability of these models, it is imperative to accurately represent real-world processes, diligently calibrate model parameters using empirical data, and validate the models by comparing their outcomes with field observations.

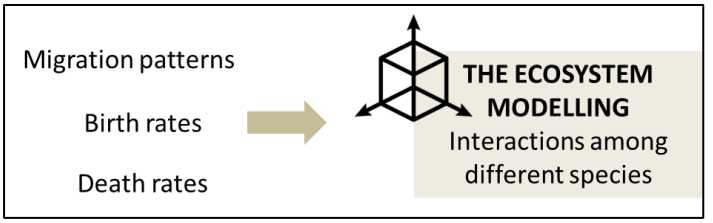

Figure 6: Modelling and Simulation

2.7 Sampling Techniques

Sampling techniques are vital in quantitative research to select a subset of individuals or cases from a larger population. Random sampling, stratified sampling, cluster sampling, or convenience sampling are used based on research objectives, resources, and desired generalizability. Careful consideration of sampling techniques ensures representative and unbiased sample selection.

The example of sampling techniques in quantitative research involves investigating the prevalence of a specific disease within a population. Researchers may utilize random sampling to select a subset of individuals from the larger population, ensuring that each member has an equal chance of being included. This approach enables the generalizability of research findings to the entire population. Alternatively, if the population comprises distinct subgroups, stratified sampling can be employed to ensure proportional representation of each subgroup. For instance, if the population consists of various age groups, stratified sampling would involve selecting participants from each age group in a manner that reflects their relative distribution in the population. Cluster sampling may be employed when it is more feasible to sample groups or clusters instead of individual participants, such as selecting specific regions or communities. In certain cases, convenience sampling may be utilized due to time and resource constraints, although caution must be exercised when generalizing the findings to the broader population. By thoughtfully considering and implementing appropriate sampling techniques, researchers can enhance the representativeness and impartiality of their sample selection, thereby bolstering the validity and reliability of their research outcomes.

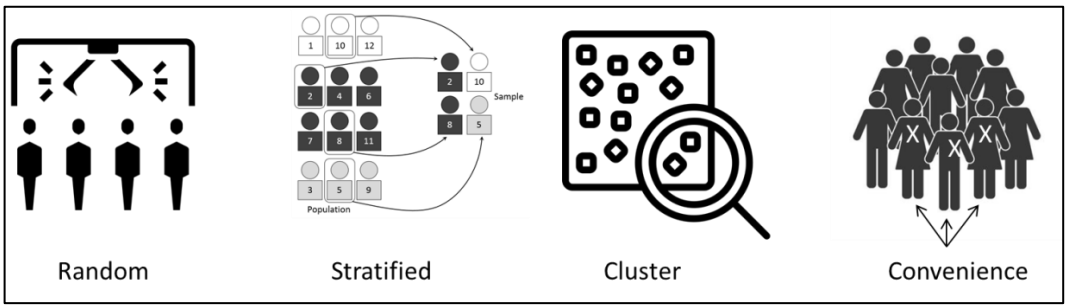

Figure 7: Sampling Techniques

2.8 Data Collection and Instrumentation

Data collection involves systematically gathering relevant information or measurements for analysis. Methods and instruments vary based on research questions and data requirements, including questionnaires, interviews, observations, physiological measurements, or digital sensors. Standardized protocols, data quality assurance, and ethical considerations are crucial during data collection to reduce bias and enhance validity and reliability.

The process of data collection can be observed in a study examining the dietary patterns of individuals within a community. To gather relevant information for analysis, researchers may employ a variety of methods and instruments tailored to their research questions and data requirements. These may include the use of questionnaires, interviews, observations, physiological measurements, or digital sensors. For instance, questionnaires could be designed to inquire about participants' food choices, portion sizes, and frequency of consumption. Additionally, researchers may conduct interviews, either in-person or via phone, to obtain more detailed insights into participants' dietary patterns. To augment data collection, physiological measurements such as heart rate or calorie expenditure could be tracked using digital sensors or wearable devices. It is crucial during the data collection process to follow standardized protocols, ensuring consistency and reliability in the gathered data. Implementing rigorous data quality assurance procedures, such as cross-checking entries and conducting periodic audits, helps to minimize errors and maintain the accuracy of the collected data. Ethical considerations, including obtaining informed consent and safeguarding participant confidentiality, must be prioritized throughout the data collection process. By adopting robust data collection methods and upholding ethical guidelines, researchers can minimize bias, enhance the validity and reliability of their research outcomes, and generate valuable insights into the dietary habits of the targeted community.

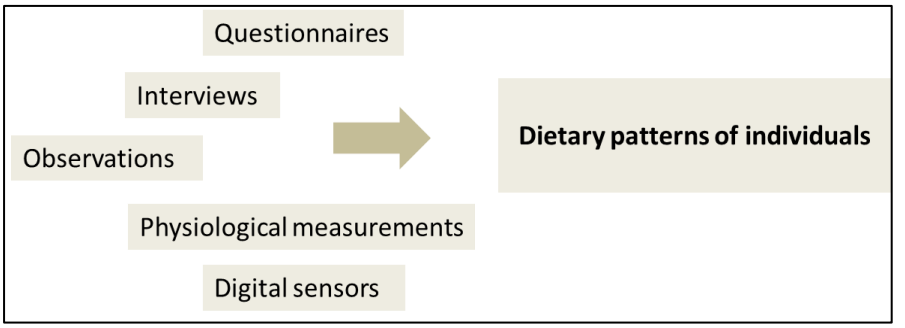

Figure 8: Data Collection and Instrumentation

2.9 Statistical Analysis Methods

Statistical analysis methods are applied to quantitative data to identify patterns, relationships, and statistical significance. They include descriptive statistics to summarize data and inferential statistics to make inferences about populations based on samples. Common techniques encompass hypothesis testing, regression analysis, analysis of variance (ANOVA), factor analysis, and chi-square tests. Careful selection and application of statistical methods ensure accurate and meaningful interpretation of the data.

To showcase the utilization of statistical analysis methods can be observed in a study examining the relationship between exercise and mental health. Quantitative data is collected, including information on participants' exercise frequency and mental health scores. To identify patterns, relationships, and statistical significance within the data, researchers employ various statistical analysis techniques. Descriptive statistics are utilized to summarize the data, providing measures such as the mean exercise frequency and average mental health scores. In addition, inferential statistics are applied to draw inferences about the larger population based on the collected sample. Hypothesis testing is employed to assess the presence of a significant relationship between exercise and mental health, while regression analysis investigates the strength and direction of this relationship. Other commonly used statistical techniques include analysis of variance (ANOVA) for comparing mental health scores among different exercise groups, factor analysis for exploring underlying factors influencing mental health outcomes, and chi-square tests for examining associations between exercise levels and mental health categories. By thoughtfully selecting and applying appropriate statistical methods, researchers ensure accurate and meaningful interpretation of the collected data, thereby contributing to a deeper understanding of the complex relationship between exercise and mental health.

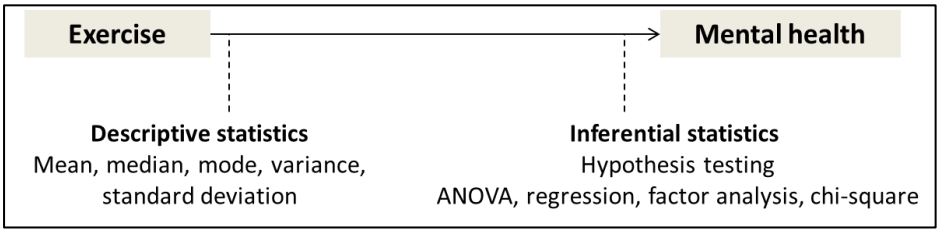

Figure 9: Statistical Analysis Methods

3. CONCLUSION

Quantitative research encompasses a wide range of methodologies that contribute to scientific knowledge in various disciplines. The methodologies discussed in this paper - experimental designs, survey research, observational studies, secondary data analysis, meta-analysis, modelling and simulation, sampling techniques, data collection and

instrumentation, and statistical analysis methods - provide researchers with a diverse set of tools to investigate research questions and generate robust findings. Understanding the purpose, applications, and considerations of each methodology is crucial for researchers to make informed choices in designing and conducting quantitative studies.

By recognizing the strengths and limitations associated with these methodologies, researchers can optimize their research design, enhance data collection and analysis, and ensure the validity and reliability of their findings. Moreover, this comprehensive examination of methodologies serves as a valuable resource to guide researchers in selecting appropriate methodologies based on their research objectives and available resources.

In conclusion, this paper underscores the significance of methodology in quantitative research and presents an in-depth overview of commonly employed methodologies in this field. By equipping researchers with knowledge about the purpose, applications, and considerations associated with each methodology, this paper aims to enhance the quality and rigor of quantitative research, thereby contributing to advancements in scientific knowledge across diverse disciplines.

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A Quick Overview of Basic Statistics: Concepts and Applications

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Abstract
This paper presents an exploration of fundamental statistical concepts, including measures and applications. It emphasizes the importance of understanding these concepts for researchers and practitioners in various fields. The paper introduces key statistical measures such as central tendency, variability, and association, demonstrating their practical relevance in data analysis. It highlights the practical applications of statistics in disciplines such as social sciences, medical research, economics, and quality control. Furthermore, it underscores the role of statistical analysis in evidence-based decision-making and knowledge advancement. By equipping readers with a strong foundation in statistics, this paper serves as a valuable resource for researchers, practitioners, and students, providing guidance on effectively utilizing statistical tools for data interpretation.

Key Words: Basic Statistics, Measures of Association, Application of Statistics

1. INTRODUCTION

Statistics, an essential field within mathematics, involves the collection, analysis, interpretation, presentation, and organization of data. It empowers researchers to draw significant conclusions and make informed judgments based on empirical evidence. This paper provides a succinct yet thorough examination of fundamental statistical concepts, measures, and their practical applications. By comprehending these core principles, researchers can confidently analyse data and draw accurate conclusions while ensuring originality in their work.

By exploring the fundamental aspects of statistics, this paper equips researchers with the necessary knowledge to navigate the complexities of data analysis. It covers vital topics such as measures of central tendency, measures of variability, probability theory, hypothesis testing, and correlation analysis. Understanding these key concepts enables researchers to effectively apply statistical techniques and derive valuable insights from their data. Through the application of statistical principles, researchers can confidently

interpret and present their findings, contributing to the advancement of knowledge in their respective fields.

2. DESCRIPTIVE STATISTICS

Descriptive statistics involves the summarization and presentation of data to gain insights into its characteristics. Measures of central tendency, such as the mean, median, and mode, provide information about the typical value of a dataset. Measures of variability, including the range, variance, and standard deviation, describe the spread or dispersion of the data. Graphical representations, such as histograms, box plots, and scatter plots, serve as useful tools for visualizing data distributions (Johnson, 2010; Stevens, 2012).

To illustrate, let us consider a study focused on examining the heights of a specific group of individuals. A dataset comprising measurements of 100 participants' heights in centimetres is collected by the researchers. In order to employ descriptive statistics, the researchers would calculate various measures of central tendency to grasp the typical height within the sample. For instance, they might compute the mean height, obtained by summing all the recorded heights and dividing it by the total number of participants. This calculation provides an average height value representing the sample. Furthermore, the researchers could determine the median height, which corresponds to the middle value when arranging all the heights in ascending order. This measure is beneficial for identifying the height at which half of the participants are taller and the other half are shorter. To gain insight into the dispersion or variability of heights within the sample, the researchers may calculate the standard deviation. This statistical measure assesses the average difference between each individual's height and the mean height, thus offering an indication of how much the heights deviate from the average.

3. INFERENTIAL STATISTICS

Inferential statistics enables researchers to draw conclusions or make predictions about a population based on a sample. It involves hypothesis testing, wherein statistical tests are employed to evaluate the likelihood of observed differences or relationships occurring by chance. Important concepts in inferential statistics include sampling methods, confidence intervals, and p-values (Sullivan, 2016).

Expanding on the aforementioned example of studying heights in a sample of individuals, we can explore the application of inferential statistics. In this case, the researchers aim to determine if the observed heights in their sample can be generalized to the entire population. To address this question, inferential statistics techniques are employed. One common approach involves hypothesis testing. The researchers formulate a null hypothesis, which assumes no significant difference between the heights in the sample and the population as a whole. They select an appropriate statistical test, such as a t-test or analysis of variance (ANOVA), tailored to their research design and specific hypotheses. By conducting the statistical test on the sample data, the researchers obtain a p-value that quantifies the probability of observing the obtained

results purely by chance. Rejecting the null hypothesis occurs when the p-value falls below a predetermined threshold (typically 0.05), suggesting that the differences in heights observed in the sample likely extend to the entire population. Additionally, inferential statistics involves constructing confidence intervals to estimate population parameters. For instance, the researchers might calculate a confidence interval for the population mean height based on the sample data. This interval provides a plausible range of values within which the true population mean height is expected to lie.

4. PROBABILITY THEORY

Probability theory serves as the mathematical foundation of statistics, providing a framework for quantifying uncertainty and measuring the likelihood of different outcomes. Probability distributions, such as the normal distribution, binomial distribution, and Poisson distribution, are utilized to model and analyse random variables. The laws of probability, including the addition and multiplication rules, govern the manipulation of probabilities (Casella & Berger, 2002; Hogg, McKean, & Craig, 2019).

To utilize probability theory, researchers can estimate the underlying probability distribution of heights in the population using the collected data. Assuming a normal distribution, commonly used for continuous variables like height, researchers can estimate parameters such as the mean and standard deviation to describe the distribution and make probabilistic statements about the population. Probability theory is also integral to hypothesis testing. By comparing heights between different groups, such as males and females, researchers can calculate the probability of observing the observed differences or more extreme differences under the assumption of no true difference. This probability, known as the p-value, aids in evaluating the strength of evidence against the null hypothesis. Moreover, probability theory supports decision-making in statistical inference. Researchers can determine the probability of making errors, such as Type I or Type II errors, when rejecting or failing to reject a null hypothesis. These probabilities, including the significance level and power, assist researchers in assessing the reliability and robustness of their conclusions. By incorporating probability theory, researchers gain a quantitative framework to assess uncertainty, make predictions, and draw conclusions based on the observed heights in the sample. This ensures a rigorous and probabilistically informed approach to data analysis and interpretation.

5. MEASURES OF ASSOCIATION

Measures of association quantify the relationship between two variables. The correlation coefficient, commonly denoted by "r," measures the strength and direction of a linear relationship between continuous variables. Additionally, contingency tables and the chi-square test are employed to assess the association between categorical variables (Field, Miles, & Field, 2012).

For the above scenario, researchers may aim to investigate the association between height and another variable, such as weight or age. Measures of association

enable researchers to assess the strength and direction of the relationship between these variables. One widely utilized measure of association is the correlation coefficient, such as the Pearson correlation coefficient. This coefficient provides a numerical value that quantifies the linear relationship between two continuous variables, indicating the extent to which changes in one variable correspond to changes in the other. For instance, researchers can calculate the correlation coefficient to determine the strength and direction of the association between height and weight in the sample. Similarly, for categorical variables, researchers can employ the contingency coefficient, which measures the strength of association between two categorical variables. This coefficient enables researchers to assess the level of relationship between variables categorized into different groups. For example, researchers may explore the association between height (categorized as "short," average or “tall” and physical activity level (categorized as "low," "moderate," or "high") using the contingency coefficient.

6. APPLICATIONS OF STATISTICS

Statistics has a wide range of applications in various disciplines, demonstrating its versatility. In the social sciences, statistics plays a crucial role in analysing survey data, studying human behaviour, and evaluating the effectiveness of interventions. It enables researchers to draw meaningful conclusions from collected data, contributing to evidence-based decision-making in fields such as psychology, sociology, and political science. By employing statistical techniques, researchers can quantify and comprehend complex social phenomena, enriching the knowledge in these domains (Agresti & Finlay, 2009; Tabachnick & Fidell, 2019).

In the realm of medical research, statistics holds immense significance in designing and analysing clinical trials, conducting epidemiological studies, and examining patient outcomes. By applying statistical methods, researchers can evaluate the efficacy of new treatments, assess the prevalence and impact of diseases, and inform healthcare policies. The utilization of statistics ensures that medical decisions are based on rigorous evidence and enhances patient care and public health outcomes.

Economics heavily relies on statistics to analyse market trends, forecast economic indicators, and assess the effects of policy interventions. It empowers economists to make informed predictions and recommendations by employing econometric models that estimate and test relationships between economic variables. Moreover, statistics is integral to fields like quality control, environmental analysis, and engineering, where it facilitates monitoring and improving processes, analysing complex data, and making data-driven decisions.

7. CONCLUSION

A firm understanding of basic statistics is essential for researchers and practitioners in various disciplines. This paper provided an overview of key concepts, measures, and applications of statistics. By employing descriptive and inferential statistics, probability

theory, and measures of association, researchers can effectively analyse data, make informed decisions, and draw meaningful conclusions. A solid foundation in statistics empowers researchers to contribute to their respective fields with evidence-based insights and reliable findings.

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