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A PRELIMINARY STUDY ON THE FEEDING ECOLOGY OF SULAWESI SAILFIN LIZARD (Hydrosaurus celebensis) IN BANTIMURUNG BULUSARAUNG NATIONAL PARK

ANDI SIADY HAMZAH[*)], PUTU OKAN NGAKAN, AMRAN ACHMAD AND NASRI NASRI

Forest Conservation Study Program, Faculty of Forestry, Hasanuddin University, Makassar, 90245, Indonesia

**Email: siadyhamzah@unhas.ac.id*

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ABSTRACT

The sailfin lizard (Hydrosaurus celebensis) is a unique reptile species whose population may be threatened by habitat destruction as well as local and global trade. As an anticipation of extinction, sufficient ecological information is required to support its conservation efforts. On the other hand, information on its ecology is still limited. The aim of this study was to collect information on its feeding ecology. This study was conducted for 78 days from June to August 2022. Direct observations were made on sailfin lizards to determine when they started feeding and the species of plants and animals consumed. To determine the availability of forage plants, we set up 22 10 x10 m plots with 5 x 5 m subplots. The results showed that the sailfin lizard started to forage at noon. They ate more plants than animals. There were 18 plant species and 7 animal species eaten by sailfin lizards. Codiaeum variegatum, which had the largest canopy cover area, was the most prevalent species of forage plant. In general, it is also relatively abundant for animal feed. Ficus hispida and Davalia trichomanoides are the two forage plant species that are most frequently consumed out of the total of 18. One species, the river crab (Gecarcinucoidea), was the only one of the seven species of animal source that was frequently consumed.

Key words: *Sailfin lizard, Hydrosaurus, feeding ecology*

INTRODUCTION

The Sailfin Lizard is a semi-aquatic lizard of the Genus Hydrosaurus with unique fin characteristic at the upper part of its tail. The presence of these fins, especially in males, looks very conspicuous. This omnivorous lizard from the Agamidae is one of the largest lizards in the world with a length that can reach more than 1 m (Whitten et al., 1987; Denzer et al, 2020). Their unique shape causes sailfin lizards to be hunted for trade as pets (Ledesma et al. 2009; Siller et al., 2013; Heinrich et al., 2021).

Five species of sailfin lizard (*H. pustulatus, H. amboinensis, H. weberi, H. microlopus* and *H. celebensis*) are distributed in Asia (Siller et al., 2013; Denzer et al., 2020). Especially, four species can be found in Indonesia (*H. amboinensis, H. weberi, H. microlopus* and *H. celebensis*) (Denzer et al, 2020) and *H. weberi* is already vulnerable in the wild (IUCN, 2022). Due to their attractive shape, sailfin lizards are now starting to be in great demand by collectors of exotic animals. Sailfin lizard is exploited through the domestic and international pet trade (Gaulke, 1998; Siller et al., 2013; Welton et al., 2013a, 2013b; Heinrich et al., 2021) and potentially be hunted excessively in the future.

Although it is known that sailfin lizards are distributed on several islands such as Sulawesi, Halmahera and Ambon, the distribution of *H. celebensis* species is quite limited in Sulawesi (Supriatna and Hedberg, 1998; Denzer et al, 2020). This species can only be found in some areas in South Sulawesi (Siller et al., 2013; Denzer et al, 2020), mostly occurs along riverbanks with vegetation. Threats of habitat destruction occurs due to its narrow choice of particular habitat for their life. For example, the sailfin lizard in the Philippines (*H. pustulatus*), according to the International Union for Conservation of Nature (IUCN) (2022) is currently experiencing a population decline and has been categorized as vulnerable due to habitat destruction. Additionally, sailfin lizard habitats will be highly vulnerable to disruption by human activitie either by the development of human settlements around the river or development of tourist destinations, such as in Bantimurung Bulusarung National Park. Development and local activities in the sailfin lizard habitat will undoubtedly have an impact on the population by destroying their habitat, either directly or indirectly. Reptiles are sensitive and vulnerable to environmental change and habitat disturbance (Mohagan et al., 2019).

Habitat has the function of providing food, water and protection (Pinotti et al., 2012). Each reptile species will respond differently when there is a change in habitat conditions (Mohagan et al., 2019). For example, the conversion of natural forests to plantations will reduce reptile populations (Kanowski et al., 2006). Good habitat conditions will greatly support the sustainability of the existence of sailfin lizards in nature.

The availability of food will be impacted by habitat destruction (Kidegesho et al, 2006). On the other hand, there is still quite limited information about feeding habit of this species. No particular information about the feeding ecology of this species has been mentioned in any of the current literature. To prevent a population decline or species extinction, we conducted a study on the feeding ecology of the sailfin lizard (*H. celebensis*) to observe the behavior and type of food consumed in the wild. This study is essential to provide information for

future conservation, captive breeding, and culture of these species in addition to anticipating their extinction.

RESEARCH METHOD

Study was conducted at Bantimurung Bulusauraung National Park in South Sulawesi during dry season (Figure 1). We collected all the data on the field for 78 days, started on June 15th and finished on August 31st 2022. To find out the weather condition (rainfall, maximum and minimum temperatures) as long as the observations process in the sailfin lizard's habitat, we collected data from the Meteorology, Climatology and Geophysics Agency Region IV Makassar.

We directly observed the sailfin lizard (*H. celebensis*) by following them and recording their activities from 06.00 am to 18.00 pm in their habitat, which is a forested area along the right and left sides of the Pattunuang River in Samangki Village, within the Bantimurung Bulusaraung National Park area. We used a binocular and a Canon DSLR D500 camera with a 250 mm telephoto lens to observe the sailfin lizards.

In order to get close to the sailfin lizard, we habituated 2 adult individuals (male and female) (Figure 2) for 14 days. It is necessary to do habituation to collect detailed behavioural information on the study subjects (Blumstein, 2016; Moszuti et al., 2017; Kundey and Phillips, 2021).

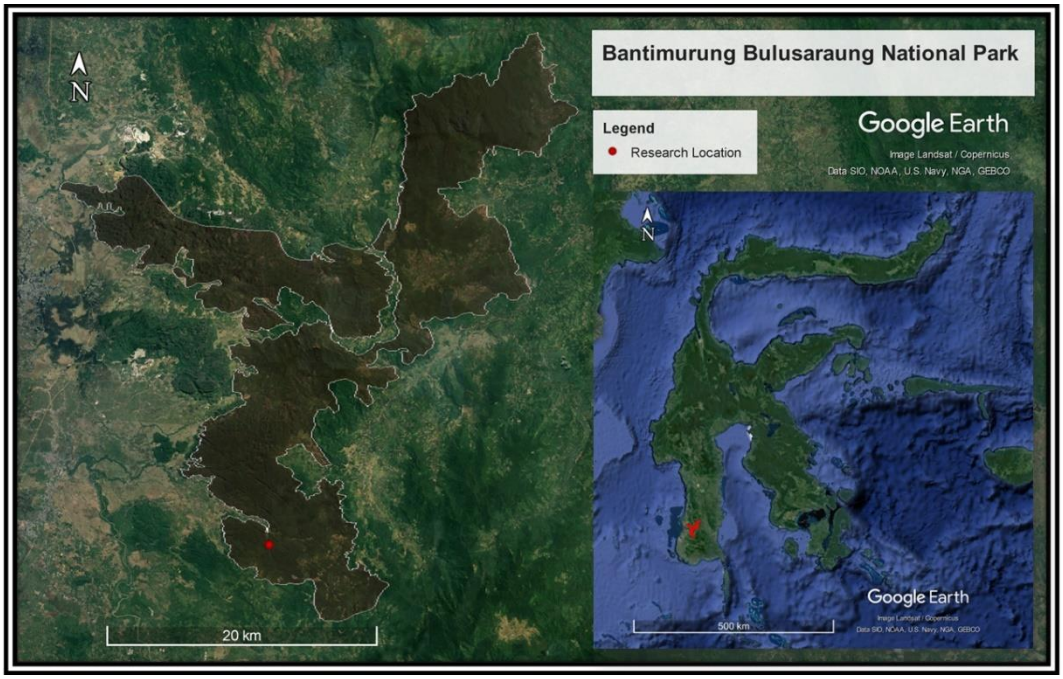

Figure 1. Research Location in Bantimurung Bulusaraung National Park

Figure 2. Adults of sailfin lizard (*H. celebensis*). a: Male of *H. celebensis*, b: Female of *H. celebensis*

Unlike other wildlife, these lizards tend not to shy away from our presence. We spotted the lizards from 7 to 10 meters away. After they got used to our presence, we started to collect the data by observing and recording their foraging activities. During the habituation, we knew that the sailfin lizards always come out from their nest to do basking first in the morning. They will start to move and look for food after basking. We followed and recorded time of activity, and the species of plants and small animals that sailfin lizards consumed. We observed their feeding behavior for 27 days.

All unknown species of food plants were collected and preserved as herbarium for identification. We also collected unknown species of prey to identify them. All samples were identified in the Forest Conservation and Ecotourism Laboratory of Hasanuddin University. Based on the result of the feeding habit, we conducted vegetation survey to observe the abundance of sailfin lizard plant-based food. In the forage area of sailfin lizard, we put 22 plots of 10 m x 10 m on the right and left banks of the river. Inside 10 m x 10 m, we constructed a 5 m x 5 m sub-plot. This allowed us to observe the availability of plant-based food. We recorded the availability of shrubs, lianas, and trees in the 10 m × 10 m plot. Meanwhile, understory (herbs) species were observed in the 5 m × 5 m sub-plot. The diameter of the canopy of each species in the plot was measured in order to determine the abundance of plant-based food.

We figured the abundance of prey from the ease with which lizards find prey by the following criteria: (a) Abundant if there are many available forage small animals near the sailfin lizards, but not all of them are consumed by sailfin lizards, (b) Moderate if the sailfin lizard consumes all of the available food, although it does not require a lot of time to find prey, (c) Rarely if the sailfin lizard spends a lot of time pursuing little animals and seldom find its prey.

All data collected were processed and presented in tabular and diagram especially for analyzing frequency and abundance of food materials. The formulas used in data processing are:

Frequency of forage plant:

$$\frac{\text{Number of plots found for a species of forage plant}}{\text{Total number of Plots}} \times 100\%,$$

The area of the canopy cover of forage plant = ¼ π d^2, Where d is diameter of the crown of a species.

RESULT AND DISCUSSION

1. *Food Composition and Food Preference*

The main habitat of the sailfin lizard is usually around a vegetated riverbank. flow. The foraging area of this species is a forested valley of karst hills, mostly is the riverbank. Sailfin lizards are omnivorous and eat small plants and animals it its foraging area, from noon to late afternoon. They begin to eat from 12.00 noon until close to 18.00 pm. The sailfin lizards eat more plants than small animals (Figure 3) and in general, they eat plants first and later small animals. However, we observed that they might choose to ate animals in one day without eating plants, especially when prey is abundant.

We recorded 18 species of plants consumed by sailfin lizards (Table 1), which belong to the family of Acanthaceae, Araceae, Euphorbiaceae, Leeaceae, Moraceae, Polypodiacea, Zingiberaceae, and Vitaceae. Of all edible plants, Ficus *sp*. From the Moraceae family (especially *Ficus hispida*), has the highest frequency of plant chosen by sailfin lizards. The part of the Ficus species that is eaten is not only the leaves but also the fruits. In addition, the species of plants that are also abundant and often eaten by sailfin lizards are plant species from the Polypodiaceae family, especially *D. trichomanoides* while the other 10 species were generally rarely eaten.

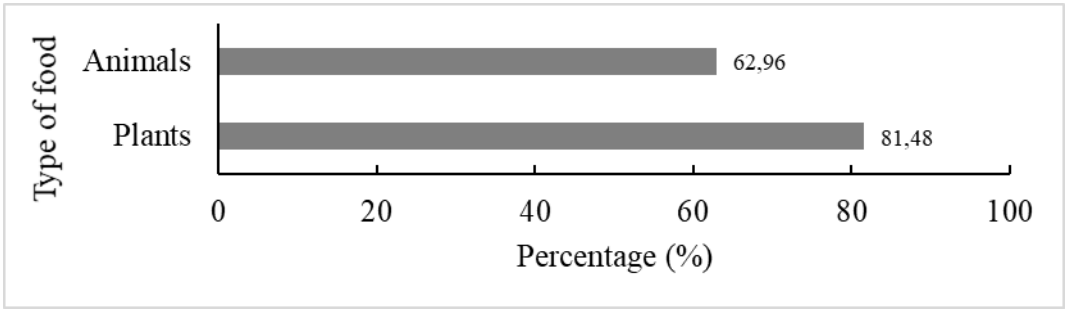

Figure 3. The percentage of Plants and Animals eaten by sailfin lizards

Sailfin lizards ate small insects, millipede and crab (Table 2). At least 5 species of insects from the Family Acrididae, Chrysomelidae, Mantidae, Libellulidae and Papilionidae were consumed, whereas the others are the millipede *Anadenobolus* sp. and freshwater decapod *Parathelphusa* sp. These species of animals are found in along the river. Sailfin lizards tend to choose animals that are rather large and easy to catch. Crab (*Parathelphusa* sp.) has the highest frequency of prey chosen by sailfin lizard, followed by grasshoppers (*Aiolopus* sp.). Other species that were eaten quite often were dragonflies (*Orthetrum serapia*), while leaf beetles (*Taumacera* sp.) were rarely eaten. The other three species, i.e. praying mantis (*Pseudomantis* sp.), millipede (*Anadenobolus* sp.) and *Graphium milon* were very rarely eaten by sailfin lizards.

To get prey, sailfin lizards must hunt. They generally started to hunt in the afternoon. They will choose a rocky area on the edge of the river as a hunting area and do not look active when hunting for food animals. They were mostly sit-and-wait (ambush) foragers, always seeming to be silent and waiting while watching their surroundings. When a small animal stops nearby, the sailfin lizards immediately ambush the prey quickly.

Table 1 Species of forage plants and the edible parts of plants

No.	Family	Species	Edible Part	Feeding frequency
1	Acanthaceae	*Lepidagathis* sp.	Leaf	2
2	Acanthaceae	*Staurogyne* sp.	Leaf	3
3	Araceae	*Arenga pinnata*	Fruit	1
4	Araceae	*Schismatoglottis calyptrata*	Leaf	1
5	Euphorbiaceae	*Codiaeum variegatum*	Leaf	3
6	Euphorbiaceae	*Codiaeum* sp.	Leaf and Fruit	1
7	Leeaceae	*Leea indica*	Leaf	1
8	Moraceae	*Ficus lawesii*	Leaf and Fruit	3
9	Moraceae	*Ficus* sp.	Leaf	1
10	Moraceae	*Ficus hispida*	Leaf	5
11	Moraceae	*Ficus pisifera*	Leaf and Fruit	1
12	Moraceae	*Ficus copiosa*	Leaf	1
13	Myrtaceae	*Syzygium acuminatissimum*	Leaf and Fruit	1
14	Polypodiaceae	*Drynaria sparsisora*	Leaf	1
15	Polypodiaceae	*Davallia trichomanoides*	Leaf	4
16	Polypodiaceae	*Microsorum* sp.	Leaf	2
17	Zingiberaceae	*Amomum* sp	Leaf	1
18	Vitaceae	*Tetrastigma lanceolarium*	Leaf	3

Figure 4. A female sailfin lizard was eating leaves of *Ficus* sp.

Table 2. List of animal species eaten by sailfin lizard during observation

No.	Species/Common name	Ordo	Family	Feeding Frequency
1	*Aiolopus* sp.	Orthoptera	Acrididae	6
2	*Taumacera* sp.	Coleoptera	Chrysomelidae	2
3	*Pseudomantis* sp.	Orthoptera	Mantidae	1
4	*Anadenobolus* sp.	Chourdeumida	Rhinocricidae	1
5	*Orthetrum serapia*	Odonata	Libellulidae	4
6	*Graphium milon*	Lepidoptera	Papilionidae	1
7	*Parathelphusa* sp.	Decapoda	Gecarcinucidea	8

2. *Food abundance*

Area of canopy cover varied from 0.4 m^2 to 78.5 m^2. The average canopy cover of per plot was less than 22.4 m^2 and most of plot has canopy cover below 10 m^2. Of the 18 species of forage plants, only 5 species have a frequency above 50%, the rest less than 50% (Figure 5). The level of canopy cover for forage plants is largely determined by the growth form of the tree. Plants with tree growth forms have a larger canopy cover area than poles and saplings. Shrubs that grow in clumps such as *Codiaeum variegatum* also have a larger canopy cover area than other solitary species.

Sailfin lizards ate mostly small animal that typically abundant in the wild (Table 3) i.e. *Aiolopus* sp., *Taumacera* sp., *Anadenobolus* sp, *Orthetrum serapia* and *Graphium milon*. While the availability of the other two species—*Pseudomantis* sp. and *Parathelphusa* sp.—was only moderate

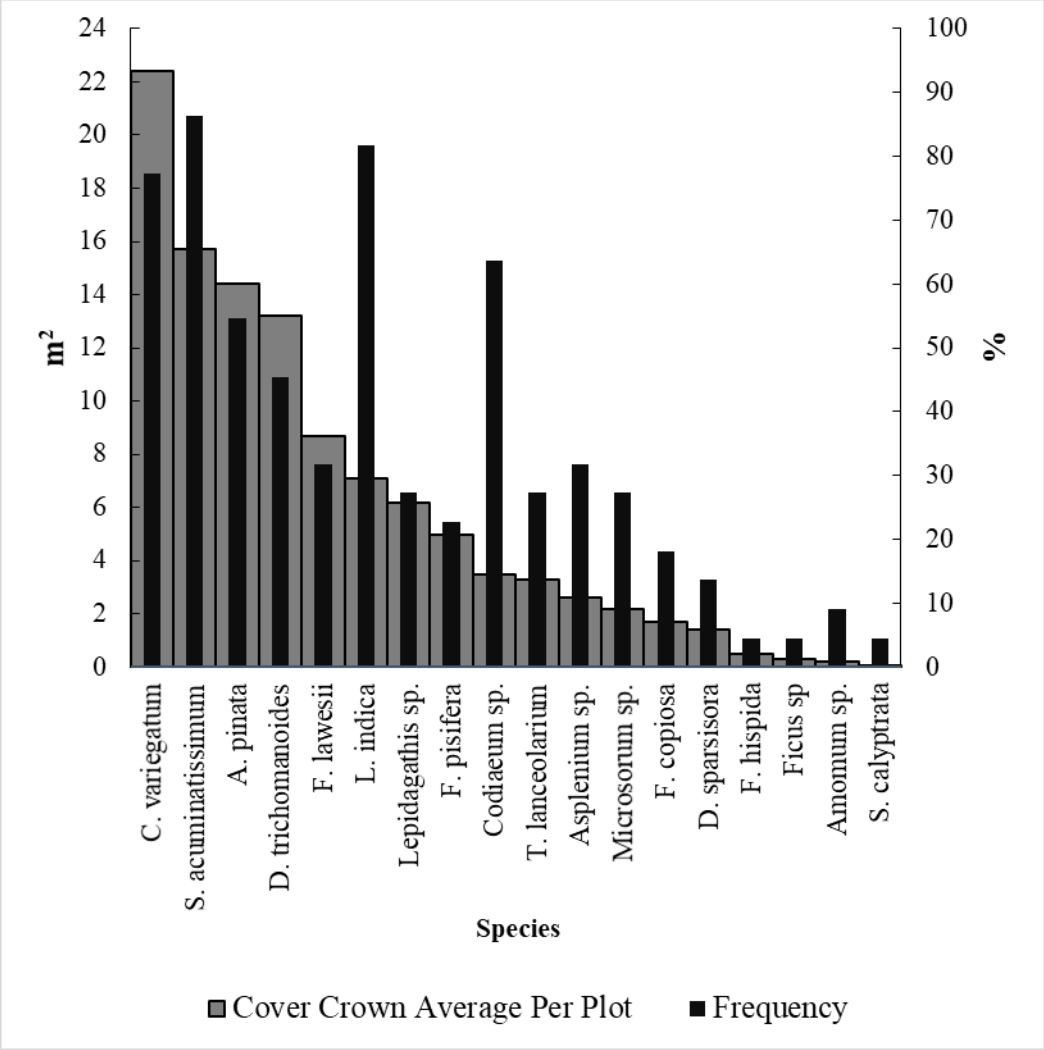

Figure 5. Average Abundance and Presence Frequency of each feed species.

Table 3. The abundance of feed animals

No	Species/Common name	Ordo	Family	Abundancy
1	*Aiolopus* sp.	Orthoptera	Acrididae	Abundant
2	*Taumacera* sp.	Coleoptera	Chrysomelidae	Abundant
3	*Pseudomantis* sp.	Orthoptera	Mantidae	Moderate
4	*Anadenobolus* sp.	Spirobolida	Rhinocricidae	Abundant
5	*Orthetrum serapia*	Odonata	Libellulidae	Abundant
6	*Graphium milon*	Lepidoptera	Papilionidae	Abundant
7	*Parathelphusa* sp.	Decapoda	Gecarcinucidea	Moderate

3. Feeding Time

Like other Agamidae reptiles in general, sailfin lizard are cold-blooded reptiles and are active during the day (diurnal). Its body temperature depends on its environment. The reptiles perform a basking mechanism to regulate their body temperature before doing some activities (Figure 6).

Based on the observation of two individuals of sailfin lizards, basking were conducted in the morning from 07.00 until 12.00 on the rocks by the river or tree trunks with sufficient sunlight. Later on, feeding start around 12.00 noon until 18.00 (Figure 7).

Twenty-seven observations showed that sailfin lizards ate mostly plants than animals. They can eat some plants and animals in one day (Figure 7). They ate plants first then animals. On the other hand, in several observations, if they cannot find prey easily, they just ate plants. On the contrary, if they can find prey easily, they can consume animals only in a day.

Figure 6. Sailfin lizards were basking (a: male; b: female)

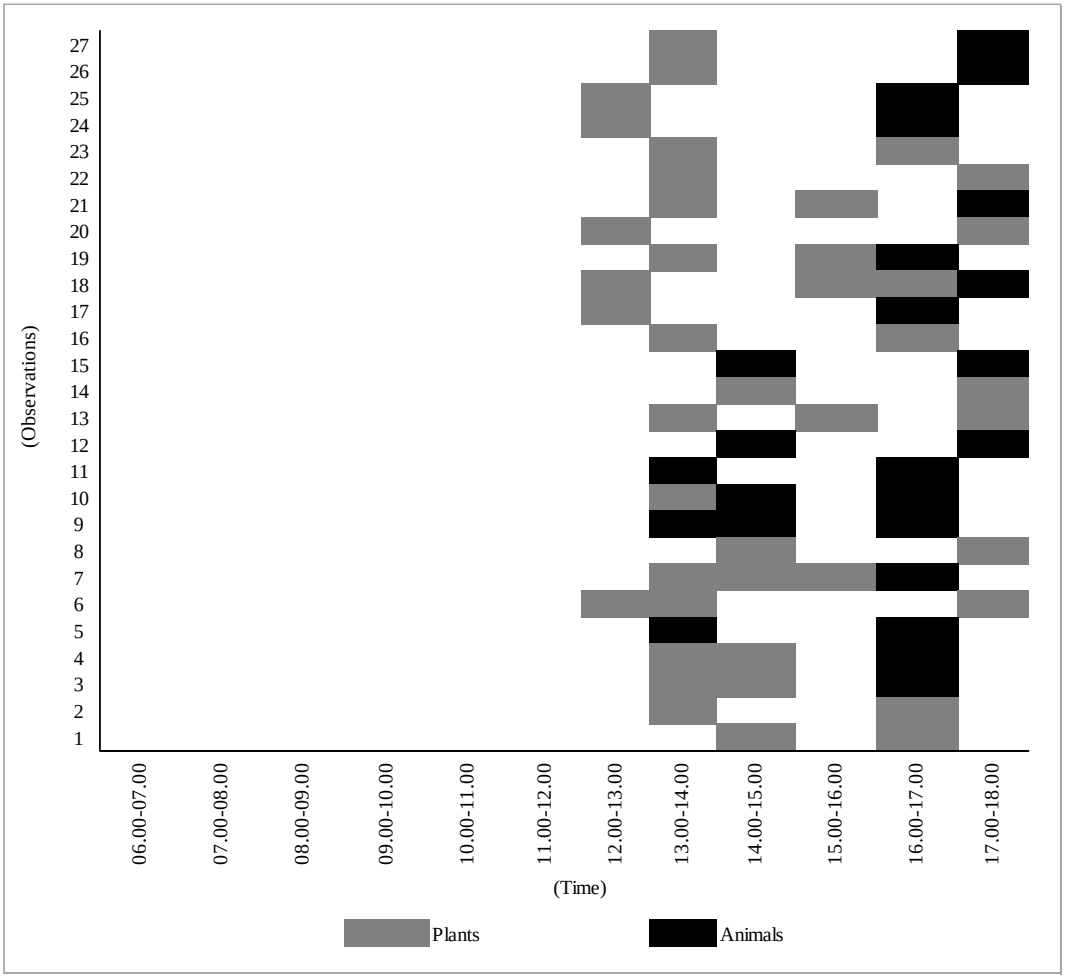

Figure 7. Observation of sailfin lizard feeding time

Because of the sailfin lizards do basking to regulate their body temperature before doing activities, we accessed the daily weather data to determine whether there is a relationship between the daily weather and the feeding time of sailfin lizards (Figure 8). Even though the observation did during the dry season, there were 7 days raining from the 27 days of observation. The maximum temperature ranged from 30.5˚C to 32.6˚C and the minimum temperature ranged from 21.6˚C to 25.4˚C. Based on observations, differences in weather do not really affect the feeding time of sailfin lizards.

4. Discussion

As reptiles, sailfin lizards are cold-blooded or their body temperature depends on the temperature of the environment in which they live (Díaz and Cabezas-Díaz, 2004; Rutschmann et al., 2020). Even though the research was conducted during the dry season, there were several days when it rained (Figure 8). In addition, the daily weather conditions also do not appear to affect the daily activities of sailfin lizards in foraging for food. Regardless of the temperature and daily weather conditions, sailfin lizards generally start their foraging activity around noon.

The results is in accordance to the report that sailfin lizards are omnivorous and polyphagous animals, which eat various plants and animals (Denzer, 2020). We have been able to identify 18 species of plants and 7 species of invertebrates as food for sailfin lizards.

Not all forage plants were available in large quantities, the species with relatively greater abundance was *C. variegatum*. Generally, the most abundant plants will also had a greater frequency selected as food (Figure 5). This means that, in addition to the large abundance of this plant, it was also evenly distributed along the sides of the river. However, there were also forage plants with a smaller abundance but had a high frequency of selection, i.e. *L. indica* and *Codeium* sp., which indicate that the size of the species was not large. The result of this research showed that most favored forage plants by sailfin lizard were not widely available and also not evenly distributed. Data from a number of observations indicated that the most commonly eaten forage plants were *F. hispida* and *D. trichomonoides* (Table 1). These two species did not have a large abundance and frequency of distribution.

Sailfin lizard mostly favored *Parathelphusa* sp. (Table 2). In addition to their larger size compared to the other invertebrate, crabs (*Parathelphusa* sp.) were easier to catch by sailfin lizard and were not poisonous or venomous. When approached by the sailfin lizard, instead of running, crab (*Parathelphusa* sp.) will try to fight back thus making it easier to be caught by the sailfin lizard. However, Table 3 shows that the number of *Parathelphusa* sp. was not abundant, but moderate. Similar to the trend with forage plants, the feeding animals favored by sailfin lizards are not abundantly available in their habitat.

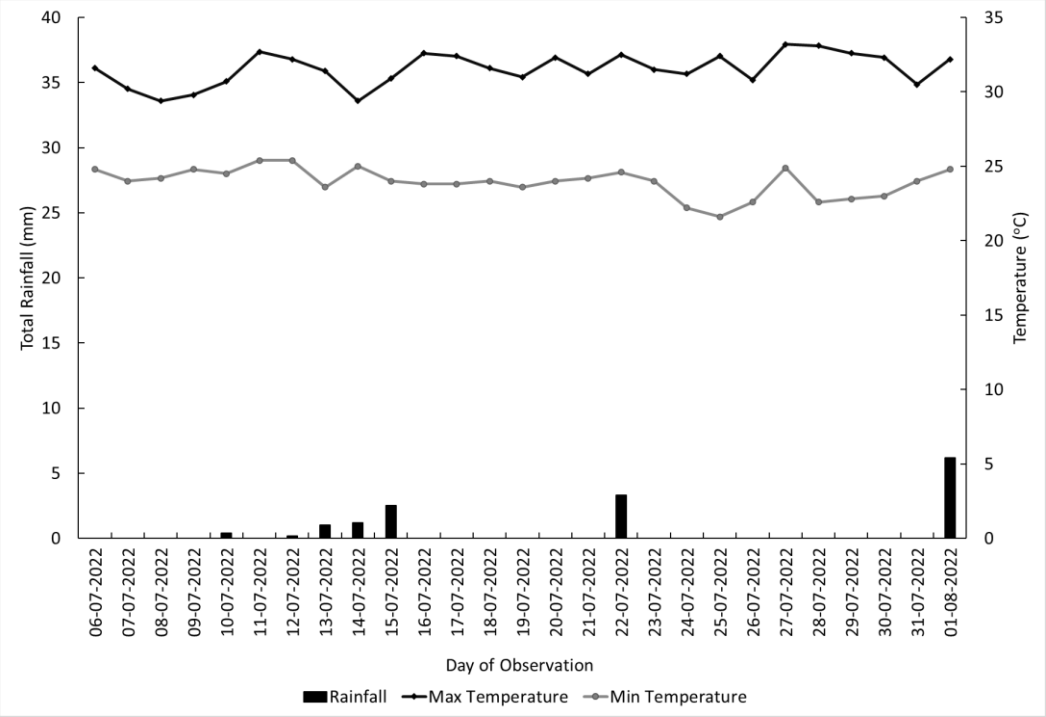

Figure 8. Daily rainfall, maximum and minimum temperature of research location

Several observations have shown that sailfin lizard competed with each other for food. During feeding time, sailfin lizard maintains their feeding territory. Other individual that come closer to its territory will be attacked, often resulting in a fight. The limited availability of favorite food can be the reason for the fighting (Brattstrom, 2015) and might be the reason of wider range of food source selection both plants and animals, for sailfin lizard.

It is also known that the sailfin lizards ate more plants than animals (Figure 3). It is easier to get plants than animals, as they will need less energy and time to get plants to eat. Plants are already available in abundance in their habitat, enabling lizard to directly obtain leaves and fruits anytime. Whitten et al. (1987) remarked that sailfin lizards in captivity tend to prefer fruit rather than leaves. Observations also show that if fruit is available (such as fruit of *Ficus* spp. *A. Pinnata* and *Syzygium*), sailfin lizards tend to eat fruit rather than leaves to meet nutritional needs. Thus, it is assumed that the number of leaves eaten in this area might be caused by the limited availability of fruit

CONCLUSION

Sailfin lizards started to forage at noon and ate a variety of plants and invertebrates. There are 18 species of plants and seven species of invertebrate selected as food by sailfin lizards in Pattunuang. Of the 18 species of forage plants, two most frequently eaten were *F. hispida* and *D. trichomonoides*. Meanwhile, for animal based food, the highest frequency of invertebrate eaten is *Parathelphusa* sp.. The abundance of selected plant and invertebrates as food is varied, but there is a tendency that the highest frequency of selected food has relatively lower abundance which might be the reason of seeking other food sources and increasing the diversity of food source. Observation also showed that sailfin lizard (*H. celebensis*) eats more plants than animal based food.

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