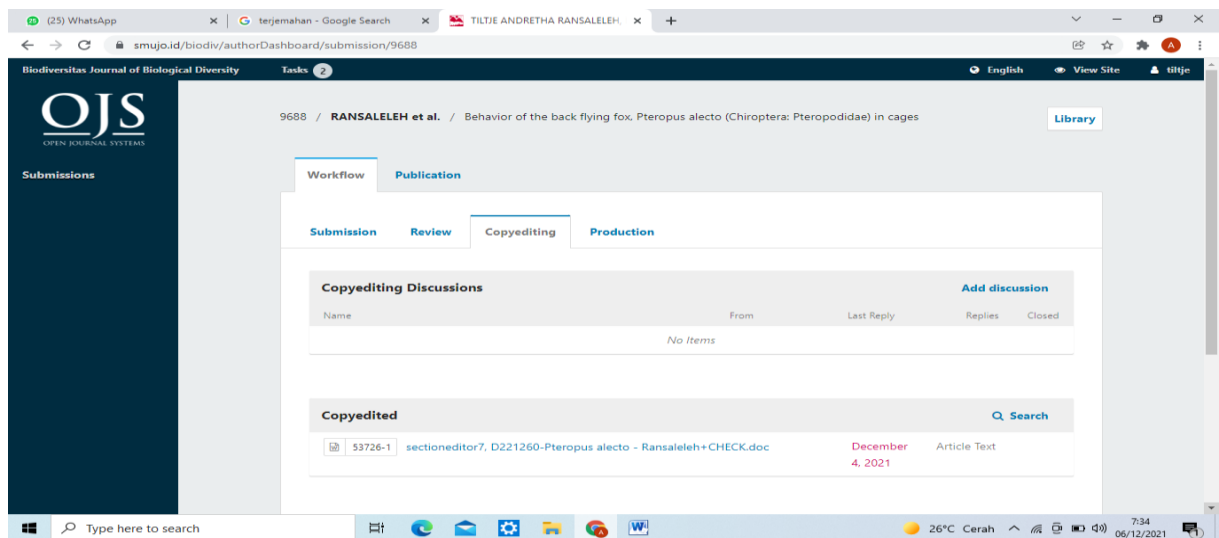
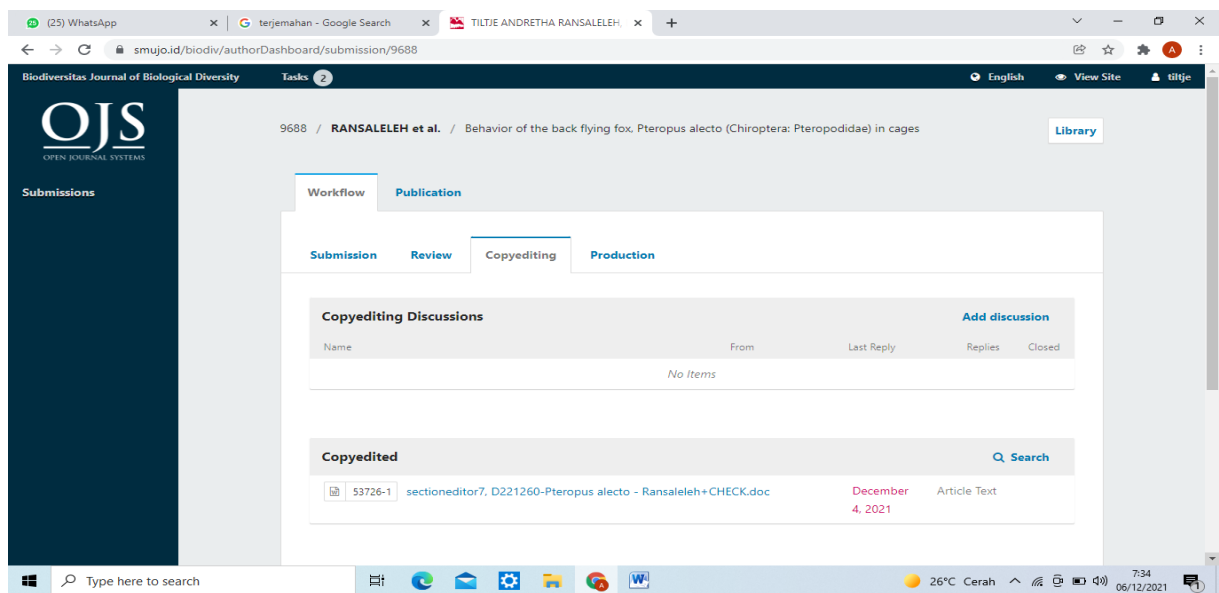
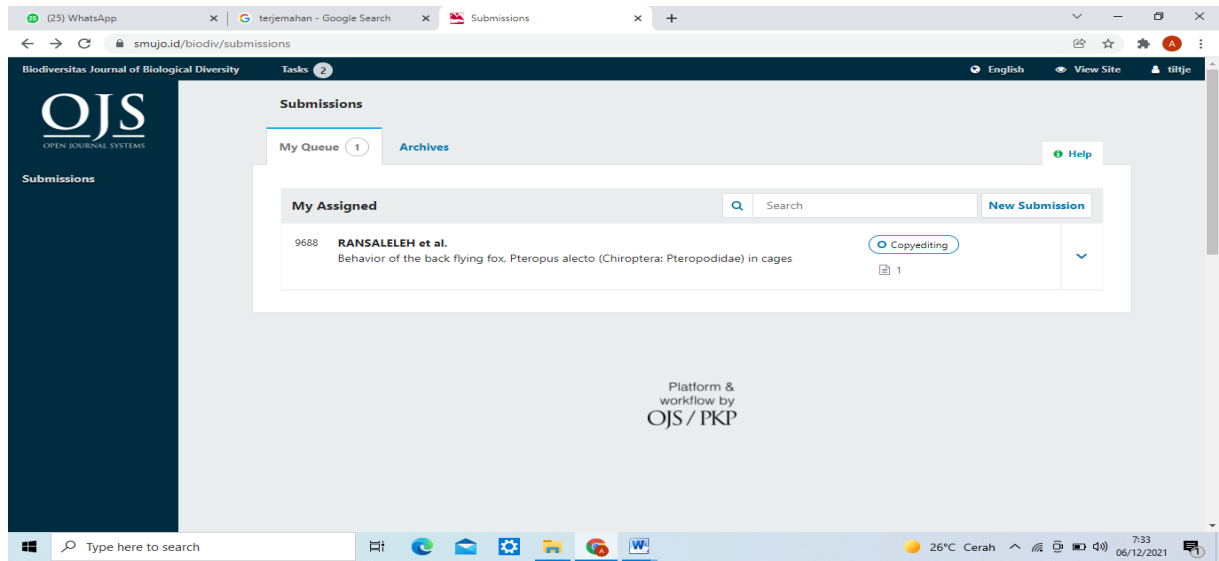


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Day and night behavior of *Pteropus alecto* (Chiroptera: Pteropodidae) in cages

KAWATU

Comment [BLIND1]: Activity or behaviour?the results show activities not behaviour
In cages or in captive?

Comment [BLIND2]: English in general needs to proof read

Comment [BLIND3R2]:

Abstract. The purpose of this study is to examine the behavioral activities of *Pteropus alecto* bats kept in cages through direct observation. The results showed that bats performed the feeding behavior by descending to the bottom of the cage before picking up fruits with their mouths and wings. Furthermore, the time associated with this process ranged from 06.01 to 10.00, and the bats had agonistic behavior performed using claws and wings, which took place from 10.01 to 14.00 in the daytime and 22.01 to 02.00 at night. Grooming behavior was carried out using the tongue and wings, from 14.01 to 18.00 during the day and 22.01 to 02.00 during the night. In addition, the bats also performed the sleeping behavior by perching while closing their eyes and wrapping their whole body with wings from 02.01 to 10.00. They also conducted the locomotion and stationary behaviors by perching with eyes open, while flying around the cage with their wings spread apart. This process is usually performed from 10.01 to 14.00 during the day and 22.01 to 02.00 at night. The percentage of day and night behavior activities was agonistic 0.12%, grooming 6.14%, eating 19.36%, sleeping 56.33%, and stationary and locomotive 17.76%.

Keywords: Activity, behavior, day, night, *Pteropus alecto*

Comment [BLIND4]: There should be an explanation on the importance of the study towards bat's conservation. How can studying animals living in captive could better understand the bio-ecological aspects of the animal species in the wild. Or is this going to be useful for future bat captivity? I think this should be emphasized more and highlighted also in the abstract - on the benefit of this particular study.

Comment [BLIND5]: In the beginning of introduction - it is not common to begin with author's names. Better to put the citation at the end of the sentence.

Comment [BLIND6]: In this case, the focused are flying foxes- Pteropodidae, therefore it is might be best to begin explaining the division of bats (mega and micro - chiroptera) and continue with the roles of bats in particular flying foxes.

Additional roles of fruit bats: not only for forest diversity but also forest rejuvenation

INTRODUCTION

Aziz et al. (2017) stated that bats play an ecological role in terms of maintaining forest diversity due to their function as seed dispersers (Seltzer et al. 2013; Deshpande and Kelkar 2015; Lartey et al. 2016) and pollinators of plants (Lim et al. 2018; Sritongchuay et al. 2019) with economic value (Scarlon et al., 2016; Lim et al. 2018; Sritongchuay et al. 2019; Tremlett et al. 2020) such as durian (Aziz et al. 2017; Muhammad et al. 2020; Low et al. 2021). However, they are hunted and consumed in some communities (Scheffers et al. 2012; Ransaleleh et al. 2013; Suwannorng and Schuler 2016) because they are believed to possess medicinal properties (Mildenstein 2016; Aziz et al. 2017; Low et al. 2021; Rocha et al. 2021), as well as increase stamina (Suwannarong et al. 2020).

In North Sulawesi, its meat (flying fox: *Acerodon celebensis* and *Pteropus alecto*) is imported (Sheherazale & Susan, 2015) and traded in traditional markets for consumption (Latinne et al. 2020; Ransaleleh et al. 2020). Based on a survey conducted during the COVID-19 pandemic, frozen flying fox bats are sold in some supermarkets in cities, such as Manado, Tomohon, and Amurang, Indonesia. *Pteropus alecto* is one of the preferred species for consumption (Ruba et al. 2016) due to its large body size of 45.37 to 54.07% (Ransaleleh et al. 2014). Meanwhile, its high demand causes uncontrollable hunting in nature. According to The IUCN Red List of Threatened Species, Least Concern means any species at low risk. However, continuous hunting causes a decline in the population due to the long reproductive cycle, which is once a year, with only one pup per birth.

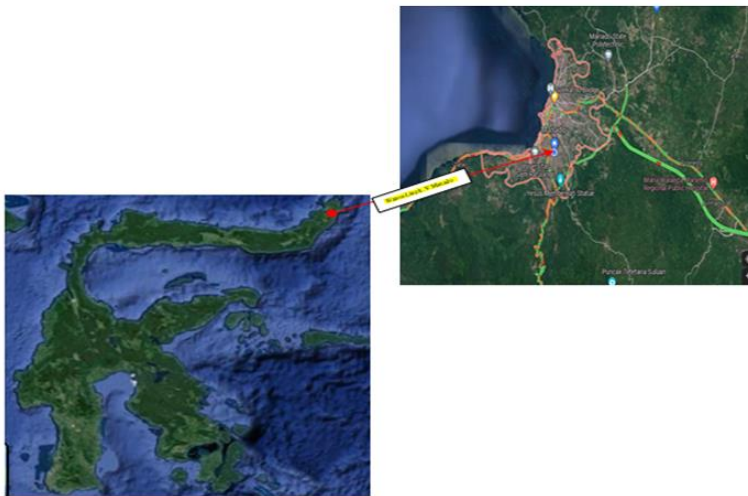
The rampant hunting and selling of bats depict that the community's understanding of its role in the ecosystem is limited and this will likely lead to the species extinction. Therefore, there is a need to determine its sustainability, including approaches related to the legal status of fruit-eating bats (Maulany et al. 2021), its socialization in human life, and conservation efforts (Frick et al. 2019). Meanwhile, conservation success depends on its management, including behavioral activities such as agonistic, grooming, sleeping, feeding, stationary, and locomotion, which needs to be studied (Markus & Blackshaw 2002; Hofstede & Fenton 2005; Connell et al. 2006). The execution of appropriate behavior during conservation expresses growth and reproduction. The behavioral activities exhibited by *Pteropus alecto* in its habitat were last reported 19 years ago (Markus & Blackshaw 2002; Markus 2002). Therefore, this study is aimed to offer a detailed explanation of

49 the *Pteropus alecto* behavioral activities in cages during the day and at night to preserve bats, thereby leading to
50 its sustainable conservation.

51 MATERIALS AND METHODS

52 Study area

53 This study was carried out in neighborhood V of Wanea Village, Manado City, with coordinates 1°27'39" N
54 and 124°50'33" E (Figure 1) for 4 months, from April to July 2021. A total of 9 *Pteropus alecto* species
55 consisted of 2 adult males, 3 juveniles, 2 females (that had never given birth), and 2 lactating ones. Furthermore,
56 a 2.5-meter cage made of tasso and ram wire, with a size of 3 x 1.5 x 1.5 meters (LxWxH), was also utilized.



57
58
59 **Figure 1.** The study area was in the neighborhood V of Wanea Village, Manado City, with coordinates of 1°27'39" N, 124
60 °50'33" E.

61 Procedures

62 The preliminary observation was carried out to determine the time and type of behavioral activities
63 exhibited in the cage. During the day, these birds were observed from 06.01 to 10.00, 10.01 to 14.00, 14.01 to
64 18.00, and at night, from 18.01 to 22.00, 22.01 to 02.00, 02.00 to 06.00. This was carried out from March to
65 July 2021. Afterward, the types of behaviors were observed include and these included agonistic, grooming,
66 feeding, sleeping, and other activities (locomotion and stationary). These were directly observed using
67 observation sheets, CCTV, and cameras. The recorded and documented data were descriptions of the duration of
68 each observed behavioral activities. This was the data recorded with CCTV cameras, which were then
69 replayed, examined, and recorded-transferred into the observation sheets. The data's information was
70 collected every 2 days during the day and at night, from 06.01 to 06.01 for 24 hours. The settings were as
71 follows, during the day, data collection was carried out by 2 students, while at night, it was performed by 3
72 people because bats are nocturnal animals. Furthermore, the timing was intended to avoid bias during
73 observations.

74 Data analysis

75 The descriptive data on the length of behavioral activities were descriptively tabulated and, averaged, and
76 presented as a percentage narrative form.

77 RESULTS AND DISCUSSION

78 Feeding behavior of *Pteropus alecto* in cages

79 Before being fed, all bats perched near the cage door while making repeated sounds. After the food was
80 spread on the floor, each of them crawled quickly to the bottom to grab some with mouth and wings. Afterward,
81 it chewed the food while holding some others with its toes. The other species fed with their legs tied together

Comment [BLIND7]: In general the outline of introduction should cover:
- Flying foxes of Order Megachiroptera
-The roles of flying foxes/fruit bats in particular
-Threats towards flying foxes – hunting & trading for meat consumption
-Captivity as one solution in increasing population of bats and sources for wildlife utilization
-Captive breeding in bats has not much been done in Indonesian's context and therefore this study will fill the existing gaps in particular the roles of behavioural study of bats in overcoming the threats

Comment [BLIND8]: This is not clear while this is the urgency of the study. There should be a clear link between how this study could contribute in reducing bat hunting.
At the same time, clear cutting on how behavioral study on captive bats could be used in the context of wild population and or in conservation needs to be stated.

Comment [BLIND9]: Where these individuals were obtained?From the wild or been captivated for some period. Is this an experimental study where all conditions set up or the captivity was already built?

A little bit history of this will provide a background on existing behavior of the bats living in the captive. This will affect on the habits build by the bat if the captive period is longer.
-Do they captivate in the same period?or different?
-Is there any animal ethic permit for this research?

Comment [BLIND10]: A better map probably better with the north Sulawesi as an insert not only projected as a dot, the map of study area should be bigger than the insert of Sulawesi island

Comment [BLIND11]: Parameter's measured should be mentioned. What do you want to examine?
For examples: ...

Comment [BLIND12]: By whom?the bats?

Comment [BLIND13]: Bats?

Comment [BLIND14]: Only type of activities? How about the time devoted for each activity?
How do you observe?because there are 9 individuals in the cage? Is it scanning methods or

Comment [BLIND15]: ?

Comment [BLIND16]: I think it is not necessary to mention that students were the one who collecting your data

Comment [BLIND17]: Maybe prior to feeding behaviour, it is better to provide explanation on what kind of activities involve during the observation in the captive set? ...

82 with wires, and their bodies leaned on the cage floor's bottom near the food. It was observed that some bats did
 83 not take food from the floor, rather from those that were perched, such as bats with cubs. Based on the
 84 behavioral descriptions, first, the mothers crawled to the bottom to get food while holding their cubs and
 85 returned to perch and chew it while they licked the liquid that came out of its mouth. Second, they were released
 86 to perch on their own, while the mothers went to the bottom of the cage to get food and returned to where they
 87 were perched with their mouths close to that of their cubs. It was observed that they chewed their food severally,
 88 then expelled the waste in the form of dietary fiber, and it was noticed that they rarely drank. The feeding
 89 behavior of bats in cages is shown in Figure 2.



90

91 **Figure 2.** Description of feeding behavior of *Pteropus alecto* bats in cages

92 The feeding behavior of *Pteropus Alecto-alecto* species in cages was similar to those in their actual habitats.
 93 However, the location, fruit type, feeding method, form of food served, and availability were different. Besides,
 94 these nocturnal animals directly feed on fruit trees, while farmers provide food for the cultivated ones. Markus
 95 and Blackshaw (2002) reported that the feeding behavior of bats in their habitat includes chewing, licking,
 96 throwing food, and drinking water. The process of chewing produces juice extract, and the ability of the cubs to
 97 lick their mother's mouth is an act of introducing adult food (Dumont & O'neal 2004). The results of this study
 98 illustrates that bat conservation in cages does not change the feeding behavior in their habitats. The difference
 99 lies in the time and place because they search for food and fruits out of their perches.

100 The feeding duration of *Pteropus alecto* species was recorded from afternoon till evening, although this
 101 activity usually occurred from 18.01 to 22.00, it consumed a lot of time, relatively 11161.4±479.4 seconds.
 102 There was no reference to the feeding time and duration, both in their habitat and those under cultivation.
 103 However, based on observations, this attribute tends to change when they are not fed at night. In addition, when
 104 they are given unlimited food (full at night), they are bound not to eat during the day, irrespective of its
 105 availability in the cage. They return to take the leftover food in the late afternoon. This illustrates that the
 106 feeding time of cultivated bats is changed to daytime. In contrast to those in their habitat, food is not available
 107 on perches, therefore they fly far in search of its sources, and this affects the timing and patterns of their feeding
 108 behavior. Schloesing et al. (2020) reported that *Pteropus lylei* species depend on experience, availability and
 109 quality of food sources, and familiarity with the habitat. Moreover, Choden et al. (2019) reported that these
 110 species fly over relatively 6.88 to 105 km at night to forage. Welbergen (2008) reported that *Pteropus alecto*
 111 species usually leave their perches in search of food starting from 17.30 to 18.00. Similarly, *Pteropus*
 112 *poliecephalus* belongs to the family of *Pteropus alecto*, with its foraging time carried out in the evenings
 113 because it depends on the weather and the presence of predators (Welbergen 2006).

114 **Agonistic behavior of *Pteropus alecto* in cages**

115 The agonistic behavior of *Pteropus alecto* species was exhibited whenever they were given food (fruits),
 116 about to mate, or awake. During the feeding procedure, the dominant ones chased and attacked the others with
 117 their claws, resulting in a fight. The chased bats continue to dodge while aiming and picking up the fruits with
 118 the help of their wings and perches far from the attacking one while eating. This behavior occurred repeatedly
 119 and stopped after they had all been fed. Meanwhile, during the mating process, it was initially observed that the
 120 male bat approaches one of the females while circling the perch and attacking its counterparts with their claws.
 121 The attacked one tend to counterattack, using its foot and claws, and this occurred severally. The female also
 122 hits back at the target, while screaming and a fight ensues, it then tries to evade by moving from one place to
 123 another and wrapping the whole body with its wings. The subsequent observed agonistic behavior relates to the

Comment [BLIND18]: How different? In time for example between wild and captive set? As there is no data shown in the results on time, therefore, it is best to present your data as suggested above.

Comment [BLIND19]: This can also be presented in a description table similar as above.

Agonistic behaviour	
No. Behaviour Time	Description Figure of behaviour
(second)	
1.	Food provision
2.	Mating process

How about frequency of each behaviour? I think this can also be measured

Comment [BLIND20]: Agonistic behaviour in feeding especially in a cage occurred due to competition in getting food.

Is there any influences of the cage size towards the agonistic behaviour?

It is actually interesting to see if we make an experiment on the methods of feeding such as provide the food in the same time with larger amount so competition will be lesser and see whether this reduced agonistic behaviour

124 male bat approaching the female from behind and then hooks its 2 wings on the back while holding that of its
 125 target and biting the neck. The female makes a sound and tries to escape from its grip, resulting in a fight.
 126 However, once released from the grip, they protect themselves by covering the entire body with their wings.
 127 Another observed agonistic behavior was the male approached the target by licking its mouth, head, body, and
 128 vagina. The female occasionally makes sounds that cause the male to pause for a moment and then continues
 129 with licking the target's vagina while circling the female bat's perched position, still grabbed from behind,
 130 which leads to copulation. This final observed agonistic activity is a fistfight that only occurs briefly.
 131 Furthermore, when bats are awake, sometimes one of them moves and scratches those next to it, which reacts by
 132 making a sound and clawing back at the attacker. The description of the agonistic behavior of *Pteropus alecto*
 133 species in cages is shown in Figure 3.



134

135 **Figure 3.** Description of the agonistic behavior of *Pteropus alecto* in cages

136 There are no scientific reports related to the agonistic behavior of *Pteropus Alecto* species during feeding in
 137 their habitat. However, their mating season is similar to the cultivated ones. Markus and Blackshaw (2002)
 138 reported that this behavior in their habitat is to maintain roost areas during the mating season. The male bats
 139 usually attack others to defend their partners. Welbergen (2011) reported that chasing and fighting using their
 140 wings and teeth is one of the territorial behaviors of *Pteropus poliocephalus* species in their habitat.

141 The agonistic behavior of *Pteropus alecto* species associated with the males trying to mate with the females
 142 was observed during the day, especially at night. Meanwhile, during the day, it often occurred from 10.01 to 14-
 143 00 for 15.7±9.1 seconds, while at night, it is usually from 22.01 to 02.00, and lasted for 28.2 ±18.2 seconds.
 144 Based on observations, the males actively attacked the females from March to early April, while a decline was
 145 observed from May to July. The agonistic activity recorded in this study is different from that observed in the
 146 habitat due to the struggle to perch, rather than the females' ability to mate, in contrast to that in the cage. No
 147 scientific reports have been recorded on the agonistic activity of *Pteropus alecto* species in their habitats both
 148 during the day and at night. Markus (2002) reported that initially, these birds flew in the afternoon, they marked
 149 tree branches by rubbing their necks and chests during the day. The agonistic activity occurs once they return to
 150 perch on the tree in the morning. Meanwhile, resident bats make sounds, chase, and fight non-resident ones
 151 perched on tree branches that have been marked, and they, in turn, fly away within a duration of 16.5 ± 6.3
 152 seconds. Furthermore, it was reported that their agonistic behavior during the mating season was relatively poor
 153 in their habitat because the distribution of the sex ratio was quite even or the number of adult females was
 154 greater than the males. This study reported that the agonistic activity of cultivated bats usually occurs during the
 155 day and at night. Therefore, in terms of breeding, it is necessary to pay attention to the duration of feeding the
 156 cubs and the ratio of males to females (number of males in one group). This is because, during this season, male
 157 bats and breastfeeding mothers are usually active.

158 **Grooming behavior of *Pteropus alecto* in cages**

159 In accordance with the grooming behavior, it was observed that all individuals, including the mothers and
 160 their cubs, nurtured themselves, using their tongues, feet, toes, and claws. These were also used to scratch the
 161 face, head, teeth, back, neck, and ears. Sometimes the toes were slowly inserted into the ear canal. However,
 162 when in a perched position, the tongue is repeatedly and rapidly used to lick the front of the body, starting from
 163 the abdomen, chest, genitals, and wings. The stroking of the genitals by the males causes a penile erection

Comment [BLIND21]: Captive?

Comment [BLIND22]: Is this also used as an assumption for *Pteropus alecto*?

Comment [BLIND23]: History on how long the animals have been in captive, because the longer the captive time, the lesser stress will be created as they have been adapte

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Comment [BLIND24]: What is resident bat and non-resident bat?there should be an explanation in the method perhaps on these two and also history of the captivity

Comment [BLIND25]: Data needs to be presented as a descriptive table accompanied by time and figure

164 without ejaculation. The description of *Pteropus alecto* species grooming behavior in cages is shown in Figure
165 4.

166 During the observation process, grooming centered on the muzzle, face, and genitals was carried out in pairs.
167 The males performed genital grooming on the females. Meanwhile, the mothers nurtured the cubs routinely,
168 including during breastfeeding, when they were hugged. In addition, the mothers lick their heads, necks, and
169 backs repeatedly. However, the front and back of their bodies, especially the muzzle are licked when they hang
170 close to their mothers. The grooming behavior of *Pteropus alecto* observed in this study was similar to the
171 process observed in its habitat. Markus and Blackshaw (2002) reported this species generally engages in the
172 wing, ear, infant, and genital grooming. Markus (2002) reported that penile grooming was specially observed
173 during the mating process in its habitat. Grooming behavior is a treatment or effort to rid oneself of food
174 remnants and oil from the skin glands (Markus and Blackshaw 2002).



175

176 **Figure 4.** Description of the grooming behavior of *Pteropus alecto* in cages

177 In respect to those in cages, this process was conducted from morning to evening, although, during the day,
178 it often occurs at 14.01 to 18.00 for 1216.7 ± 179.5 seconds, while at night, it takes place from 22.01 to 02.00 for
179 1930.9 ± 387.8 seconds. Grooming activities are frequently carried out during the day, when they are awake,
180 while at night, it is performed after they have been fed before locomotion and stationary activities. The bats in
181 the cages often engage in this process in the afternoon. Nocturnal grooming activities are reportedly performed
182 at night because bats fly in the wild looking for food sources far from their perches. However, those in cages are
183 fed. Markus and Blackshaw (2002) reported that *Pteropus alecto* species perched on Indo-roopilly and Norman
184 Greeks Islands go out to forage in the late afternoons and return to their perches in the mornings. Furthermore, it
185 was stated that this activity was conducted starting in the morning and repeated throughout the day. Connell et
186 al. (2006) reported that grooming behavior in *Pteropus poliocephalus* species mainly occurred in the mornings.

187 **Sleeping behavior of *Pteropus alecto* in a cage**

188 The sleeping behavior of *Pteropus alecto* was monitored throughout the study and described thrice. First,
189 they perched on one leg, with its wings wrapped around the body and the head tucked underneath. Second, they
190 perched on 2 legs, with wings wrapped around the body, head pointing downwards, and eyes closed. The most
191 common sleeping behavior is perching on one leg with the head tucked under the wings. The initial behavior
192 was generally exhibited during the cold weather, especially at night and in the mornings, as well as when it rains
193 along with temperatures ranging from 24°C to 28°C with humidity of 98 to 80%. The second and third were
194 conducted during the hot season with temperatures ranging from 29°C to 32°C and 76 to 59% humidity. Based
195 on observations, the *Pteropus alecto*'s perching and sleeping positions never changed according to the initial,
196 back to back, juvenile bats being close to their mothers, and males being alone, occasionally. These species are
197 usually awake when there are disturbances around the cage, such as people passing. This is proven by the
198 movement of their heads and eyes while automatically shaking their ears, as shown in Figure 5. Based on this
199 study, it was reported that the sleeping behavior in the cage is similar to that on trees. Markus and Blackshaw
200 (2002), reported that this species either perches on both legs or one, with its wings wrapped throughout the
201 body, and the head tucked underneath. Furthermore, several sleeping behavioral activities are regulated by
202 weather and disturbances, and when there is a disturbance, they react by directing their gaze. During the hot
203 weather, the bats open their wings, while in the cold season, it is folded, and in addition, heavy rain stops all
204 their activities. Additionally, the distribution of *Pteropus alecto* perch in its habitat is consistent and does not
205 change according to the existing group.

Comment [BLIND26]: It is also better to present data in a descriptive table

Comment [BLIND27]: There were no environment conditions measurement written in the method. Please cross check



206

207 **Figure 5.** Description of the sleeping behavior of *Pteropus alecto* in a cage

208 The sleeping time of those in the cage starts from 10.01 pm to 18.00. However, these nocturnal animals slept
 209 at night from 10.01 to 02.00 for 1270.6 ± 235.6 seconds and from 02.00 to 06.00 for 11513.7 ± 345.2 seconds.
 210 During this period, the bats were wake most of the time, performing certain activities such as feeding, grooming,
 211 agonistic, perching, and walking back and forth in the cage. Sleep during the day was mostly from 06.01 to
 212 10.00 for 13967.9 ± 560.9 seconds, and from 10.01 to 14.00 for 12689.4 ± 250.0 seconds. In the afternoons from
 213 14.01 to 18.00, their sleeping time decreases to reduce, to 9225.6 ± 359.1 seconds because they start to carry out
 214 other activities such as perching while grooming, being agonistic, and feeding. Most of the sleeping behavior
 215 was performed from 06.01 to 10.00 because the weather temperature ranges from 24°C to 29°C . However,
 216 towards noon, the time reduced because the temperature increased from approximately 29°C to 33°C . At this
 217 time, bats perched while opening and flapping their wings. There is no information on the duration of sleep in
 218 the habitat at night because bats usually fly at that time in search of food. In contrast to those in cages, their food
 219 was available, therefore the time for foraging was used for sleeping and other activities. There is also no
 220 information about their sleep duration in the natural habitat when perched during the day. However, Markus and
 221 Blackshaw (2002) reported that the diurnal pattern of *Pteropus alecto* is dominated by nesting, sleeping,
 222 grooming, and slight social activities, irrespective of the fact that the bats are awake for a long time during the
 223 day, although they are mostly inactive. Connell et al. (2006) reported that *Pteropus poliocephalus* species
 224 generally slept in their habitat during the day.

225 **Locomotion and stationary behavior of *Pteropus alecto* in the cage**

226 The observed stationary behavior was, first, (stretch), the bat perched, with its wings, spread wide to the left,
 227 right, and forward, and then folded backward. Second, they (wing fan) perched, with part of its wings drooping
 228 while being flapped slowly, in accordance with the movement of the head, ears, and eyes looking around the
 229 cage. Third (static flight), the bat perched while the wings were flapped rapidly for a few seconds, then folded
 230 back. The first stationary behavior is usually performed during the day and at night, while the second is usually
 231 observed during the day when the weather is hot, and the third is at night. In general, static flight is mostly
 232 practiced by cub and juvenile bats. Based on observations, the infant bats were taught to fly by their mother in a
 233 place far from the others. The cubs were hooked to the mothers' legs on a ram wire, a moment later, they flapped
 234 their wings once and touched that of the infants, which caused them to kick -flap theirs. This activity was
 235 accomplished 2 to 3 times. Afterward, they hugged their mothers again, and this activity was repeated until they
 236 were able to fly. The stationary behavior of the *Pteropus alecto* species in their habitat was also observed during
 237 cultivation, although in different places. Furthermore, the observed locomotive behavior includes the following.
 238 First, they perched on 2 legs, the head lifted straight, the wings opened, and then briefly flew around the cage.
 239 Second, bats used their feet and claws to move back and forth on the porch, crawl to the bottom, up and down
 240 through the cage rams in rapid motion. The description of the locomotion and stationary behavior of this species
 241 in cages are shown in Figure 6.

Comment [BLIND28]: The pictures look the same and not describing different sleeping behaviour

Comment [BLIND29R28]:

Comment [BLIND30R28]:

Comment [BLIND31]: Does this mean from 10 pm at night until 6pm in the evening

Comment [BLIND32]: Do not understand. Previously mentioned from 10 pm at nite til 6 pm in the evening but in this sentence there are no clear time division. Please use time indicator

Comment [BLIND33]: English needs revision

Comment [BLIND34]: Similar with the part above, this should be presented in a descriptive table so it will be easy for people to understand the results of this study



242

243 **Figure 6.** Description of locomotion and stationary behavior of *Pteropus alecto* in cages

244 The locomotion and stationary behavior generally do not involve physical contact with other bats in the
 245 cage. There are no differences between the cultivated ones and those in its habitat. Markus and Blackshaw
 246 (2002) reported that bats flapping their wings (wing fans) and opening their mouths (pant) are actions engaged
 247 in to cool their bodies during the hot weather. In addition, spreading their wings wide (stretch) is completed
 248 before they relax. The static flight was carried out to strengthen the wings and chest muscles in preparation for
 249 movement. Furthermore, in its habitat, *Pteropus alecto* performs locomotion using both legs to hold branches,
 250 drooping wings (open on the left and right), back and forth, up and downs, as well as briefly flying between
 251 trees. Locomotion (moving) and stationary (remaining at a place) behavior is an activity that involves moving
 252 from one place to another without making any physical contact with other bats, by flapping, flying, and perching
 253 while covering all or part of their bodies with its wings while shaking their heads, and opening their eyes
 254 (Markus and Blackshaw, 2002).

255 Locomotion and stationary activities of bats in cages were carried out during the day and at night. However,
 256 it was often performed at night from 10.01 to 02.00 for 9661.5 ± 389.3 seconds and from 02.01 to 06.00 for
 257 7902.7 ± 250.9 seconds (Table 1). This activity is carried out because bats are nocturnal animals and are mostly
 258 active at night. This time is used for foraging and returning to the perch in the early hours of the morning after
 259 getting food. In the cage, food is already available, therefore they engage in other activities. Locomotion and
 260 stationary activities of bats in cages at night are different from those performed during the day. At night, they
 261 move around quickly and perform motions in an active manner. At the same time, during the day, they just
 262 perch in place, awake, and move when there is internal interference from others or external factors such as
 263 exposure to sunlight. People visiting the location around the cage. These activities are different from those
 264 carried out in nature. This is because, at night, they do not stay in the perch, except for cubs that are not yet able
 265 to fly. Markus and Blackshaw (2002) reported that at night, they are left by their mothers, and they move by
 266 dragging and climbing branches, and sometimes they congregate in small groups, wrestling at close range and
 267 with their chests sticking together occasionally. Pulling wings without anyone dodging is interpreted as a play
 268 activity. Locomotion and stationary activities of *Pteropus vampirus* bats in nature have been reported by
 269 Hengyan et al. (2017), relating to the fact that they are awake and engage in various practices during the day.

270 **Duration and percentage of day and night behavioral activity of *Pteropus alecto* in a cage**

271 The percentage of day and night behavioral activity performed by *Pteropus alecto* in the cage is shown in
 272 Table 1.

273 **Table 1.** Duration and percentage of day and night behavioral activity performed by *Pteropus alecto* in cages

Behavior	Day		Night		Total Activity	
	Duration (second)	(%)	Duration (second)	(%)	Duration (second)	(%)
Feeding	2756,18	3,19	13970,21	16,17	16726,39	19,36
Agonistic	52,39	0,06	56,16	0,06	108,56	0,12
Grooming	2459,60	2,84	3088,19	3,57	5547,58	6,41
Sleeping	35882,35	41,53	12784,33	14,80	48666,68	56,33
Stationary and locomotion	2049,31	2,37	13300,91	15,39	15350,22	17,76
Total	43199,83	49,99	43199,82	49,99	86399,64	98,98

Comment [BLIND35]: Captive?

Comment [BLIND36]: Are there any differences in these behavior at individual's level?

Comment [BLIND37]: This can be integrated into the above

274 The activities were dominated by sleeping, feeding, stationary and locomotion, grooming, and agonistic
 275 behaviors at 56.33%, 19.36%, 17.76%, 6.41%, and 0.12%, respectively. This means that 56.33% of bats did not
 276 engage in these practices, only 43.67% did. The dominant behavior during the day was sleeping, which was
 277 performed by 41.53% of them, while at night 16.17% engaged in feeding. The least percentage of behavioral
 278 activities during the day and at night was agonistic. Grooming, stationary, and locomotion were often carried out
 279 at night. There was no comparative literature on the percentage of day and night behavioral activities performed
 280 by cultivated *Pteropus Alecto* species and those in nature. However, the percentage of daytime behavioral
 281 activities was observed in the *Cynopterus sphinx* and *Pteropus vampyrus* species. Syamsi (2013) reported that
 282 66.17% of *Cynopterus sphinx* slept during the day, followed by 21.09% that engaged in stationary and
 283 locomotion activities and 11.98% that participated in grooming. Hengyan et al. (2017) reported that the daytime
 284 activity of *Pteropus vampyrus* species in their habitat was 53.1 ± 13.9%, grooming 5.7±2.3%, aggression
 285 2.4±7%, locomotion 2.3±1.6. The percentage of agonistic illustrated that the bats have adapted to the
 286 environment and food provided in the cage because fights that caused injuries and stress rarely occurred.
 287 Therefore, the percentage of behavioral activities performed by the species in cages provides information and an
 288 initial description of the sustainable ex-situ breeding strategy.

Comment [BLIND38]: A conclusion on how the behavior of the species in the captive set is required. There should be a link between the findings and how this could contribute towards the conservation of the bats are also needed – to answer the urgency of this study as been mentioned in the introduction.

289 ACKNOWLEDGEMENTS

290 The authors are grateful to the Chancellor of Sam Ratulangi University through the Chair of the Institute
 291 for Research and Community Service for funding this study with the 2021 Unsrat Superior Basic Research
 292 (RDUU) scheme with contract number No. 235/UN12-13/LT/2021 and Assignment Letter No.
 293 715/UN12.13/LT/2021.

Comment [BLIND39]: Please check again and re-write the references According to thejour=

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Comment [BLIND40]: Typo error

Comment [BLIND41]: Typo error

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368

Comment [FP1]: Better delete and the title will be: The behavior of P.a. (Chiroptera: Pteropodidae) in cages

Day and night behavior of *Pteropus alecto* (Chiroptera: Pteropodidae) in cages

Abstract. The purpose of this study is to examine the behavioral activities of *Pteropus alecto* bats kept in cages through direct observation. The results showed that bats performed the feeding behavior by descending to the bottom of the cage before picking up fruits with their mouths and wings. Furthermore, the time associated with this process ranged from 06.01 to 10.00, and the bats had agonistic behavior performed using claws and wings, which took place from 10.01 to 14.00 in the daytime and 22.01 to 02.00 at night. Grooming behavior was carried out using the tongue and wings, from 14.01 to 18.00 during the day and 22.01 to 02.00 during the night. In addition, the bats also performed the sleeping behavior by perching while closing their eyes and wrapping their whole body with wings from 02.01 to 10.00. They also conducted the locomotion and stationary behaviors by perching with eyes open, while flying around the cage with their wings spread apart. This process is usually performed from 10.01 to 14.00 during the day and 22.01 to 02.00 at night. The percentage of day and night behavior activities was agonistic 0.12%, grooming 6.14%, eating 19.36%, sleeping 56.33%, and stationary and locomotive 17.76%.

Comment [FP2]: Please consult the Guideline for Author – GFA to ensure a format of abstract

Keywords: Activity, behavior, day, night, *Pteropus alecto*

INTRODUCTION

Aziz et al. (2017) stated that bats play an ecological role in terms of maintaining forest diversity due to their function as seed dispersers (Seltzer et al. 2013; Deshpande and Kelkar 2015; Lartey et al. 2016) and pollinators of plants (Lim et al. 2018; Sritongchuay et al. 2019) with economic value (Scarlon et al., 2016; Tremlett et al. 2020) such as durian (Aziz et al. 2017; Muhammad et al. 2020; Low et al. 2021). However, they are hunted and consumed in some communities (Scheffers et al. 2012; Ransaleleh et al. 2013; Suwannorang and Schuler 2016) because they are believed to possess medicinal properties (Mildenstein 2016; Aziz et al. 2017; Low et al. 2021; Rocha et al. 2021), as well as increase stamina (Suwannarong et al. 2020).

In North Sulawesi, its meat (flying fox: *Acerodon celebensis* and *Pteropus alecto*) is imported (Sheherazade & Susan, 2015) and traded in traditional markets for consumption (Latinne et al. 2020; Ransaleleh et al. 2020). Based on a survey conducted during the COVID-19 pandemic, frozen flying fox bats are sold in some supermarkets in cities, such as Manado, Tomohon, and Amurang, of North Sulawesi Indonesia. *Pteropus alecto* is one of the preferred species for consumption (Ruba et al. 2016) due to its large body size of 45.37 to 54.07% (Ransaleleh et al. 2014). Meanwhile, its high demand causes uncontrollable hunting in nature. According to the IUCN Red List of Threatened Species, Least Concern means any species at low risk. However, continuous hunting causes a decline in the population due to the long reproductive cycle, which is once a year, with only one pup per birth.

Comment [FP3]: Not clear, % or gr/kg. Percentage of consumed meat from a total body weight? Or what?

The rampant hunting and selling of bats depict that the community's understanding of its role in the ecosystem is limited and this will likely lead to the species extinction. Therefore, there is a need to determine its sustainability, including approaches related to the legal status of fruit-eating bats (Maulany et al. 2021), its socialization in human life, and conservation efforts (Frick et al. 2019). Meanwhile, conservation success depends on its management, including behavioral activities such as agonistic, grooming, sleeping, feeding, stationary, and locomotion, which needs to be studied (Markus & Blackshaw 2002; Hofstede & Fenton 2005; Connell et al. 2006). The execution of appropriate behavior during conservation expresses growth and reproduction. The behavioral activities exhibited by *Pteropus alecto* in its habitat were last reported 19 years ago (Markus & Blackshaw 2002; Markus 2002). Therefore, this study is aimed to offer a detailed explanation of the *Pteropus alecto* behavioral activities in cages during the day and at night to preserve bats, thereby leading to its sustainable conservation.

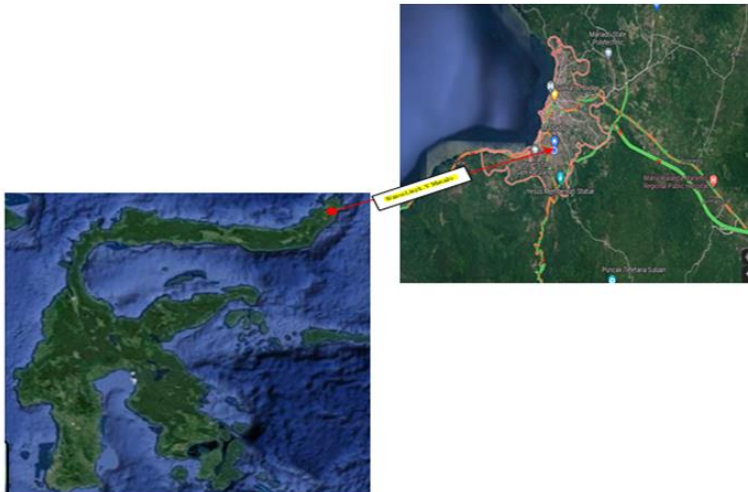
Comment [FP4]: Delete and later explain in methodology. Observation is conducted in both day and night time

50

MATERIALS AND METHODS

51 Study area

52 This study was carried out in neighborhood V of Wanea Village, Manado City, with coordinates 1°27'39" N
53 and 124°50'33" E (Figure 1) for 4 months, from April to July 2021. A total of 9 *Pteropus alecto* species
54 consisted of 2 adult males, 3 juveniles, 2 females that had never given birth, and 2 lactating ones. Furthermore, a
55 2.5-meter cage made of tasso and ram wire, with a size of 3 x 1.5 x 1.5 meters (LxWxH), was also utilized.



56

57

58 **Figure 1.** The study area was in the neighborhood V of Wanea Village, Manado City, with coordinates of 1°27'39" N, 124
59 °50'33" E.

60 Procedures

61 The preliminary observation was carried out to determine the time and type of behavioral activities exhibited
62 in the cage. During the day, these birds were observed from 06.01 to 10.00, 10.01 to 14.00, 14.01 to 18.00, and
63 at night, from 18.01 to 22.00, 22.01 to 02.00, 02.00 to 06.00. This was carried out from March to July 2021.
64 Afterward, the types of behaviors observed include agonistic, grooming, feeding, sleeping, and other activities
65 (locomotion and stationary). These were directly observed using observation sheets, CCTV, and cameras. The
66 recorded and documented data were descriptions of the duration of each observed behavioral activities. This was
67 recorded with CCTV cameras, which were re-played, examined, and recorded in the observation sheets. This
68 information was collected every 2 days during the day and at night, from 06.01 to 06.01 for 24 hours. The
69 settings were as follows, during the day, data collection was carried out by 2 students, while at night, it was
70 performed by 3 people because bats are nocturnal animals. Furthermore, the timing was intended to avoid bias
71 during observations.

Comment [FP5]: Birds or bats?

Comment [FP6]: Any literatures are referred for this method?

72 Data analysis

73 The descriptive data on the length of behavioral activities were tabulated, averaged, and presented as a
74 percentage narrative form.

75

RESULTS AND DISCUSSION

76 Feeding behavior of *Pteropus alecto* in cages

77 Before being fed, all bats perched near the cage door while making repeated sounds. After the food was
78 spread on the floor, each of them crawled quickly to the bottom to grab some with mouth and wings. Afterward,
79 it chewed the food while holding some others with its toes. The other species fed with their legs tied together
80 with wires, and their bodies leaned on the cage floor's bottom near the food. It was observed that some bats did
81 not take food from the floor, rather from those that were perched, such as bats with cubs. Based on the
82 behavioral descriptions, first, the mothers crawled to the bottom to get food while holding their cubs and
83 returned to perch and chew it while they licked the liquid that came out of its mouth. Second, they were released
84 to perch on their own, while the mothers went to the bottom of the cage to get food and returned to where they

85 were perched with their mouths close to that of their cubs. It was observed that they chewed their food severally,
 86 then expelled the waste in the form of dietary fiber, and it was noticed that they rarely drank. The feeding
 87 behavior of bats in cages is shown in Figure 2.



Comment [FP7]: Picture are numbered a, b, c and give more explanations in each number of picture. Apply for the rest of pictures that more than one

88

89 **Figure 2.** Description of feeding behavior of *Pteropus alecto* bats in cages

90 The feeding behavior of *Pteropus Alecto* species in cages was similar to those in their actual habitats.
 91 However, the location, fruit type, feeding method, form of food served, and availability were different. Besides,
 92 these nocturnal animals directly feed on fruit trees, while farmers provide food for the cultivated ones. Markus
 93 and Blackshaw (2002) reported that the feeding behavior of bats in their habitat includes chewing, licking,
 94 throwing food, and drinking water. The process of chewing produces juice extract, and the ability of the cubs to
 95 lick their mother's mouth is an act of introducing adult food (Dumont & O'neal 2004). The results of this study
 96 illustrates that bat conservation in cages does not change the feeding behavior in their habitats. The difference
 97 lies in the time and place because they search for food and fruits out of their perches.

Comment [FP8]: Natural?

98 [The feeding duration of *Pteropus alecto* species was recorded from afternoon till evening, although this
 99 activity usually occurred from 18.01 to 22.00, it consumed a lot of time, relatively 11161.4±479.4 seconds.
 100 There was no reference to the feeding time and duration, both in their habitat and those under cultivation.
 101 However, based on observations, this attribute tends to change when they are not fed at night. In addition, when
 102 they are given unlimited food (full at night), they are bound not to eat during the day, irrespective of its
 103 availability in the cage. They return to take the leftover food in the late afternoon. This illustrates that the
 104 feeding time of cultivated bats is changed to daytime. In contrast to those in their habitat, food is not available
 105 on perches, therefore they fly far in search of its sources, and this affects the timing and patterns of their feeding
 106 behavior. Schloesing et al. (2020) reported that *Pteropus lylei* species depend on experience, availability and
 107 quality of food sources, and familiarity with the habitat. Moreover, Choden et al. (2019) reported that these
 108 species fly over relatively 6.88 to 105 km at night to forage. Welbergen (2008) reported that *Pteropus alecto*
 109 species usually leave their perches in search of food starting from 17.30 to 18.00. Similarly, *Pteropus*
 110 *poliecephalus* belongs to the family of *Pteropus alecto*, with its foraging time carried out in the evenings
 111 because it depends on the weather and the presence of predators (Welbergen 2006).

Comment [FP9]: Maybe author should explain the difference between type of fruit, feeding method and form of food served, compared to the animals habits in their natural habitat. For example, why author choose particular types of fruit, or the food are served by chopping the fruit, or the whole fruit, in terms of availability maybe in cage food are always available – ad libitum etc.

112 **Agonistic behavior of *Pteropus alecto* in cages**

113 The agonistic behavior of *Pteropus alecto* species was exhibited whenever they were given food (fruits),
 114 about to mate, or awake. During the feeding procedure, the dominant ones chased and attacked the others with
 115 their claws, resulting in a fight. The chased bats continue to dodge while aiming and picking up the fruits with
 116 the help of their wings and perches far from the attacking one while eating. This behavior occurred repeatedly
 117 and stopped after they had all been fed. Meanwhile, during the mating process, it was initially observed that the
 118 male bat approaches one of the females while circling the perch and attacking its counterparts with their claws.
 119 The attacked one tend to counterattack, using its foot and claws, and this occurred severally. The female also
 120 hits back at the target, while screaming and a fight ensues, it then tries to evade by moving from one place to
 121 another and wrapping the whole body with its wings. The subsequent observed agonistic behavior relates to the
 122 male bat approaching the female from behind and then hooks its 2 wings on the back while holding that of its
 123 target and biting the neck. The female makes a sound and tries to escape from its grip, resulting in a fight.
 124 However, once released from the grip, they protect themselves by covering the entire body with their wings.
 125 Another observed agonistic behavior was the male approached the target by licking its mouth, head, body, and
 126 vagina. The female occasionally makes sounds that cause the male to pause for a moment and then continues

Comment [FP10]: How about the feeding frequency? Because in natural habitats, time for feeding is different from this study. Is this also influence the feeding behavior?

127 with licking the target's vagina while circling the female bat's perched position, still grabbed from behind,
128 which leads to copulation. This final observed agonistic activity is a fistfight that only occurs briefly.
129 Furthermore, when bats are awake, sometimes one of them moves and scratches those next to it, which reacts by
130 making a sound and clawing back at the attacker. The description of the agonistic behavior of *Pteropus alecto*
131 species in cages is shown in Figure 3.



132

133 **Figure 3.** Description of the agonistic behavior of *Pteropus alecto* in cages

134 There are no scientific reports related to the agonistic behavior of *Pteropus Alecto* species during feeding in
135 their habitat. However, their mating season is similar to the cultivated ones. Markus and Blackshaw (2002)
136 reported that this behavior in their habitat is to maintain roost areas during the mating season. The male bats
137 usually attack others to defend their partners. Welbergen (2011) reported that chasing and fighting using their
138 wings and teeth is one of the territorial behaviors of *Pteropus poliocephalus* species in their habitat.

139 The agonistic behavior of *Pteropus alecto* species associated with the males trying to mate with the females
140 was observed during the day, especially at night. Meanwhile, during the day, it often occurred from 10.01 to 14-
141 00 for 15.7±9.1 seconds, while at night, it is usually from 22.01 to 02.00, and lasted for 28.2 ±18.2 seconds.
142 Based on observations, the males actively attacked the females from March to early April, while a decline was
143 observed from May to July. The agonistic activity recorded in this study is different from that observed in the
144 habitat due to the struggle to perch, rather than the females' ability to mate, in contrast to that in the cage. No
145 scientific reports have been recorded on the agonistic activity of *Pteropus alecto* species in their habitats both
146 during the day and at night. Markus (2002) reported that initially, these birds flew in the afternoon, they marked
147 tree branches by rubbing their necks and chests during the day. The agonistic activity occurs once they return to
148 perch on the tree in the morning. Meanwhile, resident bats make sounds, chase, and fight non-resident ones
149 perched on tree branches that have been marked, and they, in turn, fly away within a duration of 16.5 ± 6.3
150 seconds. Furthermore, it was reported that their agonistic behavior during the mating season was relatively poor
151 in their habitat because the distribution of the sex ratio was quite even or the number of adult females was
152 greater than the males. This study reported that the agonistic activity of cultivated bats usually occurs during the
153 day and at night. Therefore, in terms of breeding, it is necessary to pay attention to the duration of feeding the
154 cubs and the ratio of males to females (number of males in one group). This is because, during this season, male
155 bats and breastfeeding mothers are usually active.

156 **Grooming behavior of *Pteropus alecto* in cages**

157 In accordance with the grooming behavior, it was observed that all individuals, including the mothers and
158 their cubs, nurtured themselves, using their tongues, feet, toes, and claws. These were also used to scratch the
159 face, head, teeth, back, neck, and ears. Sometimes the toes were slowly inserted into the ear canal. However,
160 when in a perched position, the tongue is repeatedly and rapidly used to lick the front of the body, starting from
161 the abdomen, chest, genitals, and wings. The stroking of the genitals by the males causes a penile erection
162 without ejaculation. The description of *Pteropus alecto* species grooming behavior in cages is shown in Figure
163 4.

164 During the observation process, grooming centered on the muzzle, face, and genitals was carried out in pairs.
165 The males performed genital grooming on the females. Meanwhile, the mothers nurtured the cubs routinely,
166 including during breastfeeding, when they were hugged. In addition, the mothers lick their heads, necks, and
167 backs repeatedly. However, the front and back of their bodies, especially the muzzle are licked when they hang

Comment [FP11]: It is better to provide the mating season. It occurs along the year, or on particular months? So we can compare with the period of this study between March and July

168 close to their mothers. The grooming behavior of *Pteropus alecto* observed in this study was similar to the
169 process observed in its habitat. Markus and Blackshaw (2002) reported this species generally engages in the
170 wing, ear, infant, and genital grooming. Markus (2002) reported that penile grooming was specially observed
171 during the mating process in its habitat. Grooming behavior is a treatment or effort to rid oneself of food
172 remnants and oil from the skin glands (Markus and Blackshaw 2002).



173

174 **Figure 4.** Description of the grooming behavior of *Pteropus alecto* in cages

175 In respect to those in cages, this process was conducted from morning to evening, although, during the day,
176 it often occurs at 14.01 to 18.00 for 1216.7 ± 179.5 seconds, while at night, it takes place from 22.01 to 02.00 for
177 1930.9 ± 387.8 seconds. Grooming activities are frequently carried out during the day, when they are awake,
178 while at night, it is performed after they have been fed before locomotion and stationary activities. The bats in
179 the cages often engage in this process in the afternoon. Nocturnal grooming activities are reportedly performed
180 at night because bats fly in the wild looking for food sources far from their perches. However, those in cages are
181 fed. Markus and Blackshaw (2002) reported that *Pteropus alecto* species perched on Indo-roopilly and Norman
182 Greeks Islands go out to forage in the late afternoons and return to their perches in the mornings. Furthermore, it
183 was stated that this activity was conducted starting in the morning and repeated throughout the day. Connell et
184 al. (2006) reported that grooming behavior in *Pteropus poliocephalus* species mainly occurred in the mornings.

185 **Sleeping behavior of *Pteropus alecto* in a cage**

186 The sleeping behavior of *Pteropus alecto* was monitored throughout the study and described thrice. First,
187 they perched on one leg, with its wings wrapped around the body and the head tucked underneath. Second, they
188 perched on 2 legs, with wings wrapped around the body, head pointing downwards, and eyes closed. The most
189 common sleeping behavior is perching on one leg with the head tucked under the wings. The initial behavior
190 was generally exhibited during the cold weather, especially at night and in the mornings, as well as when it rains
191 along with temperatures ranging from 24°C to 28°C with humidity of 98 to 80%. The second and third were
192 conducted during the hot season with temperatures ranging from 29°C to 32°C and 76 to 59% humidity. Based
193 on observations, the *Pteropus alecto*'s perching and sleeping positions never changed according to the initial,
194 back to back, juvenile bats being close to their mothers, and males being alone, occasionally. These species are
195 usually awake when there are disturbances around the cage, such as people passing. This is proven by the
196 movement of their heads and eyes while automatically shaking their ears, as shown in Figure 5. Based on this
197 study, it was reported that the sleeping behavior in the cage is similar to that on trees. Markus and Blackshaw
198 (2002), reported that this species either perches on both legs or one, with its wings wrapped throughout the
199 body, and the head tucked underneath. Furthermore, several sleeping behavioral activities are regulated by
200 weather and disturbances, and when there is a disturbance, they react by directing their gaze. During the hot
201 weather, the bats open their wings, while in the cold season, it is folded, and in addition, heavy rain stops all
202 their activities. Additionally, the distribution of *Pteropus alecto* perch in its habitat is consistent and does not
203 change according to the existing group.



204

205 **Figure 5.** Description of the sleeping behavior of *Pteropus alecto* in a cage

206 The sleeping time of those in the cage starts from 10.01 pm to 18.00. However, these nocturnal animals slept
 207 at night from 10.01 to 02.00 for 1270.6 ± 235.6 seconds and from 02.00 to 06.00 for 11513.7 ± 345.2 seconds.
 208 During this period, the bats were awake most of the time, performing certain activities such as feeding, grooming,
 209 agonistic, perching, and walking back and forth in the cage. Sleep during the day was mostly from 06.01 to
 210 10.00 for 13967.9 ± 560.9 seconds, and from 10.01 to 14.00 for 12689.4 ± 250.0 seconds. In the afternoons from
 211 14.01 to 18.00, their sleeping time decreases to reduce, to 9225.6 ± 359.1 seconds because they start to carry out
 212 other activities such as perching while grooming, being agonistic, and feeding. Most of the sleeping behavior
 213 was performed from 06.01 to 10.00 because the weather temperature ranges from 24°C to 29°C. However,
 214 towards noon, the time reduced because the temperature increased from approximately 29°C to 33°C. At this
 215 time, bats perched while opening and flapping their wings. There is no information on the duration of sleep in
 216 the habitat at night because bats usually fly at that time in search of food. In contrast to those in cages, their food
 217 was available, therefore the time for foraging was used for sleeping and other activities. There is also no
 218 information about their sleep duration in the natural habitat when perched during the day. However, Markus and
 219 Blackshaw (2002) reported that the diurnal pattern of *Pteropus alecto* is dominated by nesting, sleeping,
 220 grooming, and slight social activities, irrespective of the fact that the bats are awake for a long time during the
 221 day, although they are mostly inactive. Connell et al. (2006) reported that *Pteropus poliocephalus* species
 222 generally slept in their habitat during the day.

223 **Locomotion and stationary behavior of *Pteropus alecto* in the cage**

224 The observed stationary behavior was, first, (stretch), the bat perched, with its wings, spread wide to the left,
 225 right, and forward, and then folded backward. Second, they (wing fan) perched, with part of its wings drooping
 226 while being flapped slowly, in accordance with the movement of the head, ears, and eyes looking around the
 227 cage. Third (static flight), the bat perched while the wings were flapped rapidly for a few seconds, then folded
 228 back. The first stationary behavior is usually performed during the day and at night, while the second is usually
 229 observed during the day when the weather is hot, and the third is at night. In general, static flight is mostly
 230 practiced by cub and juvenile bats. Based on observations, the infant bats were taught to fly by their mother in a
 231 place far from the others. The cubs were hooked to the mothers' legs on a ram wire, a moment later, they flapped
 232 their wings once and touched that of the infants, which caused them to kick -flap theirs. This activity was
 233 accomplished 2 to 3 times. Afterward, they hugged their mothers again, and this activity was repeated until they
 234 were able to fly. The stationary behavior of the *Pteropus alecto* species in their habitat was also observed during
 235 cultivation, although in different places. Furthermore, the observed locomotive behavior includes the following.
 236 First, they perched on 2 legs, the head lifted straight, the wings opened, and then briefly flew around the cage.
 237 Second, bats used their feet and claws to move back and forth on the porch, crawl to the bottom, up and down
 238 through the cage rams in rapid motion. The description of the locomotion and stationary behavior of this species
 239 in cages are shown in Figure 6.



240

241 **Figure 6.** Description of locomotion and stationary behavior of *Pteropus alecto* in cages

242 The locomotion and stationary behavior generally do not involve physical contact with other bats in the
 243 cage. There are no differences between the cultivated ones and those in its habitat. Markus and Blackshaw
 244 (2002) reported that bats flapping their wings (wing fans) and opening their mouths (pant) are actions engaged
 245 in to cool their bodies during the hot weather. In addition, spreading their wings wide (stretch) is completed
 246 before they relax. The static flight was carried out to strengthen the wings and chest muscles in preparation for
 247 movement. Furthermore, in its habitat, *Pteropus alecto* performs locomotion using both legs to hold branches,
 248 drooping wings (open on the left and right), back and forth, up and downs, as well as briefly flying between
 249 trees. Locomotion (moving) and stationary (remaining at a place) behavior is an activity that involves moving
 250 from one place to another without making any physical contact with other bats, by flapping, flying, and perching
 251 while covering all or part of their bodies with its wings while shaking their heads, and opening their eyes
 252 (Markus and Blackshaw, 2002).

253 Locomotion and stationary activities of bats in cages were carried out during the day and at night. However,
 254 it was often performed at night from 10.01 to 02.00 for 9661.5 ± 389.3 seconds and from 02.01 to 06.00 for
 255 7902.7 ± 250.9 seconds (Table 1). This activity is carried out because bats are nocturnal animals and are mostly
 256 active at night. This time is used for foraging and returning to the perch in the early hours of the morning after
 257 getting food. In the cage, food is already available, therefore they engage in other activities. Locomotion and
 258 stationary activities of bats in cages at night are different from those performed during the day. At night, they
 259 move around quickly and perform motions in an active manner. At the same time, during the day, they just
 260 perch in place, awake, and move when there is internal interference from others or external factors such as
 261 exposure to sunlight. People visiting the location around the cage. These activities are different from those
 262 carried out in nature. This is because, at night, they do not stay in the perch, except for cubs that are not yet able
 263 to fly. Markus and Blackshaw (2002) reported that at night, they are left by their mothers, and they move by
 264 dragging and climbing branches, and sometimes they congregate in small groups, wrestling at close range and
 265 with their chests sticking together occasionally. Pulling wings without anyone dodging is interpreted as a play
 266 activity. Locomotion and stationary activities of *Pteropus vampirus* bats in nature have been reported by
 267 Hengyan et al. (2017), relating to the fact that they are awake and engage in various practices during the day.

268 **Duration and percentage of day and night behavioral activity of *Pteropus alecto* in a cage**

269 The percentage of day and night behavioral activity performed by *Pteropus alecto* in the cage is shown in
 270 Table 1.

271 **Table 1.** Duration and percentage of day and night behavioral activity performed by *Pteropus alecto* in cages

Behavior	Day		Night		Total Activity	
	Duration (second)	(%)	Duration (second)	(%)	Duration (second)	(%)
Feeding	2756,18	3,19	13970,21	16,17	16726,39	19,36
Agonistic	52,39	0,06	56,16	0,06	108,56	0,12
Grooming	2459,60	2,84	3088,19	3,57	5547,58	6,41
Sleeping	35882,35	41,53	12784,33	14,80	48666,68	56,33
Stationary and locomotion	2049,31	2,37	13300,91	15,39	15350,22	17,76
Total	43199,83	49,99	43199,82	49,99	86399,64	98,98

272 The activities were dominated by sleeping, feeding, stationary and locomotion, grooming, and agonistic
 273 behaviors at 56.33%, 19.36%, 17.76%, 6.41%, and 0.12%, respectively. This means that 56.33% of bats did not
 274 engage in these practices, only 43.67% did. The dominant behavior during the day was sleeping, which was
 275 performed by 41.53% of them, while at night 16.17% engaged in feeding. The least percentage of behavioral
 276 activities during the day and at night was agonistic. Grooming, stationary, and locomotion were often carried out
 277 at night. There was no comparative literature on the percentage of day and night behavioral activities performed
 278 by cultivated *Pteropus Alecto* species and those in nature. However, the percentage of daytime behavioral
 279 activities was observed in the *Cynopterus sphinx* and *Pteropus vampyrus* species. Syamsi (2013) reported that
 280 66.17% of *Cynopterus sphinx* slept during the day, followed by 21.09% that engaged in stationary and
 281 locomotion activities and 11.98% that participated in grooming. Hengyan et al. (2017) reported that the daytime
 282 activity of *Pteropus vampyrus* species in their habitat was $53.1 \pm 13.9\%$, grooming $5.7 \pm 2.3\%$, aggression
 283 $2.4 \pm 7\%$, locomotion 2.3 ± 1.6 . The percentage of agonistic illustrated that the bats have adapted to the
 284 environment and food provided in the cage because fights that caused injuries and stress rarely occurred.
 285 Therefore, the percentage of behavioral activities performed by the species in cages provides information and an
 286 initial description of the sustainable ex-situ breeding strategy.

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Comment [FP12]: Please consult the GFA to ensure that authors have applied the guidance in reference writing

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Behavior of the Black Flying Fox, *Pteropus alecto* (Chiroptera: Pteropodidae) in cages

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Abstract. Hunting and illegal trading are have become serious common thread for the Black Flying Fox in Sulawesi. On the other hand, but information on its biology and behavior as a baseline for conservation and management program is still lacking. The aim of Therefore, this study is aims to examine the behavioral activities of Black Flying Fox, *Pteropus alecto* -kept in a cages through direct observation. The results showed that bats performed the feeding behavior was carried out by descending to the bottom of the cage before picking up fruits with their mouths the mouth and wings. Furthermore, the time associated with this process ranged from 06.01 to 10.00, and while agonistic behavior performed using claws and wings, which took place from 10.01 to 14.00 in the daytime and 22.01 to 02.00 at night. Grooming behavior was done by carried out using their the tongue and wings, from 14.01 to 18.00 during the day and 22.01 to 02.00 during the night. In addition Subsequently, the bats also performed a sleeping behaviors lept by perching while closing their with the eyes closed and wrapping their the whole body wrapped with the wings from 02.01 to 10.00. Locomotion, while locomotion and stationary behaviors were performed by perching with eyes open, while and flying around the cage with their the wings spread apart from 10.01 to 14.00 during the day and 22.01 to 02.00 at night. The percentage of day and night behavior activities consist of agonistic 0.12%, grooming 6.14%, eating 19.36%, sleeping 56.33%, and stationary and locomotive 17.76%. This study increases a better. The results improve the understanding on the of *P. alecto*'s daily activities of *P. alecto* in the cage which it is are difficult to be observed observe in the wild, and provides provide insight for conservation and wildlife management. Furthermore, information from this study is useful for future bat captivity program in the next future programs.

Key words/Keywords: activity, behavior, day, night, Flying fox, *Pteropus alecto*.

Running title: The behavior of the bat in the cage.

INTRODUCTION

Bats play an ecological role in terms of maintaining forest diversity due to their the function as seed dispersers (Seltzer *et al.* 2013; Deshpande and Kelkar 2015; Lartey *et al.* 2016) and pollinators of plants which has high with high economic value (such as durian (Scarlon *et al.*, 2016; Lim *et al.* 2018; Sritongchuay *et al.* 2019; Tremlett *et al.* 2020) such as durian (Aziz *et al.* 2017; Muhammad *et al.* 2020; Low *et al.* 2021). However, they are hunted and consumed in some communities (Scheffers *et al.* 2012; Ransaleleh *et al.* 2013; Suwannorang and Schuler 2016) because they are believed due to possess the medicinal properties (Mildenstein 2016; Aziz *et al.* 2017; Low *et al.* 2021; Rocha *et al.* 2021), as well as and the ability to increase stamina (Suwannarang *et al.* 2020).

In North Sulawesi, bat bats meat (particularly flying foxes such as *Acerodon celebensis* and *Pteropus alecto*) is are imported and traded in traditional markets for consumption (Sheherazale & Susan, 2015; Latinne *et al.* 2020; Ransaleleh *et al.* 2020). Based on a survey conducted during the COVID-19 pandemic, frozen flying fox are sold in some supermarkets in cities, such as Manado, Tomohon, and Amurang, of North Sulawesi, Indonesia, Meanwhile, *P. alecto* is one of the preferred species for consumption (Ruba *et al.* 2016) due to its large body size with the percentage of carcass ranging from 45.37 to 54.07% of the total body weight (Ransaleleh *et al.* 2014). Meanwhile, but its high demand causes uncontrollable hunting in nature. According to The the IUCN Red List category and criteria, *P. alecto* is listed categorized as Least Concern means any, indicating that it is a species at low risk. However, the continuous hunting of this species which has a long reproductive cycle, once a year, with only one pup per birth. Causes might lead to a serious population decline.

The rampant hunting and selling of bats depict that the community's understanding understandi'ng of its role in the ecosystem is limited and this will likely might lead to the species extinction. Therefore, there is a need to determine its sustainability, including through approaches related to the legal status of fruit-eating bats (Maulany *et al.* 2021), its socialization in human life, and conservation efforts (Frick *et al.* 2019). Despite of biology of bats, in particular its The behavioral activities such as agonistic, grooming, sleeping, feeding, stationary, and locomotion, are provide essential

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52 information for its conservation and management (Markus & Blackshaw 2002; Hofstede & Fenton 2005; Connell *et al.*
 53 2006). ~~There~~ However, there is a lack of information and study on the behavior of flying fox bats in Indonesia. The
 54 behavioral activities exhibited by *P. alecto* in its habitat were last reported 19 years ago (Markus & Blackshaw 2002;
 55 Markus 2002), ~~which~~ and were observed during the day. ~~Complete~~ This is because a complete observation of flying fox
 56 behavior covering day and night activities in ~~their~~ the habitat is difficult to be done. Hence, consequently, observation in
 57 captivity ~~could be~~ is one of the suggested methods to. Therefore, this study ~~their~~ behavior. This study is aimed aims
 58 to observe the behavioral activities of *P. alecto* in cages during the day and at night. ~~Other than to support~~ Aside from
 59 supporting an effective wildlife management program, this study also provides information or as a pilot study to develop
 60 ~~bat~~ bats captivity which ~~never has not been done~~ carried out previously. Captivity and domestication ~~could be~~ are proposed
 61 as one of the solutions to increase ~~bat~~ bats population, a source for wildlife utilization, and overcome the threats such as bat
 62 hunting in ~~their~~ the natural habitat.

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63 **MATERIALS AND METHODS**

64 **Study area**

65 This study was carried out in neighborhood V of Wanea Village, Manado City, with coordinates 1°27'39" N and
 66 124°50'33" E (Figure 1) for four months, from April to July 2021. A total of ~~nine individuals of 9~~ *P. alecto* species
 67 ~~consisted~~ consisting of two adult males, three juveniles, two females that had never given birth, and two lactating
 68 ~~individual individuals were used~~. All ~~individual~~ subjects were kept in the 2.5-meter cage made of tasso and ram wire, with
 69 a size of 3 x 1.5 x 1.5 meters (LxWxH). ~~Meanwhile, the adult~~ ~~individual~~ subjects were rescued from the wildlife market
 70 and ~~put~~ placed in the ~~captivity~~ cage since 2011. In 2020, they were moved from the old cage ~~which was~~ made from wood to
 71 a new one, while the ~~current~~ cage. ~~Sub-adult~~ sub-adults and juveniles were born in this new cage in 2020.

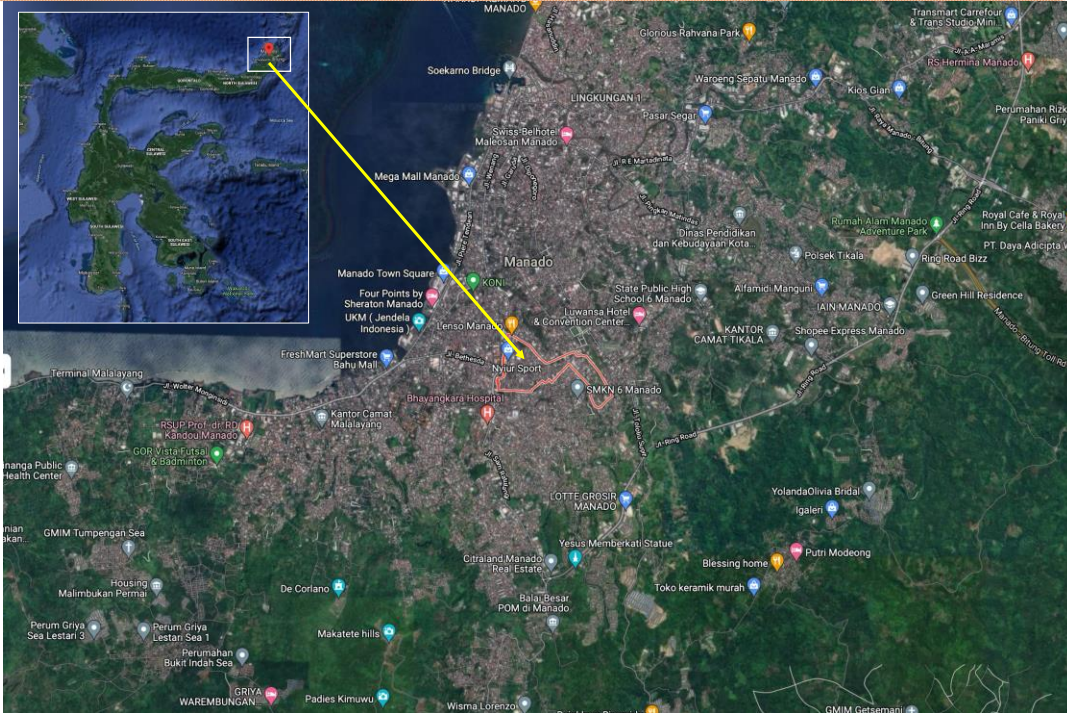
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 76 **Figure 1:** The study area was in the neighborhood V of Wanea Village, Manado City, with coordinates of 1°27'39" N, 124
 77 °50'33" E.
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Procedures

The preliminary observation was ~~carried out~~conducted to determine the time and type of behavioral activities exhibited in the cage. During the day, ~~individuals of flying fox~~the subjects were observed from 06.01 to 10.00, 10.01 to 14.00, 14.01 to 18.00, and at night, from 18.01 to 22.00, 22.01 to 02.00, 02.00 to 06.00. This was carried out from March to July 2021. ~~The and the~~ types of behaviors ~~which were~~ observed include agonistic, grooming, feeding, sleeping, and other activities ~~(such as~~ locomotion and stationary). ~~These which~~ were directly observed using observation sheets, CCTV, and cameras. The recorded and documented data were ~~the duration~~ descriptions of ~~the duration of~~ each observed behavioral ~~activities.~~ ~~Recorded activity.~~ Furthermore, the recorded activities from ~~the~~ CCTV cameras, were ~~then~~ re-played, examined, and recorded in the observation sheets. ~~Because of~~Given that there is no previous similar study, ~~we set the~~ data and information collection ~~were set consistently~~ for every two days during the day and at night, from 06.01 to 06.01 for 24 hours, throughout this study ~~consistently (method was modified from~~ (Markus and Blackshaw, 2002). Furthermore, environmental conditions including the air temperature and humidity were also recorded periodically, during the day (06.00- 10.00, 10.00-14.00, 14.00-18.00) and at night (18.00-22.00, 22.00-02.00, 02.00-06.00). During the day, data collection was carried out by two persons, while at night, it was performed by three persons to avoid bias observation since bats ~~as nocturnal animals,~~is are more active during the night.

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Data analysis

The descriptive data on ~~the flying fox~~*P. alecto* behavior including the length of activities were then tabulated, averaged, and presented as a percentage narrative form.

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RESULTS AND DISCUSSION

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Feeding behavior of *P. alecto* in cages.

Before ~~being fed~~feeding, all bats perched near the cage door while making repeated sounds. ~~After, then after~~ the food was spread on the floor, each ~~of them~~crawled down quickly to grab some with ~~the~~ mouth and wings. Afterward, they chewed the food ~~while holding~~and also held some ~~others~~with ~~its~~the toes. ~~The other individual~~Other individuals fed with ~~their~~the legs tied together with wires, and ~~their~~the bodies ~~leaned~~leaning on the cage floor near the food. It was observed that some bats did not take food from the floor, rather from those that were perched, such as bats with cubs. Based on the ~~observed~~ behavioral descriptions, first, the mothers crawled to the bottom to get food while holding ~~their~~the cubs ~~and~~, returned to perch, ~~as well as~~ chewed and ~~chew it~~ while they licked the liquid that came out of its mouth. Second, ~~they~~the cubs were released to perch ~~on their own~~separately, while the mothers went to the bottom of the cage to get food and returned to ~~where they were perched with their mouths~~ close to ~~that of their cubs.~~ It was observed that ~~they~~chewed ~~their~~the cubs. The food ~~was~~ chewed severally, then ~~expelled~~the waste in the form of dietary fiber ~~was expelled~~, and it was noticed that ~~they~~the subjects rarely drank. The feeding behavior of bats in cages is shown in Figure 2.

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Figure 2. Description of feeding behavior of *P. alecto* in the cage. (a) perch close to the cage door before feeding time, (b) take the food with their the mouth, (c) eating with physical distancing between one individual to the others, (d) eating while hanging in the cage roof, (e) eating close to the cage floor, (f) bite the fruit and move back to the perch site, (g) feeding the infant, (h) grab (steal) the food from the other individual individuals.

The feeding behavior of *P. alecto* species in cages was similar to those others in their the natural habitats. However, but the location, fruit type, feeding method, form of food served, and availability were different. Papaya (*Carica papaya*) was chosen as the main type of food during this study based on the previous observations. Based on our The preliminary observation, *P. alecto* examination showed that the subjects tend to choose chopped papaya compared to the other provided fruit fruits such as guava, water apple, and banana which were hung in the cage roof. Chopped papaya was scattered around the cage to give more options for the batbats and avoid fighting among them. Markus and Blackshaw (2002) reported that the feeding behavior of bats in their the habitat includes chewing, licking, throwing food, and drinking water. The Meanwhile, the process of chewing produces juice extract, and the ability of the cubs to lick their the mother's mouth is an act of introducing adult food (Dumont & O'neal 2004). Results of this study illustrates The results illustrate that bat the bats in cages showed show similar feeding behavior with the bat others in their the natural habitats as mentioned by Markus and Blackshaw (2002). However, but It differs on the in relation to food availability and how to get it. Food sources. In this study, the feed was always prepared in the captivity cage, while wild bats need to forage to get their own obtain food.

Bats active are nocturnal animals, hence, they are active during the night and spend most of the day time for rest and sleeping. Ad Consequently, ad libitum feeding was chosen in this study with most of the fruit was being prepared at 18.00. The feeding duration of *P. alecto* was recorded from afternoon till evening, although this activity usually occurred occurs from 18.01 to 22.00, and it consumed took a lot of long time, relatively 11161.4±479.4 seconds. There was Although there are no report or study reports on their the feeding time and duration, both in their the natural habitat and those under captivity. However, based on in the cage, the observations, carried out showed that this attribute tends to change when they are not fed at night. In addition Furthermore, when they are given unlimited the subjects were not fed with sufficient food (full at night), they are bound not to eat during the day, irrespective of its availability in the cage. They but rather return to take the leftover food in the late afternoon. This illustrates that the feeding time of the captive bats is has changed to daytime. In contrast to those in their habitat, food is not available on perches, for subjects in the natural habitat, therefore, they fly far in search of other sources, and this affects the timing and patterns of their the feeding behavior. Schloesing et al. (2020) reported that other flying fox species, *P. lylei* depend on experience, availability and quality of food sources, and as well as familiarity with the habitat. Moreover, Choden et al. (2019) reported stated that these species fly over relatively 6.88 to 105 km at night to forage, while Welbergen (2008) reported that *P. alecto* species usually leave their the perches in search of food starting from 17.30 to 18.00. Similarly, *P. poliocephalus* foraging time carried out is often in the evenings because it depends on the weather and the presence of predators (Welbergen, 2006).

Agonistic behavior of *P. alecto* in cages

The agonistic behavior of *Pteropus P. alecto* species was exhibited whenever they were given when receiving food (fruits), about to mate, or awake. During the feeding procedure, the dominant ones chased and attacked the others with their claws, resulting thereby culminating in a fight. The chased bats continue to dodge while aiming and picking up the

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150 fruits ~~with using the help of their~~ wings and perches far from the attacking one while eating. This behavior occurred
 151 repeatedly and stopped after they had all been fed. Meanwhile, during the mating process, ~~it was the male bats~~ initially
 152 ~~observed that the male bat approaches~~ ~~approache~~ one of the females while circling the perch and attacking its counterparts
 153 with ~~their~~ ~~the~~ claws. The attacked one ~~tend~~ ~~tends~~ to counterattack, using its foot and claws, and this occurred severally. The
 154 female also hits back at the target, while screaming and a fight ensues, it then tries to evade by moving from one place to
 155 another and wrapping the whole body with its wings. The subsequent observed agonistic behavior relates to the male
 156 ~~bat~~ ~~bats~~ approaching the female from behind and then ~~hook~~ ~~hooking~~ its 2 wings on the back while holding that of its target
 157 and biting the neck. The female makes a sound and tries to escape from its grip, ~~resulting in~~ ~~leading to~~ a fight. However,
 158 once released from the grip, they protect themselves by covering the entire body with ~~their~~ ~~the~~ wings. Another observed
 159 ~~agonistic~~ behavior was the male ~~approached~~ ~~approaching~~ the target by licking its mouth, head, body, and vagina. The
 160 female occasionally ~~makes~~ ~~produces~~ sounds that cause the male to pause for a moment and then continues with licking the
 161 target's vagina while circling the ~~female bat's~~ perched position, ~~still grabbed and grabbing~~ from behind, which leads to
 162 copulation. ~~This~~ ~~The~~ final observed ~~agonistic~~ activity is a fistfight that only occurs briefly. Furthermore, when bats are
 163 awake, ~~sometimes one of them~~ ~~often~~ moves and scratches ~~these~~ ~~others~~ next to it, which reacts by making a sound and
 164 clawing back at the attacker. The description of the agonistic behavior of *P. alecto* in cages is shown in Figure 3.

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 166 Figure 3. Description of the agonistic behavior of *P. alecto* in the cage. (a) chasing other ~~individual~~ ~~individuals~~ (b) fighting
 167 over the food, (c) attacking with the ~~wing to other individual~~ ~~wings~~ which move down to take the fruit, (d) fighting ~~in~~ ~~on~~ the
 168 floor, (e) male moving closer to female, (f) male attack female with the wing thumb, (g) male and female attack each
 169 other, (h) male embrace and bite the female's neck

170 There are no scientific reports related to the agonistic behavior of *P. alecto* species during feeding in ~~their~~ ~~the~~ habitat.
 171 However, ~~their~~ ~~the~~ mating season which ~~were predicted~~ ~~was suggested to be~~ from February to April (-Markus and
 172 Blackshaw, 2002), is similar to the ~~bat~~ ~~bats~~ in ~~the~~ ~~captivity~~. -Markus and Blackshaw (-2002) reported that this behavior in
 173 ~~their~~ ~~the~~ habitat is to maintain roost areas during the mating season. The male bats usually attack others to defend ~~their~~ ~~the~~
 174 partners. ~~This, this behavior was also recorded in other species of flying fox, P. poliochalus which chasing~~ ~~chases~~ and
 175 ~~fighting~~ ~~fight~~ ~~each other~~ using ~~their~~ wings and teeth to defend ~~their~~ ~~individual~~ territory (Welbergen, 2011).

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176 The agonistic behavior of *P. alecto* associated with the males trying to mate with the females was observed during the
 177 day and at night. During the day, it often occurred from 10.01 to 14-00 for 15.7±9.1 seconds, while at night, it is usually
 178 from 22.01 to 02.00, and lasted for 28.2 ±18.2 seconds. Based on ~~the~~ observations, the males actively attacked the females
 179 from March to early April, while it rarely happen from May to July. ~~The~~ ~~However, the~~ agonistic activity recorded in this
 180 study is different from that observed in the habitat due to the struggle to perch, ~~rather than the females' ability compared to~~
 181 ~~mate, in contrast to that in~~ the cage. ~~No scientific~~ ~~There are no previous~~ reports, ~~have been recorded~~ on the agonistic activity
 182 of *P. alecto* in ~~their~~ ~~the~~ natural habitats both during the day and night. Markus (2002) reported that initially, these ~~bat~~
 183 ~~flew~~ ~~bats fly~~ in the afternoon, ~~they marked~~ ~~mark~~ tree branches by rubbing ~~their~~ ~~the~~ necks and chests during the day, and the
 184 agonistic activity occurs once they return to perch on the tree in the morning. Moreover, Markus (2002) also ~~it was~~
 185 ~~observed that resident bats which is are~~ the individuals that ~~have their own roost and stay on it permanently~~ ~~stay on the~~
 186 ~~roost~~ make sounds, chase, and fight non-resident ones, ~~perched~~ ~~which perch on, the marked tree branches that have been~~
 187 ~~marked~~, and they, in turn, fly away within a duration of 16.5 ± 6.3 seconds. Furthermore, ~~it was reported that their~~ ~~the~~

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188 agonistic behavior during the mating season was relatively poor in ~~their~~the natural habitat ~~because~~due to the ~~uneven sex~~
 189 ~~ratio distribution of the sex ratio was quite even or that is,~~ the number of adult females was greater than the males. ~~This~~
 190 ~~study reported~~The results also showed that the agonistic activity of ~~captive~~ bats usually occurs during the day and at night.
 191 Therefore, in terms of breeding, ~~it~~there is ~~necessary~~a need to pay ~~serious~~ attention to the duration of feeding the cubs and
 192 the ratio of males to females, ~~(namely the number of males in one group)~~. This is because, during this season, male bats
 193 and breastfeeding mothers are usually active.

195 **Grooming behavior of *P. alecto* in cages**

196 ~~In accordance with the grooming~~Grooming behavior, ~~it was observed that is a treatment or effort to rid oneself of food~~
 197 ~~remnants and oil from the skin glands~~ (Markus and Blackshaw, 2002). Based on the observation, all individuals, including
 198 the mothers and ~~their~~the cubs, nurtured themselves, using ~~their~~the tongues, feet, toes, and claws. These were also used to
 199 scratch the face, head, teeth, back, neck, and ears. Sometimes the toes were slowly inserted into the ear canal. ~~However,~~
 200 ~~but~~ when in a perched position, the tongue is repeatedly and rapidly used to lick the front of the body, starting from the
 201 abdomen, chest, genitals, and wings. The stroking of the genitals by the males causes a penile erection without ejaculation.
 202 The grooming behavior of *P. alecto* in cages is shown in Figure 4.

203 During the observation process, grooming centered on the muzzle, face, and genitals was carried out in pairs. The
 204 males performed genital grooming on the females. ~~Meanwhile,~~ while the mothers nurtured the cubs routinely, including
 205 during breastfeeding, ~~when they were hugged. In addition by hugging.~~ Also, the mothers lick ~~their~~the heads, necks, and
 206 backs repeatedly. ~~However,~~ but the front and back of ~~their~~the bodies, especially the muzzle are licked when they
 207 ~~hang~~hanging close to ~~their~~the mothers. The grooming behavior of *P. alecto* observed in this study was similar to the
 208 process observed in its natural habitat. Markus and Blackshaw (2002) reported, ~~that~~ this species generally engages in ~~the~~
 209 wing, ear, infant, and genital grooming. ~~Furthermore,~~ Markus (2002) ~~reported~~stated that penile grooming was
 210 ~~especially~~particularly observed during the mating process in ~~its~~the natural habitat. ~~Grooming behavior is a treatment or~~
 211 ~~effort to rid oneself of food remnants and oil from the skin glands~~ (Markus and Blackshaw 2002).



212 **Figure 4.** Description of the grooming behavior of *P. alecto* in the cage. (a) wing ~~autogrooming~~auto grooming, (b) mouth
 213 and ear ~~autogrooming~~auto grooming, (c) male ~~autogrooming~~auto grooming caused the erection of its penis, (d) muzzle
 214 allogrooming, (e) vaginal allogrooming, (f) mouth allogrooming, (g) female grooming to its infant mouth, (h) female
 215 grooming to its infant mouth
 216 grooming to its infant mouth

217 ~~In respect to those in cages, this~~The grooming process was conducted from morning to evening, ~~although~~, during the
 218 day, it often occurs at 14.01 to 18.00 for 1216.7±179.5 seconds, while at night, it takes place from 22.01 to 02.00 for
 219 1930.9±387.8 seconds. Grooming activities ~~are~~were frequently carried out during the day, when ~~they are~~the subjects were
 220 awake, while at night, it ~~is~~was performed after they have been fed before locomotion and stationary activities. ~~The bats in~~
 221 ~~the cages often engage in this process in the afternoon. Nocturnal~~Meanwhile, ~~nocturnal~~ grooming activities in ~~their~~the
 222 natural habitat are reported rarely because bats emerge from ~~their~~the roost and fly to forage. ~~However,~~ those, while others
 223 in cages are fed. Markus and Blackshaw (2002) reported that *P. alecto*, ~~perched on~~found in Indooroopilly and Norman
 224 Greeks Islands go out to forage in the late afternoons and return to ~~their~~the perches in the mornings. Furthermore, it was
 225 stated that this activity ~~was conducted starting~~starts in the morning and ~~is~~repeated throughout the day. ~~This is consistent~~

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226 | with Connell et al. (2006) which reported that grooming behavior in *P. poliocephalus* species mainly occurred in the
227 | mornings.

230 | Sleeping behavior of *P. alecto* in cages.

231 | The sleeping behavior of *P. alecto* was monitored throughout the study in two ways. ~~First, first,~~ they perched on one
232 | leg, with its wings wrapped around the body and the head tucked underneath. Second, they perched on two legs, with
233 | wings wrapped around the body, head pointing downwards, and eyes closed. ~~The~~ However, the most common sleeping
234 | behavior is perching on one leg with the head tucked under the wings. The first behavior was generally exhibited during
235 | the cold weather, especially at night and in the mornings, as well as when it rains along during rainfall with temperatures
236 | ranging from 24°C to 28°C with humidity of 98 to 80%. The second— was conducted during the hot season with
237 | temperatures ranging from 29°C to 32°C and 76 to 59% humidity. Based on ~~our~~ the observations, the *P. alecto*'s perching
238 | and sleeping positions never changed according to the initial, back to back, did not change as the juvenile bats being were
239 | close to ~~their~~ the mothers, and while the males being alone were occasionally alone. This species usually awake wakes up
240 | when there are disturbances around the cage, such as people passing. This is proven by the movement of ~~their~~ the heads and
241 | eyes while automatically shaking ~~their~~ the ears, as shown in Figure 5. Based on this study, it was reported that the results,
242 | the sleeping behavior in the cage is similar to that on trees. Markus and Blackshaw (2002), reported that this species
243 | either usually perches on both legs or one, with its wings wrapped throughout the body, and the head tucked underneath.
244 | Furthermore, several the sleeping behavioral activities are were regulated by the weather and disturbances, and when there
245 | is a disturbance, they react by directing ~~their~~ the gaze. During the hot weather, the bats open ~~their~~ the wings, while in the
246 | cold season, it is folded, and in addition but when there is heavy rain stops rainfall, all their activities are stopped.
247 | Additionally, the distribution of *P. alecto* perch in its natural habitat is consistent and does not change according to the
248 | existing group.



249 | **Figure 5.** Description of the sleeping behavior of *P. alecto* in the cage. (a) sleeping in a group, hanging with one leg and
250 | cover covering the head with ~~their~~ the wing, (b) sleeping in a sub group sub-group, hanging with one leg and cover covering
251 | the head with ~~their~~ the wing, (c) sleeping alone, (d) sleeping in back to back position, (e) sleeping in a group, hanging with
252 | one leg and face the ground, (f) sleeping in a sub group sub-group, hanging with two leg and face the ground, (g) sub-adult
253 | individual sleep close to ~~their~~ the mother, (h) sleep in their own individual position

256 | The sleeping time of those for the subjects in the cage starts from 10.01 -to 18.00. ~~However, these nocturnal animals but~~
257 | they slept at night from 10.01 to 02.00 for 1270.6±235.6 seconds and from 02.00 to 06.00 for 11513.7±345.2 seconds.
258 | During this period, the bats were wake awake most of the time, performing certain activities such as feeding, grooming,
259 | agonistic, perching, and walking back and forth in the cage. Sleep during the day was mostly from 06.01 to 10.00 for
260 | 13967.9±560.9 seconds, and from 10.01 to 14.00 for 12689.4±250.0 seconds. In the afternoons from 14.01 to 18.00,
261 | their the sleeping time decreases to reduce, to 9225.6±359.1 seconds because they start to carry out other due to certain
262 | activities such as perching while, grooming, being agonistic, and feeding. Most Furthermore, most of the sleeping behavior
263 | was performed from 06.01 to 10.00 because the weather temperature ranges ranged from 24°C to 29°C. However, towards
264 | noon, the time reduced because the temperature increased from approximately 29°C -to 33°C. At this time, bats perched

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265 while opening and flapping ~~their~~the wings. There is no information on the duration of sleep in the natural habitat at night
 266 because bats usually fly at that time in search of food. ~~In contrast~~Compared to ~~those~~others in the cages, ~~their~~the food ~~was~~is
 267 usually available, therefore the time for foraging was used for sleeping and other activities. ~~There is also no information~~
 268 ~~about their sleep duration in the natural habitat when perched during the day.~~ However, Markus and Blackshaw (2002)
 269 reported that the diurnal pattern of *P. alecto* is dominated by nesting, sleeping, grooming, and slight social activities,
 270 ~~irrespective of the fact that the bats are~~despite being awake for a long time during the day, although ~~they are~~ mostly
 271 inactive. Also, Connell *et al.* (2006) reported that *P. poliocephalus* generally ~~sleeps~~sleeps in ~~their~~the habitat during the day.

272
 273 **Locomotion and stationary behavior of *P. alecto* in cages**

274 The observed stationary behavior ~~was~~is as follows, first, ~~(stretch)~~, the bat ~~perched~~bats stretch by perching with its
 275 wings, ~~spreads~~spreading wide to the left, right, and forward, and then ~~folded~~folding backward. Second, ~~(the wing fan they)~~
 276 ~~they perched~~is used by perching with part of its wings drooping while ~~being flapped~~flapping slowly, ~~in accordance with~~
 277 according to the movement of the head, ears, and eyes looking around the cage. ~~Third, (The third is static flight), bat~~
 278 ~~perched~~performed by perching while the wings were flapped rapidly for a few seconds, and then folded back. The first
 279 stationary behavior ~~is~~ usually performed during the day and at night, while the second is usually observed during the day
 280 when the weather is hot, and the third is at night. In general, the static flight is mostly practiced by cub and juvenile bats.
 281 ~~Based on observations, the infant bats that were taught~~still learning how to fly ~~by their mother in a place far~~from the
 282 ~~others~~mother. The cubs were hooked to the mothers' legs on a ram wire, a moment later, they flapped ~~their~~the wings once
 283 and touched that of the infants, ~~which caused them to kick~~ flap theirs. ~~This~~this activity was accomplished 2 to 3 times.
 284 ~~Afterward, they~~Furthermore, the infants hugged ~~their~~the mothers again, and this activity was repeated until they were able
 285 to fly. The stationary behavior of the *P. alecto* ~~in their~~the natural habitat was also observed, ~~although~~ but in different
 286 places. ~~Furthermore, the~~The observed locomotive behavior includes the following—~~First, first~~, they perched on the
 287 legs, the head lifted straight, the wings opened, and then briefly flew around the cage. Second, the bats used ~~their~~both
 288 feet and claws to move back and forth on the porch, and crawl to the bottom, up and down through the cage rams in rapid
 289 motion. The description of the locomotion and stationary behavior of this species in cages are shown in Figure 6.



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Figure 6. Description of locomotion and stationary behavior of *P. alecto* in cages (a) perch with eyes looking ahead, (b) flight preparation, (c) wings drooping while being fluttered, (d) wings spread wide, (e) infant learn to fly, (f) mother opens wings behind her infant, (g)- juvenile opens wings while others are awake, (h) perch while awake

The locomotion and stationary behavior generally do not involve physical contact with other bats in the cage. There, also, there are no differences between the captive ones and those others in its the natural habitat. Markus and Blackshaw (2002) reported that bats the flapping their of wings and opening their of mouths (*pant*) are actions engaged in to cool their bodies the body during the hot weather. In addition, while the spreading their of wings wide (stretch) is completed before they performed to relax. Furthermore, the static flight was carried out to strengthen the wings and chest muscles in preparation for movement. Furthermore, in its In the natural habitat, *P. alecto* performs locomotion using both legs to hold branches, drooping wings (which open on the left and right), back and forth, up and down down, as well as briefly flying between the trees. Locomotion (moving) and stationary (remaining at a place) behavior is an activity that involves moving from one place to another without making any physical contact with other bats, by flapping, flying, and perching while covering all or part of their bodies the body with its wings while shaking their the heads, and opening their the eyes (Markus and Blackshaw, 2002).

Locomotion and stationary activities of bats in cages were carried out during the day and at night. However, it was often performed at night from 10.01 to 02.00 for 9661.5±389.3 seconds and from 02.01 to 06.00 for 7902.7±250.9 seconds (Table 1). This activity is carried out because bats are nocturnal animals and are mostly active at night. This as this time is used for foraging and returning to the perch in the early hours of the morning after getting food. In the cage, food is already available, therefore, they engage in other activities. Locomotion However, the locomotion and stationary activities of bats in cages at night are were different from those others performed during the day. At night, they the bats move around quickly and actively perform motions in an active manner. At the same time, while during the day, they just simply perch in a place, stay awake, and move when there is internal interference from others or external factors such as exposure to sunlight. People or people visiting the location around the cage. These activities are different from those carried out in nature. This is compared to others in the natural habitat, because, at night, they do not stay in the perch, except for cubs that are not yet able to fly. Markus and Blackshaw (2002) reported that at night, they the cubs are left by their the mothers, and they move by dragging and/or climbing branches, and sometimes they congregate into form small groups, wrestling at close range and with their the chests sticking together occasionally. Pulling wings without anyone dodging is interpreted as a play activity. Locomotion Meanwhile, the locomotion and stationary activities of *P. vampyrus* bats in nature have been reported by Hengyan et al. (2017), relating to the fact which stated that they are mostly awake and engage in various practices during the day.

Duration and percentage of day and night behavioral activity of *P. alecto* in cages

Table 1: Duration and percentage of day and night behavioral activity performed by *P. alecto* in cages.

Behavior	Day		Night		Total Activity	
	Duration (second)	(%)	Duration (second)	(%)	Duration (second)	(%)
Feeding	2756,18	3,19	13970,21	16,17	16726,39	19,36

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Agonistic		52,3	0,06	56,16	-0,06	108,56	-0,12
Grooming	9		2,84	3088,19	-3,57	5547,58	-6,41
Sleeping		2459,60	41,53	12784,33	14,80	48666,68	56,33
Stationary and locomotion		35882,35	-2,37	13300,91	15,39	15350,22	17,76
Total		2049,31	49,99	43199,82	49,99	86399,64	98,98
		43199,83					

The activities of *P. alecto* were dominated by sleeping, feeding, stationary and locomotion, grooming, and as well as agonistic behaviors at 56.33%, 19.36%, 17.76%, 6.41%, and 0.12%, respectively (Table 1). This means indicates that 56.33% of bats did not engage in these practices, only while 43.67% did. The dominant behavior during the day was sleeping, which was performed by 41.53% of them, while at night 16.17% engaged in feeding. In contrast, the least percentage of behavioral activities during the day and at night were agonistic, grooming, while grooming, stationary, and locomotion were often carried out at night. There was no comparative literature on the percentage of day and night behavioral activities performed by captive *P. alecto* species and those others in nature the natural habitat. The percentage of daytime behavioral activities was observed in the *Cynopterus sphinx* and *Pteropus vampyrus* species. Syamsi (2013) reported that 66.17% of *Cynopterus sphinx* slept during the day, followed by 21.09% that engaged in stationary and locomotion activities and as well as 11.98% that participated in grooming. Furthermore, Hengyan, et al. (2017) reported that the daytime activity of *P. vampyrus* species in their the habitat was 53.1 ± 13.9%, grooming 5.7 ± 2.3%, aggression% agonistic, 2.4 ± 7.7%, locomotion, and 2.3 ± 1.6 stationary. The percentage of agonistic illustrated behavior illustrates that the bats have adapted to the environment and food provided in the cage because, consequently, fights that caused cause injuries and stress rarely occurred occur. Therefore, the percentage of behavioral activities performed by the species in cages provides information and an initial description of the sustainable ex-situ breeding strategy. Bat Based on the results, cage breeding in the captivity could be suggested as one of the solutions to provide source for bat utilisation bats utilization and reduce the threat threats, such as bat hunting in their the natural habitat. Moreover, we hope it is expected that the success story and important behavior information of obtained from flying fox in the cage can be implemented for other species of bat.

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Behavior of the Black Flying Fox, *Pteropus alecto* (Chiroptera: Pteropodidae) in cages

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Abstract. Hunting and illegal trading have become a common thread for the Black Flying Fox in Sulawesi but information on its biology and behavior as a baseline for conservation and management program is still lacking. Therefore, this study aims to examine the behavioral activities of Black Flying Fox, *Pteropus alecto* kept in cages through direct observation. The results showed that feeding was carried out by descending to the bottom of the cage before picking up fruits with the mouth and wings. Furthermore, the time associated with this process ranged from 06.01 to 10.00, while agonistic behavior performed using claws and wings took place from 10.01 to 14.00 in the daytime and 22.01 to 02.00 at night. Grooming was carried out using the tongue and wings, from 14.01 to 18.00 during the day and 22.01 to 02.00 during the night. Subsequently, the bats slept by perching with the eyes closed and the whole body wrapped with the wings from 02.01 to 10.00, while locomotion and stationary behaviors were performed by perching with eyes open and flying around the cage with the wings spread apart from 10.01 to 14.00 during the day and 22.01 to 02.00 at night. The percentage of day and night behavior activities consist of agonistic 0.12%, grooming 6.14%, eating 19.36%, sleeping 56.33%, and stationary and locomotive 17.76%. The results improve the understanding of *P. alecto's* daily activities in the cage which are difficult to observe in the wild and provide insight for conservation and wildlife management. Furthermore, information from this study is useful for future bat captivity programs.

Keywords: activity, behavior, day, night, Flying fox, *Pteropus alecto*.

Running title: The behavior of the bat in the cage

INTRODUCTION

Bats play an ecological role in maintaining forest diversity due to the function as seed dispersers (Seltzer *et al.* 2013; Deshpande and Kelkar 2015; Lartey *et al.* 2016) and pollinators of plants with high economic value such as durian (Scarlon *et al.*, 2016; Lim *et al.* 2018; Sritongchuay *et al.* 2019; Tremlett *et al.* 2020; Aziz *et al.* 2017; Muhammad *et al.* 2020; Low *et al.* 2021). However, they are hunted and consumed in some communities (Scheffers *et al.* 2012; Ransaleleh *et al.* 2013; Suwannorang and Schuler 2016) due to the medicinal properties (Mildenstein 2016; Aziz *et al.* 2017; Low *et al.* 2021; Rocha *et al.* 2021), and the ability to increase stamina (Suwannarong *et al.* 2020).

In North Sulawesi, bats meat particularly flying foxes such as *Acerodon celebensis* and *Pteropus alecto* are imported and traded in traditional markets for consumption (Sheherazale & Susan, 2015; Latinne *et al.* 2020; Ransaleleh *et al.* 2020). Based on a survey conducted during the COVID-19 pandemic, frozen flying fox are sold in some supermarkets in cities, such as Manado, Tomohon, and Amurang, of North Sulawesi, Indonesia. Meanwhile, *P. alecto* is one of the preferred species for consumption (Ruba *et al.* 2016) due to its large body size with the percentage of carcass ranging from 45.37 to 54.07% of the total body weight (Ransaleleh *et al.* 2014), but its high demand causes uncontrollable hunting. According to the IUCN Red List category and criteria, *P. alecto* is categorized as Least Concern, indicating that it is a species at low risk. However, the continuous hunting of this species which has a long reproductive cycle, once a year, with only one pup per birth might lead to a serious population decline.

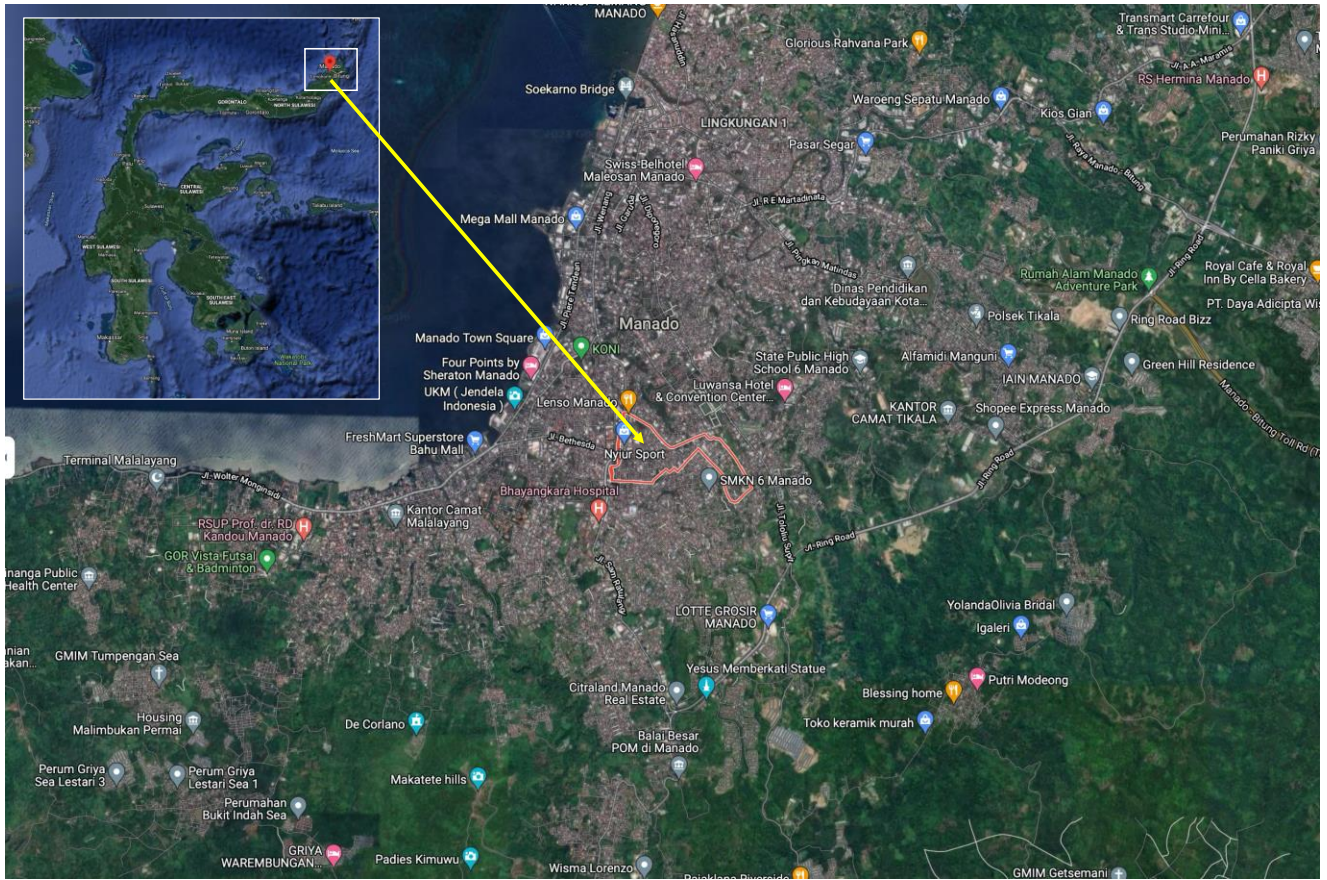
The rampant hunting and selling of bats depict that the community's understanding of its role in the ecosystem is limited and this might lead to extinction. Therefore, there is a need to determine its sustainability, through approaches related to the legal status of fruit-eating bats (Maulany *et al.* 2021), socialization in human life, and conservation efforts (Frick *et al.* 2019). The behavioral activities such as agonistic, grooming, sleeping, feeding, stationary, and locomotion provide essential information for its conservation and management (Markus & Blackshaw 2002; Hofstede & Fenton 2005; Connell *et al.* 2006). However, there is a lack of information and study on the behavior of flying fox bats in Indonesia. The behavioral activities exhibited by *P. alecto* in its habitat were reported 19 years ago (Markus & Blackshaw 2002; Markus 2002), and were observed during the day. This is because a complete observation of flying fox behavior covering day and night activities in the habitat is difficult, consequently, observation in captivity is one of the suggested methods. Therefore, this study aims to observe the behavioral activities of *P. alecto* in cages during the day and at night. Aside from supporting an effective wildlife management program, this study also provides information to develop bats captivity which has not

53 been carried out previously. Captivity and domestication are proposed as one of the solutions to increase bats population, a
54 source for wildlife utilization, and overcome the threats such as hunting in the natural habitat.

55 MATERIALS AND METHODS

56 Study area

57 This study was carried out in neighborhood V of Wanea Village, Manado City, with coordinates 1°27'39" N and
58 124°50'33" E (Figure 1) for four months, from April to July 2021. A total of 9 *P. alecto* species consisting of two adult
59 males, three juveniles, two females that had never given birth, and two lactating individuals were used. All subjects were
60 kept in the 2.5-meter cage made of tasso and ram wire, with a size of 3 x 1.5 x 1.5 meters (LxWxH). Meanwhile, the adult
61 subjects were rescued from the wildlife market and placed in the cage since 2011. In 2020, they were moved from the old
62 cage made from wood to a new one, while the sub-adults and juveniles were born in this new cage in 2020.



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67 **Figure 1:** The study area was in the neighborhood V of Wanea Village, Manado City, with coordinates of 1°27'39" N, 124
68 °50'33" E.

70 Procedures

71 The preliminary observation was conducted to determine the time and type of behavioral activities exhibited in the
72 cage. During the day, the subjects were observed from 06.01 to 10.00, 10.01 to 14.00, 14.01 to 18.00, and at night, from
73 18.01 to 22.00, 22.01 to 02.00, 02.00 to 06.00. This was carried out from March to July 2021 and the types of behaviors
74 observed include agonistic, grooming, feeding, sleeping, and other activities such as locomotion and stationary which were
75 directly observed using observation sheets, CCTV, and cameras. The recorded and documented data were the duration
76 descriptions of each observed behavioral activity. Furthermore, the recorded activities from the CCTV cameras were re-
77 played, examined, and recorded in the observation sheets. Given that there is no previous similar study, data and
78 information collection were set consistently for every two days during the day and at night, from 06.01 to 06.01 for 24
79 hours throughout this study (Markus and Blackshaw, 2002). Furthermore, environmental conditions including the air
80 temperature and humidity were also recorded periodically, during the day (06.00- 10.00, 10.00-14.00, 14.00-18.00) and at
81 night (18.00-22.00, 22.00-02.00, 02.00-06.00). During the day, data collection was carried out by two persons, while at

82 night, it was performed by three persons to avoid bias observation since bats as nocturnal animals are more active during
83 the night.
84

85 Data analysis

86 The descriptive data on *P. alecto* behavior including the length of activities were then tabulated, averaged, and
87 presented as a percentage narrative form.

88 RESULTS AND DISCUSSION

89 Feeding behavior of *P. alecto* in cages.

90 Before feeding, all bats perched near the cage door while making repeated sounds, then after the food was spread on
91 the floor, each crawled down quickly to grab some with the mouth and wings. Afterward, they chewed the food and also
92 held some with the toes. Other individuals fed with the legs tied together with wires, and the bodies leaning on the cage
93 floor near the food. It was observed that some bats did not take food from the floor, rather from those that were perched,
94 such as bats with cubs. Based on the observed behavioral descriptions, first, the mothers crawled to the bottom to get food
95 while holding the cubs, returned to perch, as well as chewed and licked the liquid that came out of its mouth. Second, the
96 cubs were released to perch separately, while the mothers went to the bottom of the cage to get food and returned to close
97 to the cubs. The food was chewed severally, then the waste in the form of dietary fiber was expelled, and it was noticed
98 that the subjects rarely drank. The feeding behavior of bats in cages is shown in Figure 2.



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Figure 2. Description of feeding behavior of *P. alecto* in the cage. (a) perch close to the cage door before feeding time, (b) take the food with the mouth, (c) eating with physical distancing between one individual to the others, (d) eating while hanging in the cage roof, (e) eating close to the cage floor, (f) bite the fruit and move back to the perch site, (g) feeding the infant, (h) grab (steal) the food from the other individuals.

105 The feeding behavior of *P. alecto* species in cages was similar to others in the natural habitats, but the location, fruit
106 type, feeding method, form of food served, and availability were different. Papaya (*Carica papaya*) was chosen as the
107 main type of food based on the previous observations. The preliminary examination showed that the subjects tend to
108 choose chopped papaya compared to other provided fruits such as guava, water apple, and banana which were hung in the
109 cage roof. Chopped papaya was scattered around the cage to give more options for the bats and avoid fighting. Markus and
110 Blackshaw (2002) reported that the feeding behavior of bats in the habitat includes chewing, licking, throwing food, and
111 drinking water. Meanwhile, the process of chewing produces juice extract, and the ability of the cubs to lick the mother's
112 mouth is an act of introducing adult food (Dumont & O'neal 2004). The results illustrate that the bats in cages show similar
113 feeding behavior with others in the natural habitats as mentioned by Markus and Blackshaw (2002), but It differs in
114 relation to food availability and sources. In this study, the feed was always prepared in the cage, while wild bats need to
115 forage to obtain food.

116 Bats are nocturnal animals, hence, they are active during the night and spend most of the day time for rest and sleeping.
117 Consequently, ad libitum feeding was chosen in this study with most of the fruit being prepared at 18.00. The feeding
118 duration was recorded from afternoon till evening, although this activity usually occurs from 18.01 to 22.00, and it took a
119 long time, relatively 11161.4 ± 479.4 seconds. Although there are no reports on the feeding time and duration, both in the
120 natural habitat and in the cage. the observations carried out showed that this attribute tends to change when they are not fed
121 at night. Furthermore, when the subjects were not fed with sufficient food (full at night), they are bound not to eat during
122 the day, irrespective of its availability in the cage but rather return to take the leftover food in the late afternoon. This
123 illustrates that the feeding time of the captive bats has changed to daytime. In contrast, food is not available on perches for
124 subjects in the natural habitat, therefore, they fly far in search of other sources, and this affects the timing and patterns of
125 the feeding behavior. Schloesing *et al.* (2020) reported that other flying fox species, *P. lylei* depend on experience,
126 availability and quality of food sources, as well as familiarity with the habitat. Moreover, Choden *et al.* (2019) stated that
127 these species fly over relatively 6.88 to 105 km at night to forage, while Welbergen (2008) reported that *P. alecto* species
128 usually leave the perches in search of food starting from 17.30 to 18.00. Similarly, *P. poliocephalus* foraging time is often
129 in the evenings because it depends on the weather and the presence of predators (Welbergen, 2006).

130 **Agonistic behavior of *P. alecto* in cages**

131 The agonistic behavior of *P. alecto* species was exhibited when receiving food (fruits), about to mate, or awake. During
132 the feeding procedure, the dominant ones chased and attacked the others with claws, thereby culminating in a fight. The
133 chased bats continue to dodge while aiming and picking up the fruits using the wings and perches far from the attacking
134 one while eating. This behavior occurred repeatedly and stopped after they had all been fed. Meanwhile, during the mating
135 process, the male bats initially approach one of the females while circling the perch and attacking its counterparts with the
136 claws. The attacked one tends to counterattack, using its foot and claws, and this occurred severally. The female also hits
137 back at the target, while screaming and a fight ensues, it then tries to evade by moving from one place to another and
138 wrapping the whole body with its wings. The subsequent observed agonistic behavior relates to the male bats approaching
139 the female from behind and then hooking its 2 wings on the back while holding that of its target and biting the neck. The
140 female makes a sound and tries to escape from its grip, leading to a fight. However, once released from the grip, they
141 protect themselves by covering the entire body with the wings. Another observed behavior was the male approaching the
142 target by licking its mouth, head, body, and vagina. The female occasionally produces sounds that cause the male to pause
143 for a moment and then continues with licking the target's vagina while circling the perched position and grabbing from
144 behind, which leads to copulation. The final observed activity is a fistfight that only occurs briefly. Furthermore, when bats
145 are awake, one often moves and scratches others next to it, which reacts by making a sound and clawing back at the
146 attacker. The description of the agonistic behavior of *P. alecto* in cages is shown in Figure 3.



147 Figure 3. Description of the agonistic behavior of *P. alecto* in the cage. (a) chasing other individuals (b) fighting over the
148 food, (c) attacking with the wings which move down to take the fruit, (d) fighting on the floor, (e) male moving closer to
149 female, (f) male attack female with the wing thumb, (g) male and female attack each other, (h) male embrace and bite the
150 female's neck
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152 There are no scientific reports related to the agonistic behavior of *P. alecto* species during feeding in the habitat.
153 However, the mating season which was suggested to be from February to April (Markus and Blackshaw, 2002), is similar

154 to the bats in captivity. Markus and Blackshaw (2002) reported that this behavior in the habitat is to maintain roost areas
155 during the mating season. The male bats usually attack others to defend the partners, this behavior was also recorded in
156 other species of flying fox, *P. poliochalus* which chases and fights each other using wings and teeth to defend individual
157 territory (Welbergen, 2011).

158 The agonistic behavior of *P. alecto* associated with the males trying to mate with the females was observed during the
159 day and at night. During the day, it often occurred from 10.01 to 14-00 for 15.7 ± 9.1 seconds, while at night, it is usually
160 from 22.01 to 02.00, and lasted for 28.2 ± 18.2 seconds. Based on the observations, the males actively attacked the females
161 from March to early April, while it rarely happen from May to July. However, the agonistic activity recorded in this study
162 is different from that observed in the habitat due to the struggle to perch compared to the cage. There are no previous
163 reports on the agonistic activity of *P. alecto* in the natural habitats both during the day and night. Markus (2002) reported
164 that initially, these bats fly in the afternoon, mark tree branches by rubbing the necks and chests during the day, and the
165 agonistic activity occurs once they return to perch on the tree in the morning. Moreover, it was observed that resident bats
166 which are the individuals that own and permanently stay on the roost make sounds, chase, and fight non-resident ones
167 which perch on the marked tree branches, and they, in turn fly away within a duration of 16.5 ± 6.3 seconds. Furthermore,
168 the agonistic behavior during the mating season was relatively poor in the natural habitat due to the uneven sex ratio
169 distribution that is, the number of adult females was greater than the males. The results also showed that the agonistic
170 activity of captive bats usually occurs during the day and at night. Therefore, in terms of breeding, there is a need to pay
171 serious attention to the duration of feeding the cubs and the ratio of males to females namely the number of males in one
172 group. This is because, during this season, male bats and breastfeeding mothers are usually active.

173 174 **Grooming behavior of *P. alecto* in cages**

175 Grooming behavior is a treatment or effort to rid oneself of food remnants and oil from the skin glands (Markus and
176 Blackshaw, 2002). Based on the observation, all individuals, including the mothers and the cubs, nurtured themselves,
177 using the tongues, feet, toes, and claws. These were also used to scratch the face, head, teeth, back, neck, and ears.
178 Sometimes the toes were slowly inserted into the ear canal, but when in a perched position, the tongue is repeatedly and
179 rapidly used to lick the front of the body, starting from the abdomen, chest, genitals, and wings. The stroking of the
180 genitals by the males causes a penile erection without ejaculation. The grooming behavior of *P. alecto* in cages is shown in
181 Figure 4.

182 During the observation process, grooming centered on the muzzle, face, and genitals was carried out in pairs. The
183 males performed genital grooming on the females, while the mothers nurtured the cubs routinely, including during
184 breastfeeding by hugging. Also, the mothers lick the heads, necks, and backs repeatedly, but the front and back of the
185 bodies, especially the muzzle are licked when hanging close to the mothers. The grooming behavior of *P. alecto* observed
186 in this study was similar to the process observed in its natural habitat. Markus and Blackshaw (2002) reported that this
187 species generally engages in wing, ear, infant, and genital grooming. Furthermore, Markus (2002) stated that penile
188 grooming was particularly observed during the mating process in the natural habitat.



189
190 Figure 4. Description of the grooming behavior of *P. alecto* in the cage. (a) wing auto grooming, (b) mouth and ear auto
191 grooming, (c) male auto grooming caused the erection of its penis, (d) muzzle allogrooming, (e) vaginal allogrooming, (f)
192 mouth allogrooming, (g) female grooming to its infant wing, (h) female grooming to its infant mouth

193 The grooming process was conducted from morning to evening, during the day, it often occurs at 14.01 to 18.00 for
 194 1216.7±179.5 seconds, while at night, it takes place from 22.01 to 02.00 for 1930.9±387.8 seconds. Grooming activities
 195 were frequently carried out during the day, when the subjects were awake, while at night, it was performed after they have
 196 been fed before locomotion and stationary activities. Meanwhile, nocturnal grooming activities in the natural habitat are
 197 reported rarely because bats emerge from the roost and fly to forage, while others in cages are fed. Markus and Blackshaw
 198 (2002) reported that *P. alecto* found in Indooroopilly and Norman Greeks Islands go out to forage in the late afternoons
 199 and return to the perches in the mornings. Furthermore, it was stated that this activity starts in the morning and is repeated
 200 throughout the day. This is consistent with Connell *et al.* (2006) which reported that grooming behavior in *P.*
 201 *poliocephalus* species mainly occurred in the mornings.
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204 **Sleeping behavior of *P. alecto* in cages.**

205 The sleeping behavior of *P. alecto* was monitored throughout the study in two ways, first, they perched on one leg,
 206 with its wings wrapped around the body and the head tucked underneath. Second, they perched on two legs, with wings
 207 wrapped around the body, head pointing downwards, and eyes closed. However, the most common sleeping behavior is
 208 perching on one leg with the head tucked under the wings. The first behavior was generally exhibited during the cold
 209 weather, especially at night and in the mornings, as well as during rainfall with temperatures ranging from 24°C to 28°C
 210 with humidity of 98 to 80%. The second was conducted during the hot season with temperatures ranging from 29°C to
 211 32°C and 76 to 59% humidity. Based on the observations, the *P. alecto*'s perching and sleeping positions did not change as
 212 the juvenile bats were close to the mothers, while the males were occasionally alone. This species usually wakes up when
 213 there are disturbances around the cage, such as people passing. This is proven by the movement of the heads and eyes
 214 while automatically shaking the ears, as shown in Figure 5. Based on the results, the sleeping behavior in the cage is
 215 similar to that on trees. Markus and Blackshaw (2002), reported that this species usually perches on both legs or one,
 216 with its wings wrapped throughout the body, and the head tucked underneath. Furthermore, the sleeping behavioral activities
 217 were regulated by the weather and when there is a disturbance, they react by directing the gaze. During hot weather, the
 218 bats open the wings, while in the cold season, it is folded, but when there is heavy rainfall, all activities are stopped.
 219 Additionally, the distribution of *P. alecto* perch in its natural habitat is consistent and does not change according to the
 220 existing group.



221 Figure 5. Description of the sleeping behavior of *P. alecto* in the cage. (a) sleeping in a group, hanging with one leg and
 222 covering the head with the wing, (b) sleeping in a sub-group, hanging with one leg and covering the head with the wing,
 223 (c) sleeping alone, (d) sleeping in back to back position, (e) sleeping in a group, hanging with one leg and face the ground,
 224 (f) sleeping in a sub-group, hanging with two leg and face the ground, (g) sub-adult individual sleep close to the mother,
 225 (h) sleep individual position
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228 The sleeping time for the subjects in the cage starts from 10.01 to 18.00 but they slept at night from 10.01 to 02.00 for
 229 1270.6±235.6 seconds and from 02.00 to 06.00 for 11513.7±345.2 seconds. During this period, the bats were awake most
 230 of the time, performing certain activities such as feeding, grooming, agonistic, perching, and walking back and forth in the
 231 cage. Sleep during the day was mostly from 06.01 to 10.00 for 13967.9±560.9 seconds, and from 10.01 to 14.00 for

232 12689.4±250.0 seconds. In the afternoons from 14.01 to 18.00, the sleeping time decreases to 9225.6±359.1 seconds due
 233 to certain activities such as perching, grooming, agonistic, and feeding. Furthermore, most of the sleeping behavior was
 234 performed from 06.01 to 10.00 because the weather temperature ranged from 24°C to 29°C. However, towards noon, the
 235 time reduced because the temperature increased from approximately 29°C to 33°C. At this time, bats perched while
 236 opening and flapping the wings. There is no information on the duration of sleep in the natural habitat at night because bats
 237 usually fly at that time in search of food. Compared to others in the cages, the food is usually available, therefore the time
 238 for foraging was used for sleeping and other activities. However, Markus and Blackshaw (2002) reported that the diurnal
 239 pattern of *P. alecto* is dominated by nesting, sleeping, grooming, and slight social activities, despite being awake for a long
 240 time during the day although mostly inactive. Also, Connell *et al.* (2006) reported that *P. poliocephalus* generally sleeps in
 241 the habitat during the day.

242
 243 **Locomotion and stationary behavior of *P. alecto* in cages**

244 The observed stationary behavior is as follows, first, the bats *stretch* by perching with its wings, spreading wide to the
 245 left, right, and forward, and then folding backward. Second, the *wing fan* is used by perching with part of its wings
 246 drooping while flapping slowly according to the movement of the head, ears, and eyes looking around the cage. The third
 247 is *static flight* performed by perching while the wings were flapped rapidly for a few seconds, and then folded back. The
 248 first stationary behavior is usually performed during the day and at night, while the second is usually observed during the
 249 day when the weather is hot, and the third is at night. In general, the static flight is mostly practiced by cub and juvenile
 250 bats that were still learning how to fly from the mother. The cubs were hooked to the mothers' legs on a ram wire, a
 251 moment later, they flapped the wings once and touched that of the infants, this activity was accomplished 2 to 3 times.
 252 Furthermore, the infants hugged the mothers again, and this activity was repeated until they were able to fly. The
 253 stationary behavior of the *P. alecto* in the natural habitat was also observed but in different places. The observed
 254 locomotive behavior includes the following, first, they perched on the two legs, the head lifted straight, the wings opened,
 255 and then briefly flew around the cage. Second, the bats used both feet and claws to move back and forth on the porch, and
 256 crawl to the bottom, up and down through the cage rams in rapid motion. The description of the locomotion and stationary
 257 behavior of this species in cages are shown in Figure 6.



258
 259 Figure 6. Description of locomotion and stationary behavior of *P. alecto* in cages (a) perch with eyes looking ahead, (b)
 260 flight preparation, (c) wings drooping while being fluttered, (d) wings spread wide, (e) infant learn to fly, (f) mother opens
 261 wings behind the infant, (g) juvenile opens wings while others are awake, (h) perch while awake
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263 The locomotion and stationary behavior generally do not involve physical contact with other bats in the cage, also,
 264 there are no differences between the captives and others in the natural habitat. Markus and Blackshaw (2002) reported that
 265 the flapping of wings and opening of mouths (*pant*) are actions engaged to cool the body during hot weather, while the
 266 spreading of wings wide (*stretch*) is performed to relax. Furthermore, the static flight was carried out to strengthen the
 267 wings and chest muscles in preparation for movement. In the natural habitat, *P. alecto* performs locomotion using both
 268 legs to hold branches, drooping wings which open on the left-right, back and forth, up-down, as well as briefly flying
 269 between the trees. Locomotion (moving) and stationary (remaining at a place) behavior is an activity that involves moving
 270 from one place to another without making any physical contact with other bats, by flapping, flying, and perching while

271 covering all or part of the body with its wings while shaking the heads, and opening the eyes (Markus and Blackshaw,
272 2002).

273 Locomotion and stationary activities of bats in cages were carried out during the day and at night. However, it was
274 often performed at night from 10.01 to 02.00 for 9661.5 ± 389.3 seconds and from 02.01 to 06.00 for 7902.7 ± 250.9 seconds
275 (Table 1). This is because bats are nocturnal animals and are mostly active at night as this time is used for foraging and
276 returning to the perch in the early hours of the morning after getting food. In the cage, food is already available, therefore,
277 they engage in other activities. However, the locomotion and stationary activities of bats in cages at night were different
278 from others performed during the day. At night, the bats move around quickly and actively perform motions, while during
279 the day, they simply perch in a place, stay awake, and move when there is internal interference from others or external
280 factors such as exposure to sunlight or people visiting the location around the cage. These activities are different compared
281 to others in the natural habitat, because, at night, they do not stay in the perch, except for cubs that are yet unable to fly.
282 Markus and Blackshaw (2002) reported that at night, the cubs are left by the mothers, and they move by dragging or
283 climbing branches and sometimes congregate to form small groups, wrestling at close range with the chests sticking
284 together occasionally. Pulling wings without anyone dodging is interpreted as a play activity. Meanwhile, the locomotion
285 and stationary activities of *P. vampyrus* bats in nature have been reported by Hengyan *et al.* (2017), which stated that they
286 are mostly awake and engage in various practices during the day.

287

288 **Duration and percentage of day and night behavioral activity of *P. alecto* in cages**

289

290 Table 1: Duration and percentage of day and night behavioral activity performed by *P. alecto* in cages.

Behavior	Day		Night		Total Activity	
	Duration (second)	(%)	Duration (second)	(%)	Duration (second)	(%)
Feeding	2756,18	3,19	13970,21	16,17	16726,39	19,36
Agonistic	52,39	0,06	56,16	0,06	108,56	0,12
Grooming	2459,60	2,84	3088,19	3,57	5547,58	6,41
Sleeping	35882,35	41,53	12784,33	14,80	48666,68	56,33
Stationary and locomotion	2049,31	2,37	13300,91	15,39	15350,22	17,76
Total	43199,83	49,99	43199,82	49,99	86399,64	98,98

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292 The activities of *P. alecto* were dominated by sleeping, feeding, stationary and locomotion, grooming, as well as
293 agonistic behaviors at 56.33%, 19.36%, 17.76%, 6.41%, and 0.12%, respectively (Table 1). This indicates that 56.33% of
294 bats did not engage in these practices, while 43.67% did. The dominant behavior during the day was sleeping, which was
295 performed by 41.53%, while at night 16.17% engaged in feeding. In contrast, the least behavioral activities during the day
296 and at night were agonistic, while grooming, stationary, and locomotion were often carried out at night. There is no
297 comparative literature on the percentage of day and night behavioral activities performed by captive *P. alecto* species and
298 others in the natural habitat. The percentage of daytime behavioral activities was observed in the *Cynopterus sphinx* and
299 *Pteropus vampyrus* species. Syamsi (2013) reported that 66.17% of *Cynopterus sphinx* slept during the day, followed by
300 21.09% that engaged in stationary and locomotion activities as well as 11.98% that participated in grooming. Furthermore,
301 Hengyan *et al.* (2017) reported that the daytime activity of *P. vampyrus* species in the habitat was $53.1 \pm 13.9\%$ grooming,
302 $5.7 \pm 2.3\%$ agonistic, $2.4 \pm 7\%$ locomotion, and 2.3 ± 1.6 stationary. The percentage of agonistic behavior illustrates that the
303 bats have adapted to the environment and food provided in the cage, consequently, fights that cause injuries and stress
304 rarely occur. Therefore, the percentage of behavioral activities performed by the species in cages provides information and
305 an initial description of the sustainable ex-situ breeding strategy. Based on the results, cage breeding is suggested as one of
306 the solutions to provide source for bats utilization and reduce threats such as hunting in the natural habitat. Moreover, it is
307 expected that the important behavior information obtained from flying fox in the cage is implemented for other species of
308 bat.

309

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We just revised our title.

Original title : “Day and Night Behavior of *Pteropus alecto* (Chiroptera: Pteropodidae) in Cages”

Corrected title : “Behavior of the Black Flying Fox, *Pteropus alecto* (Chiroptera: Pteropodidae) in Cages.”

All the comments and response, are in this table below:

Reviewer 01	Author Responses
<p><i>Abstract</i> on line 10-11</p> <p>Please consult the Guideline for Author – GFA to ensure a format of abstract</p>	<p>The abstract has been corrected according to the guide.</p>
<p><i>Introduction</i></p> <p><i>Line 34</i></p> <p>Not clear, % or gr/kg. Percentage of consumed meat from a total body weight? Or what?</p> <p><i>line 48</i></p> <p>Delete and later explain in methodology. Observation is conducted in both day and night time</p>	<p>I have corrected the sentence that is. The sentence should be ” due to its large body size with the percentage of carcass ranging from of 45.37 to 54.07% of the total body weight.</p> <p>Action has been taken following the suggestion form the reviewer.</p>
<p><i>Procedures</i></p> <p><i>Line 62</i></p> <p>Birds or bats?</p> <p><i>Line 68</i></p> <p>Any literatures are referred for this method?</p>	<p>Sentence has been revised Change : bird to flying fox</p> <p>Literature has been added (Method was modified from Markus and Blackshaw,2002).</p>
<p><i>Result and discussion</i></p> <p>Picture are numbered a, b, c and give more explanations in each number of picture. Apply for the rest of pictures that more than one</p> <p><i>Line 90</i></p> <p>Natural?</p> <p>Maybe author should explain the difference between type of fruit, feeding method and form of food served, compared to the animals habits in their natural habitat. For example, why author choose particular types of</p>	<p>Action has been taken following the reviewer suggestion. All pictures have been numbered along with explanations</p> <p>Change : “ actual to natural”</p> <p>Explanations have been added.</p>

<p>fruit, or the food are served by chopping the fruit, or the whole fruit, in terms of availability maybe in cage food are always available – ad libitum etc.</p> <p>How about the feeding frequency? Because in natural habitats, time for feeding is different from this study. Is this also influence the feeding behavior?</p> <p>It is better to provide the mating season. It occurs along the year, or on particular moths? So we can compare with the period of this study between March and July</p>	
<p><i>References</i></p> <p><i>Line 293-295</i></p> <p>Please consult the GFA to ensure that authors have applied the guidance in reference writing</p>	<p>The reference has been corrected according to the guide</p>
<p>Reviewer 02</p>	<p>Author Responses</p>
<p>Line 1-2 Title</p>	<p>Action has been taken. Title has been modified</p>
<p><i>Line 19-20 (Abstract)</i></p> <p>Importance of the study for conservation and future captivity program</p>	<p>Action has been taken. Adding the importance of this study in abstract</p>
<p><i>Line 23-29</i></p> <p>Revise the paragraph</p>	<p>Action has been taken. First paragraph of the Introduction section has been revised.</p>
<p><i>Line 41-48</i></p> <p>Rewrite the paragraph: explain the urgency of the study related to the conservation, reducing the bat hunting. Furthermore how the behavioral study of bat captivity could be used in the context of wildlife population and conservation.</p>	<p>Action has been taken. Paragraph has been revised following the suggestion from Reviewer.</p>
<p><i>Line 54</i></p> <p>Where these individuals were obtained? From the wild or been captivated for some period. Is this an experimental study where all conditions set</p>	<p>Action has been taken</p>

<p>up or the captivity was already built?</p> <p>A little bit history of this will provide a background on existing behavior of the bats living in the captive. This will affect on the habits build by the bat if the captive period is longer.</p>	<p>Information about the studied individuals and captivity have been added.</p>								
<p><i>Line 59</i></p> <p>A better map probably better with the north Sulawesi as an insert not only projected as a dot, the map of study area should be bigger than the insert of Sulawesi island</p>	<p>Action has been taken. Map has been revised.</p>								
<p><i>Line 60</i></p> <p>Parameter's measured should be mentioned. What do you want to examine? For examples:</p> <ol style="list-style-type: none"> 1. Behavioural activities of bats in captive: type of behaviour's observed, length of each activity, frequency of activities 	<p>Measured parameters have been explained in this paragraph.</p>								
<p><i>Line 64</i></p> <p>Only type of activities? How about the time devoted for each activity? How do you observe?because there are 9 individuals in the cage? Is it scanning methods or</p>	<p>Action has been taken. How the observation been done has been explained, including the time (and duration) of observation and the use of CCTV (Camera recording).</p>								
<p><i>Line 69</i></p> <p>I think it is not necessary to mention that students were the one who collecting your data</p>	<p>Action has been taken. Student was changed with person.</p>								
<p><i>Line 75</i></p> <p>Maybe prior to feeding behaviour, it is better to provide explanation on what kind of activities involve during the observation in the captive set? if the feeding depending on human food provision, then explain on how many times for daily feeding time, what kind of food provided and what time. Then explain on feeding, what kind of common behaviour during the observation.</p> <p>Why there is no data on time required for each activity? Accompanied by a descriptive table on each behaviour made during feeding so it will be easier for the reader to grasp the results of this study along with the figures.</p> <p>Feeding behaviour</p> <table border="1" data-bbox="185 1871 787 1898"> <thead> <tr> <th>No.</th> <th>Behaviour</th> <th>Description</th> <th>Time</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table>	No.	Behaviour	Description	Time					<p>Action has been taken. Activities prior to feeding behavior, how many time of daily feeding, type of food (fruit) have been added.</p> <p>Moreover, we prefer to present our data as a descriptive style (not in table) and continued with the discussion.</p>
No.	Behaviour	Description	Time						

<p>Figure</p> <p>1. Beginning of Feeding time</p> <p>of behaviour all bats perching near the cage</p> <p>(second) 30</p>	
<p><i>Line 98</i></p> <p>How different? In time for example between wild and captive set? As there is no data shown in the results on time, therefore, it is best to present your data as suggested above.</p>	<p>Action has been taken. The differences of how the bat in captivity and wild bat getting the food have been added.</p>
<p><i>Line 114</i></p> <p>Agonistic behaviour in feeding especially in a cage occurred due to competition in getting food.</p> <p>Is there any influences of the cage size towards the agonistic behaviour?</p> <p>It is actually interesting to see if we make an experiment on the methods of feeding such as provide the food in the same time with larger amount so competition will be lesser and see whether this reduced agonistic behavior</p>	<p>Thank you for the suggestion from reviewer 2. Up till now, these suggestions were not covered in the scope of the current presented study, however it will be considered in our next study of bat in the captivity.</p>
<p><i>Line 136</i></p> <p>Captive?</p>	<p>Action has been taken. Change the “cultivated ones” with “ bat in the captivity”</p>
<p><i>Line 139</i></p> <p>Is this also used as an assumption for Pteropus alecto?</p>	<p>Action has been taken. More explanation has been added.</p>
<p><i>Line 143</i></p> <p>History on how long the animals have been in captive, because the longer the captive time, the lesser stress will be created as they have been adapte</p>	<p>History of the studied individuals has been mentioned and explained in the revised Material and Method section</p>
<p><i>Line 149</i></p> <p>What is resident bat and non-resident bat? there should be an explanation in the method perhaps on these two and also history of the captivity</p>	<p>Action has been taken An explanation about the resident – non-resident bats has been added</p>
<p><i>Line 192</i></p> <p>There were no environment conditions measurement written in the method. Please cross check</p>	<p>Action has been taken. Measurement of the environmental conditions has been added to the Material and Method section.</p>

<p><i>Line 207</i></p> <p>Does this mean from 10 pm at night until 6pm in the evening</p> <p><i>Line 207-208</i></p> <p>Do not understand. Previously mentioned from 10 pm at nite til 6 pm in the evening but in this sentence there are no clear time division. Please use time indicator</p>	<p>Action has been taken. Time division has been changed</p> <p>Action has been taken. Time division has been changed in the first sentence of this paragraph.</p>
<p><i>Line 245</i></p> <p>Captive?</p>	<p>Action has been taken. Sentence has been revised</p>
<p><i>Line 272</i></p> <p>Are there any differences in these behavior at individual's level?</p>	<p>Detail individual behavior has not been included in the Table 1 which present the behavioral activity were performed by all individuals in the cage. However, information about individual activity were mentioned in the discussion descriptively.</p>
<p><i>Line 287</i></p> <p>A conclusion on how the behavior of the species in the captive set is required. There should be a link between the findings and how this could contribute towards the conservation of the bats are also needed – to answer the urgency of this study as been mentioned in the introduction.</p>	<p>Cation has been taken. Revised conclusion has been added to the last paragraph.</p>
<p><i>Line 293</i></p> <p>Please check again and re-write the references According to the jour</p>	<p>Action has been taken. Typos have been checked and revised.</p>