A R T I C L E

AN ECOLOGICAL STUDY OF THE PREY OF THE OTTER IN AN ASYNCHRONOUS PADDY FIELD LANDSCAPE

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Abstract: Otters are the top predators in wetlands. Otters have an essential ecological role in preserving the species richness of their food web. The availability of prey species in the habitat influences otter prey selection. Because of the cultivation stage, paddy fields in the tropical area have a distinct temporal seasonality. Consequently, information on the prey species of otter temporarily availability in Paddy field settings is essential for developing wildlife-friendly agricultural techniques. From January to April 2020, researchers studied the ecology of otters' prey in rice fields in West Sumatra. We examined the ecological indexes of otters' prey and whether cultivation stages influence the availability of otters' prey. Fish, snails, frogs, and water insects were the prey species studied in four cultivation stages. Ecological indices such as diversity index (H'), evenness index (E), and species richness index (R) are used to compare the findings of each type of otter prey. The ecological index values of the prey animals obtained by otters varied quite a lot depending on the type of prey and the growing season. The abundance of snails, the number of snails, the abundance of fish and the abundance of *Oreochromis nilloticus* were significantly different across cultivation stages (P<0.05) according to the results of the ANOVA test. The asynchronous paddy field system is suitable for providing otters with abundant prey all year round. Therefore it will be used to create an otter-friendly rice field landscape.
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INTRODUCTION

Paddy fields are artificial wetland ecosystem very useful for human life as food producers. Paddy fields are also stagnant water ecosystems that support the life of various aquatic animals and plants. The paddy field ecosystem has a high diversity of fauna. Various types of fauna are native inhabitants of paddy field habitats, and humans intentionally introduce some for cultivation purposes (Puspita et al., 2005). Paddy field cultivation activities can regulate the abundance and diversity of aquatic insect organisms (Asghar, 2010; Che Salmah and Abu Hassan, 2002; Hayasaka et al., 2012; Mogi, 2007). Paddy field cultivation is divided into multiple stages during the cultivation process (Fernando, 1993), resulting in variations in the composition of aquatic insects in different phases (Che Salmah et al., 1998). Other organisms in the paddy fields outside aquatic insects include wild plants, plankton, several types of bacteria, rodents, and water snakes (Lu et al., 2002). The interaction of these organisms produces a balanced ecosystem, providing paddy fields with an ideal environment for various species (Deb, 2009). It has otters, the primary predators of the rice field landscape.

The otter is one of the species that are dependent on the existence of wetlands (Asmoro et al., 1994). They are the top predators in their habitat. Otters are essential in maintaining the balance of animal abundance in their ecosystems (Foster-Turley & Santiapillai, 1990). Otters primarily consume fish, although each species has varied dietary preferences (Anoop and Hussain, 2005; Kasper et al., 2008). Indonesia has four otter species out of the world's thirteen. These are *Aonyx cinereus* (Illiger, 1815), *Lutra sumatrana* (Gray, 1865), *Lutrogale perspicillata* (Geofroy Saint-Hilaire, 1826) and *Lutra lutra* (Linnaeus, 1758). (Corbet and Hill, 1992). Only *A. cinereus* is not protected by the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia.

Small-clawed otters *(A. cinereus*) are widespread throughout South and Southeast Asia. The International Union for Conservation of Nature (IUCN) Red List has categorized them as vulnerable species (Wright et al., 2015). Rivers, peat swamps, mangroves, paddy fields, ditches, and fish ponds are among the natural and artificial habitats used by small-clawed otters (Hussain et al., 2011). Small-clawed otters forage in paddy fields and use those as latrines in several Southeast Asian contries, including Malaysia, Thailand, the Philippines, and Indonesia (Foster-Turley, 1992; Aadrean et al., 2010; Gonzalez, 2010; Kanchanasaka and Duplaix, 2011). In the Malaysian Peninsula, otter latrine sites were discovered in paddy fields near mangrove muck (Foster-Turley, 1992). While conducting a preliminary study on the occurrence of small-clawed otters (Aadrean et al., 2010) and their feeding characteristics (Aadrean et al., 2011), it was discovered that they utilize a paddy field near the settlement for foraging and as a latrine site.

The diet of small-clawed otters has been previously studied with the composition of the diet having aquatic animals such as crabs, fish, frogs, arthropods, mammals, and snails in natural wetlands dominated by crabs (Kruuk et al., 1994; Hon et al., 2010) While in artificial wetlands such as paddy fields, fish dominate (Andeska et al., 2021). The difference is influenced by prey availability in their habitat (De Silva, 1991). In the present study the researchers wanted to reveal the effect of different stages of paddy-field cultivation on the prey abundance of small-clawed otters. Previous studies, several related to the ecology of otters, have been carried out to examine the influence of spatial and temporal characteristics on visits to latrine sites (Aadrean and Usio, 2017; 2020) and temporal environmental factors on the diet of otters in paddy fields (Andeska et al., 2021). The results of this study can complement previous research to develop the basis for creating a paddy field cultivation system suitable for the survival of otters.

STUDY SITE AND METHODS

Study site

This research was carried out from January - April 2020. The research location was selected in the rice fields of Lubuk Alung sub-district, Padang Pariaman district, West Sumatra (longitude 0°38'00"S - 0°40'40"S, latitude 100°17'10"E - 100° 20'20"E), with an altitude of 25 - 50 m above sea level. The paddy field cultivation system is carried out individually by the owner of the paddy fields and the owner can determine the timing of his rice cultivation, thus creating heterogeneous rice fields (Aadrean and Usio, 2017).

The tools and materials used in this research are digital cameras, G.P.S., plastic bags, collection bottles, sticky labels, compound microscopes, ropes, petri dishes, dip nets, filters, electro-fishing instruments, fishing nets, flash lights, data sheets, 70% alcohol, and 4% and 10% formalin.

The Abundance of Otter Prey

This study uses quantitative methods and purposive sampling to determine the location of the selected planting season. The selected location should be close to the latrine site surveyed (Aadrean and Usio, 2017). We divided the cultivation stage into four categories: preparatory, vegetative, generative, and postharvest. The preparation stage is the period that starts from the time the fields are ploughed until the farmers plant rice seeds. The vegetative stage is when farmers start planting rice until the emergence of rice flowers. The generative stage starts from flowering until the farmer harvests the rice. Postharvest is the period after harvesting until the land is ploughed again (Andeska et al., 2021).

At every cultivation stage, we collected prey animals of small-clawed otter such as insects, molluscs, fish, and frogs. The limitation of the animals collected is based on the research of Andeska et al. (2021). He used the category of prey animals that have an occurrence frequency above 10% in the diet of small-clawed otters in rice fields. The density of prey animals was calculated at each different rice growing season. Sampling was carried out in the rice field plots, and the dich closest to the rice field. Methods and efforts for taking samples were adjusted to taxa groups and rice growing season. Sampling at every cultivation stage was done at five different locations.

Table 1. Prey animal survey methods and identification guidebooks used.

No	Category	Method	Effort	Identification guide
1	Insect	*Dip Net*	20 cm x 500 cm	Merrit and Cummin, 1984
2	Mollusc	*Dip Net* and *Hand Sorting*	20 cm x 500 cm	Pennak,1978, Djajasasmita, 1999
3	Fishes	Electrofishing	200 m transect distance x 40 cm net width	Kottelat, *et al.*,1993
4	Frog	*Visual encounter survey*	200 m transect with 5 m left and right visibility	Inger and Stuebing, 2005

Data Analysis

We calculated the abundance of prey for the small-clawed otter at each cultivation stage. The number of species and density of otter prey categories in each cultivation stage was also calculated. Using this data ecological indices, such as the Shannon-Wiener diversity index (H'), evenness index (E), and Margalef species richness index (R), were calculated to compare community patterns in each cultivation stage. In addition, the one-way ANOVA test and Tukey's test were conducted to see the effect of different cultivation stages on the prey abundance of the Small-clawed otter.

RESULTS

A wide variety of prey items were identified (Table 2, Table 3).

Table 2. Number of individual otter prey in each cultivation season

Category	No	Taxa/species	Cultivation Stage			
			Preparation	Vegetative	Generative	Postharvest
Insect	1	Bezzia	1	-	1	-
	2	Cullicoides	-	1	14	-
	3	Disticidae	2	2	-	-
	4	Glossiphonidae	-	3	-	-
	5	*Orthemis* sp.	-	3	1	-
	6	*Pantala* sp.	-	1	-	-
	7	*Plathemis* sp.	-	6	5	-
	8	Pseudocloeon	1	-	-	2
	9	Tipulidae	-	3	2	-
	10	*sp* 1	5	3	-	-
	11	*sp* 2	-	-	3	-
Mollusc	1	*Acroloxus lacustris*	56	-	-	-
	2	*Gyraulus* sp.	3	5	-	-
	3	*Corbicula* sp.	-	3	2	-
	4	*Lymnaea rubiginosa*	326	131	61	-
	5	*Melanoides granifera*	70	57	62	-
	6	*Melanoides tuberculata*	223	242	210	-
	7	*Pomacea canaliculata*	225	131	169	16
	8	*Thiara* sp.	117	177	144	-
Pisces	1	*Pterygoplichthys* sp.	1	1	1	-
	2	*Oreochromis niloticus*	-	4	16	-
	3	*Anabas testudineus*	9	10	9	-
	4	*Channa striata*	-	-	4	-
	5	*Aplocheilus panchax*	3	2	4	-
	6	*Gambusia affinis*	4	-	8	8
	7	*Puntius brevis*	-	-	1	-
	8	*Rasbora* sp.	-	10	2	-
	9	*Hemibagrus hoevenii*	-	-	-	-
	10	*Barbonymus gonionotus*	1	-	-	-
Amphibia	1	*Fejervarya cancrivora*	72	29	21	11
	2	*Fejervarya limnocharis*	6	5	1	1
	3	*Hylarana nicobariensis*	-	-	1	-
	4	*Hylarana erythraea*	1	1	2	-
	5	*Mycrohylidae*	3	-	-	-

Table 3. Number of species and individuals in each growing season

No	Prey Category	Preparation		Vegetative		Generative		Postharvest	
		S	N	S	N	S	N	S	N
1	Insect	4	9	8	22	6	26	1	2
2	Mollusc	7	1020	7	746	6	648	1	16
3	Fish	5	18	6	27	8	45	1	8
4	Frog	4	82	3	35	4	25	2	12

S = Total Species/taxa; N = Total Individuals

Based on the observations of otter prey in the paddy fields, it was found that the most common prey category was Molluscs during the preparation stage (N: 1020; Table 3), which was dominated by the species *L. rubiginosa*. While for the category of Fishes most commonly found during the generative stage, namely 45 individuals with a total of 8 species (Table 3), the most common species found was *O. niloticus* (16; Table 2). Furthermore, for the amphibian category, the highest number of individuals was found in the preparation stage, and insects in the vegetative stage (Table 3), dominated by the species *F. cancrivora* for frog prey and Cullicoides for insect prey (Table 2). The prey density of otters observed shows that the number of individuals changes according to the cultivation stage. The number of individuals appears to be high if the environmental factors of the cultivation stage support the presence of otter prey.

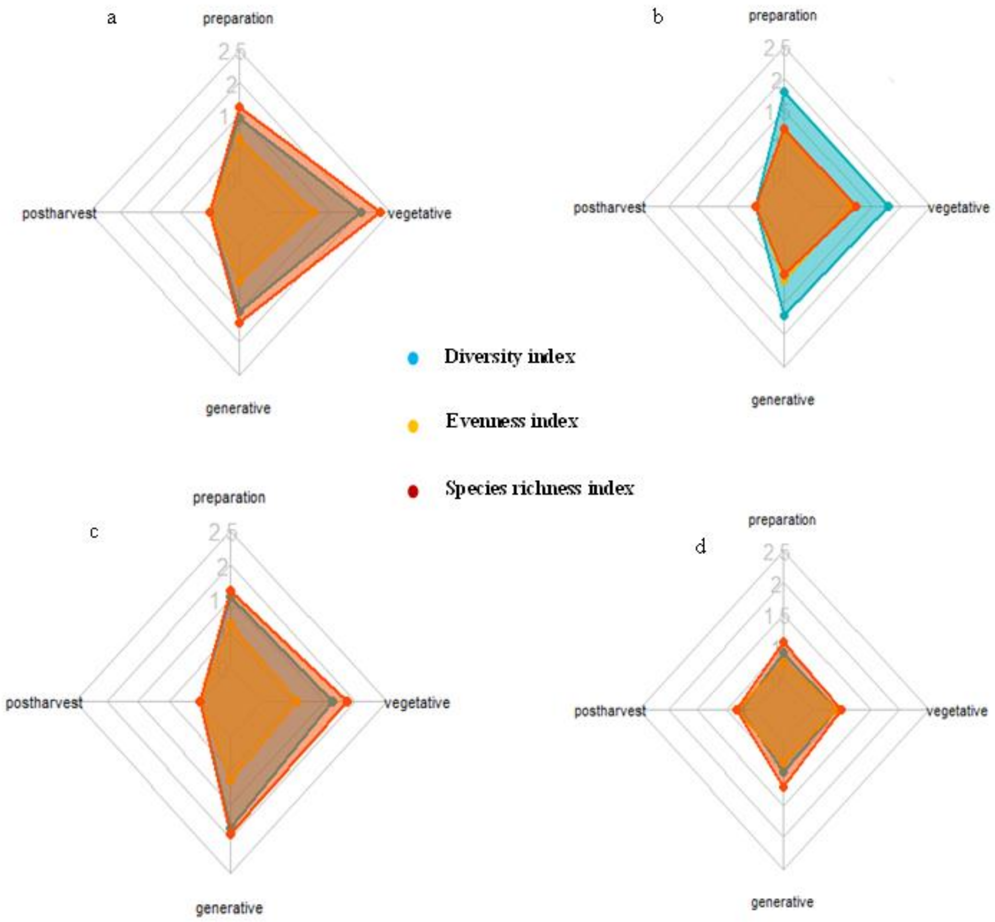

Figure 1. Chart diagram ecological index otter prey a. insect b. snail c. fish d. frog

Based on Figure 1, the ecological index values calculated varied depending on the cultivation stage and the type of prey category. The highest biodiversity index of insects, evenness index, and species richness index were in the vegetative stage (H': 1.94, E: 0.93, R: 2.64), while for the snails, the highest biodiversity index was in the preparation stage (H':1.64), the highest evenness index was during the generative stage (E: 0.85), and the species richness index was during the vegetative stage (R: 0.91). The highest ecological index for the Fishes category is the generative stage (H': 1.73, E: 0.83, R: 1.84), whereas for the frog, the highest biodiversity index was in the generative stage (H': 0.6), the evenness index (E: 0.49), and the species richness index in the generative stage (R: 0.93). Frogs have the smallest ecological index value for the prey category compared to other prey categories, while insects have the highest ecological index.

Table 4. The effect of seasonal differences on prey categories, number of prey species, and every single species of prey for small-clawed otters

Category of prey	*P*-Value (95%)		Taxa/Species	*P*-value (95%)
	Abundance	Total of species		
Insect	0.10	0.05	Bezzia	0.55
			Coleoptera	0.42
			Culicoides	0.29
			Disticidae	0.55
			Glossiphonidae	0.12
			Orthemis sp.	0.52
			Pantala sp.	0.42
			Plathemis sp.	0.20
			Pseudocloeon	0.55
			sp1	0.32
			sp2	0.42
			Tipulidae	0.22
Molluscs	**0.02***	**0.01***	*Acroloxus lacustris*	0.42
			Gyraulus sp.	0.56
			Corbicula sp.	0.57
			lymnaea rubiginosa	0.33
			Melanoides granifera	0.65
			Melanoides tuberculate	0.65
			Pomacea canaliculata	0.27
			Thiara sp.	0.50
Fishes	**0.04***	0.11	*Anabas testudineus*	0.72
			Aplocheilus panchax	0.66
			Barbonymus gonionotus	0.58
			Channa striata	0.42
			Gambusia affinis	0.66
			Hemibagrus hoevenii	0.42
			Oreochromis niloticus	**0.01***
			Pterygoplichthys sp.	0.80
			Puntius brevis	0.42
			Rasbora sp.	0.20
Amphibians	0.49	0.24	*Fejervarya cancrivora*	0.40
			Fejervarya limnocaris	0.86
			Hylarana erytrhea	0.25
			Hylarana nicobariensis	0.42
			Mycrohyla gadjahmadai	0.42

Statistically significant variables are indicated in bold font ($P< 0.05$)

We split the dependent variable into three levels in the ANOVA test: the abundance of otter diet categories, the number of species from each prey category, and the abundance of each prey species collected. Of the four abundance categories of prey, only two were impacted by the cultivation stage in the ANOVA test of the effect of molluscs and fish ($P<0.05$; Table 4). For the number of species of prey, only mollusc was affected by the cultivation stage ($P<0.05$; Table 4). Meanwhile, only *O. niloticus* was shown to be influenced by the cultivation stage in terms of otter prey quantity ($P<0.05$; Table 4).

DISCUSSION

The diversity index categorizes the features of insects, snails, and fish as moderate. The highest insect diversity index occurs during the vegetative stage because it may provide shaded conditions that aquatic insects prefer (Norela et al., 2013). Paddies are essential for insects that reproduce in shallow water. Flooded paddy fields are frequently rich in algae, plankton, and other aquatic insect food (Roger et al., 1991). During growth from the tiller stage to the adult stage of paddy or when the paddy plant is actively producing rice grains, the abundance of Disticidae and Odonata is more abundant (Che Salmah and Abu Hassan, 2002; Mogi and Miyagi, 1990). The ANOVA test results show that the difference in the cultivation stage does not affect the number of insects. This research discusses other characteristics that have a distinct impact on insects. Climate, geographical conditions, altitude, food type, insect spreadability, habitat selection, and food availability are all environmental elements that may impact bug prevalence (Tofani, 2008).

In the snail prey category, the highest diversity index was in the preparation stage (Figure 2), and the difference in the cultivation stage impacted the abundance and number of snail species (P<0.05; Table 4). If related to paddy growth, the number of molluscs increased in the initial processing phase, then stayed steady until 2-3 weeks before harvesting. According to Aadrean and Usio's (2020), snails are most commonly found in rice fields that have been flooded, such as during the processing and vegetative periods. Figure 2 demonstrates that the cultivation stage that had the most significant impact on snail abundance was the preparation stage, while in Figure 3, the number of species of snails was found at the most in the generative stage. It was because when the paddy phase actively produces grains, it creates a suitable microhabitat for aquatic organisms to find food. The highest number of species and individuals of snail was generally found in paddy fields that are still waterlogged and soil is still slightly moist during one to two weeks of age of rice plants. In paddy fields with these conditions, sunlight penetration is still sufficient to reach the substrate because paddy plants have not blocked it.

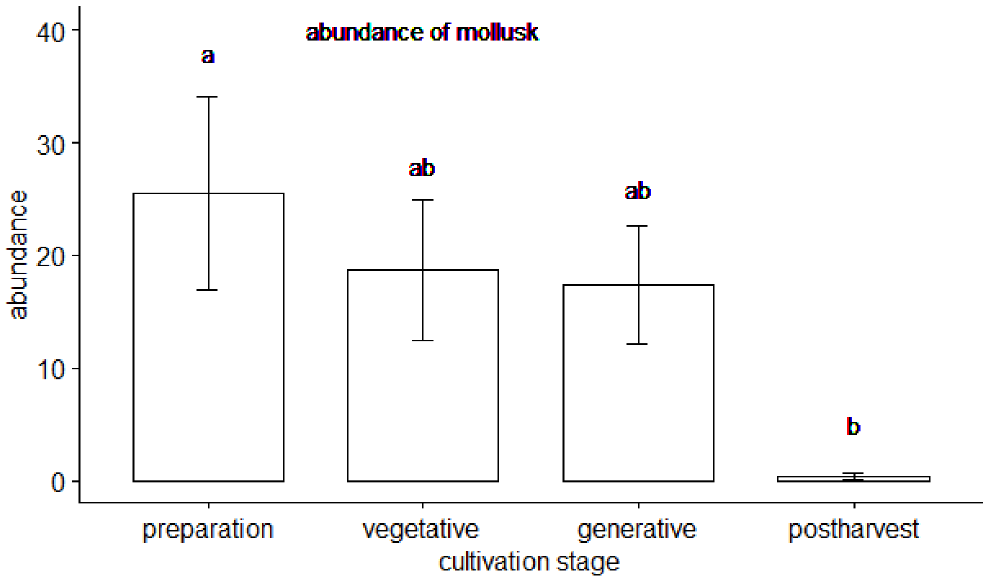

Figure 2. Boxplot diagram of the relationship between mollusc abundance and growing season in asynchronous rice fields

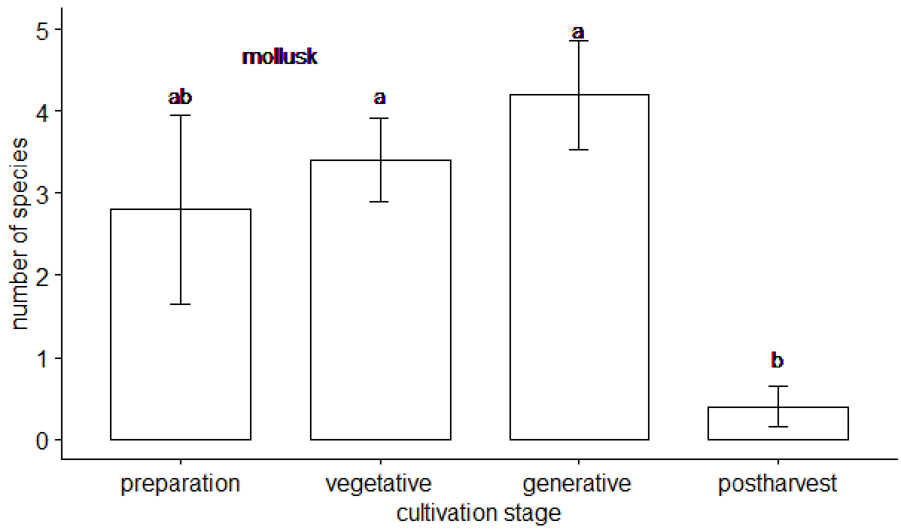

Figure 3. Box plot diagram of the relationship of cultivation stage on total species of snail in asynchronous paddy fields

On the other hand, fish abundance is influenced by the cultivation stage (Table 4; *P*=0.04*). Figure 4 shows the difference in the generative stage. Furthermore, among the ten taxa/species found, just *O.niloticus* abundance was affected by changes in the cultivation stage (Table 4; *P*=0.01*). Figure 5 illustrates the generative stage of *O. niloticus* with the greatest average abundance caused by water availability throughout the growing season, which is a determining factor for the survival of fish in rice fields. The number and diversity of fish will be high when fish can easily travel from the river/upstream to the rice fields since the paddy fields in this region use an irrigation system.

Furthermore, the water level will decrease in the last half of the generative stage. The water level is only raised at the margins of the paddy fields to create space for fish to be restricted or trapped, making it simpler to sample fish. The generative stage is highly beneficial to aquatic creatures foraging, especially fish. In a report by Andeska et al. (2021), the choice of fish in otters' diet was not influenced by an ecological factor. Existence of fish is always available during the cultivation stage.

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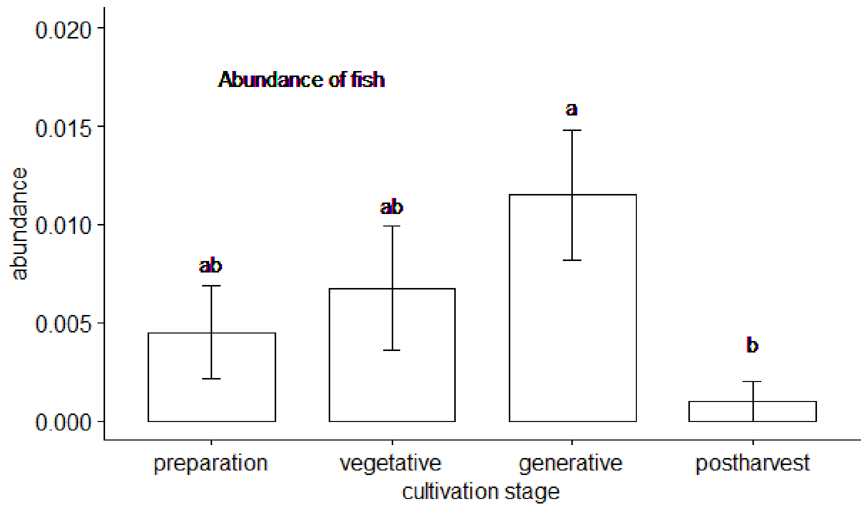

Figure 4. Box plot diagram of the relationship of cultivation stage on fish abundance in asynchronous paddy fields.

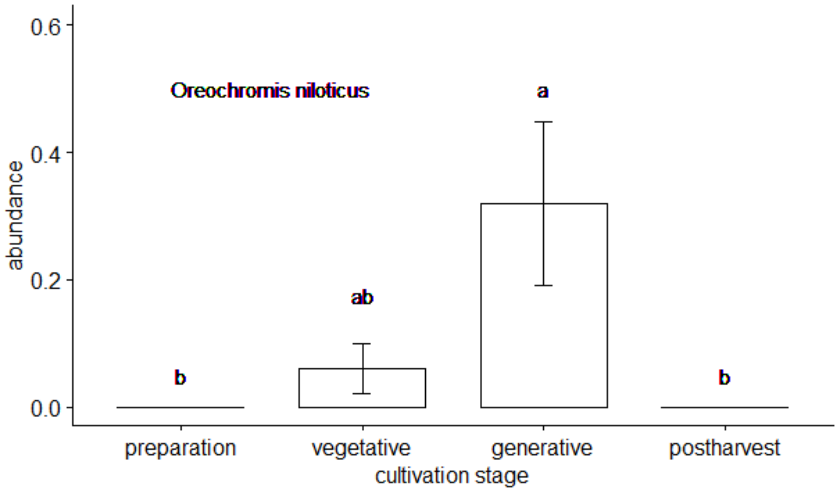

Figure 5. Box plot diagram of the relationship of cultivation stage on *O. niloticus* abundance in asynchronous paddy fields.

The diversity index of frogs in Lubuk Alung paddy fields generally includes low diversity (H'<1). It can be seen from the low evenness index of amphibians, which means that the distribution of species in each cultivation stage was uneven. Of all cultivation stages, the preparation stage has the highest diversity value. Naturally, frogs will be highly abundant when the rice is still young because there is still a lot of water available, and it inundates all land surfaces of the paddy fields. Their abundance will decrease as water supply decreases and the age of paddy plants. Differences in the cultivation stage also did not affect the abundance and number of frog species in the study area. It was because other independent factors, such as surface water temperature, can affect the abundance of frogs. Kurniati (2017) stated that environmental factors in the form of surface water temperature affects the individual density of frogs and pre-adults of frogs (*F. cancrivora*).

In the natural habitat of paddy fields, small-clawed otters prey on fish, snails, insects, frogs, reptiles, crustaceans, birds, and mammals. Fish and molluscs were the most dominant prey hunted by small-clawed otters (Andeska et al., 2021). That was interesting because the cultivation stage influenced the abundance of small-clawed otter prey according to this study. In the research of Andeska et al. (2021), the selection of snails as prey was influenced by the water level in the paddy fields, and any environmental factors did not influence the selection of fish as prey. The results of this study can support the conclusion of Aadrean and Usio (2020), which states that small-clawed otters prefer the vegetative stage as a foraging area.

CONCLUSION

The existence of an asynchronous paddy field system throughout the year can maintain the availability of prey for small-clawed otters. If the paddy fields use a simultaneous planting system, it will result in otters experiencing food shortages (Aadrean and Usio, 2020). Therefore, applying the paddy cultivation system and paying attention to aspects of food security also needs to consider conservation aspects so that the existence of the small-clawed otter is not increasingly threatened. Therefore, it is necessary to have a sustainable rice cultivation that can increase the environment's carrying capacity to support the lives of present and future generations.

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RESUME

ETUDE ÉCOLOGIQUE DES PROIES DES LOUTRES DANS UN PAYSAGE ASYNCHRONE DE RIZIÈRES A l'OUEST DE SUMATRA

Les loutres sont les principaux prédateurs des zones humides. Les loutres ont un rôle écologique essentiel dans la préservation de la richesse spécifique de leur réseau trophique. La disponibilité des espèces de proies dans l'habitat influence la sélection des proies des loutres. En fonction du stade de culture, les rizières de la zone tropicale ont une saisonnalité temporelle distincte. Par conséquent, les informations sur les espèces de proies de loutre temporairement disponibles dans les rizières sont essentielles pour développer des techniques agricoles respectueuses de la faune. De janvier à avril 2020, des chercheurs ont étudié l'écologie des proies des loutres dans les rizières de l'ouest de Sumatra. Nous avons examiné les indices écologiques des proies des loutres afin de voir si les stades de culture influencent la disponibilité en proies des loutres. Nous avons étudié les espèces de proies suivantes : les poissons, les escargots, les grenouilles et les insectes aquatiques, à quatre stades différents de culture. Des indices écologiques tels que l'indice de diversité (H), l'indice d'uniformité (E) et l'indice de richesse spécifique (R) sont utilisés pour comparer les résultats de chaque type de proie de loutre. Les valeurs de l'indice écologique des proies obtenues pour les loutres variaient fortement selon le type de proie et la saison de culture. Selon les résultats du test ANOVA, l'abondance d'escargots, le nombre d'escargots, l'abondance de poissons et de tilapia du Nil (*Oreochromis nilo*ticus) étaient significativement différents suivant le stade de culture (P<0,05). Le système de rizière asynchrone est donc adapté pour fournir aux loutres des proies abondantes tout au long de l'année. En conséquence, il sera utilisé pour créer un paysage de rizières respectueux des loutres.

RESUMEN

ESTUDIO ECOLÓGICO DE LAS PRESAS DE LA NUTRIA EN UN PAISAJE ASINCRÓNICO DE ARROZAL

Las nutrias son los predadores tope en los humedales. Las nutrias tienen un rol ecológico esencial en la preservación de la riqueza de especies de su red alimenticia. La disponibilidad de especies-presa en el hábitat influencia la selección de presas por la nutria. A causa del estadío del cultivo, los arrozales en el área tropical tienen una clara estacionalidad temporal. Consecuentemente, la información sobre la disponibilidad temporal de las especies-presa de la nutria en contextos de Arrozal es esencial para desarrollar técnicas agrícolas compatibles con la fauna. Entre Enero y Abril de 2020, estudiamos la ecología de las presas de la nutria en arrozales en Sumatra Occidental. Examinamos los índices ecológicos de las presas de la nutria, y si los estadíos del cultivo influencian la disponibilidad de presas. Las especies-presa estudiadas en cuatro estadíos de cultivo, fueron peces, caracoles, ranas, e insectos acuáticos. Usamos índices ecológicos como el índice de diversidad (H′), índice de equitatividad (E), e índice de riqueza de especies (R), para comparar los hallazgos de cada tipo de presa. Los valores de los índices ecológicos de las presas animales obtenidas por las nutrias, variaron considerablemente, dependiendo del tipo de presa y la estación de crecimiento. La abundancia de caracoles, el número de caracoles, la abundancia de peces y la abundancia de *Oreochromis niloticus* fueron significativamente diferentes en el estadío de cultivo (*P*<0.05), de acuerdo a los resultados del test ANOVA. El sistema de arrozal asincrónico es adecuado para proveer a las nutrias con presas abundantes a lo largo de todo el año. Por lo tanto, será utilizado para crear un paisaje de arrozales compatible con las nutrias.

RINGKASAN

KAJIAN EKOLOGIS MANGSA BERANG-BERANG DI LANDSKAP SAWAH ASINKRON

Berang-berang adalah predator teratas di lahan basah. Berang-berang memiliki peran ekologis yang penting dalam melestarikan kekayaan jenis rantai makanannya. Ketersediaan spesies mangsa di habitat mempengaruhi pemilihan mangsa berang-berang. Karena tahapan waktu budidaya, sawah di daerah tropis memiliki musim tahap yang berbeda. Konsekuensinya, informasi tentang spesies mangsa berang-berang yang tersedia sementara di sawah sangat penting untuk mengembangkan teknik pertanian ramah satwa liar. Dari Januari hingga April 2020, peneliti mempelajari ekologi mangsa berang-berang di persawahan di Sumatera Barat. Kami memeriksa indeks ekologi mangsa berang-berang dan apakah tahap budidaya mempengaruhi ketersediaan mangsa berang-berang. Ikan, siput, katak, dan serangga air merupakan spesies mangsa yang dipelajari dalam empat tahap budidaya. Indeks ekologi seperti indeks keanekaragaman (H'), indeks kemerataan (E), dan indeks kekayaan spesies (R) digunakan untuk membandingkan temuan setiap jenis mangsa berang-berang. Nilai indeks ekologi hewan mangsa yang diperoleh berang-berang cukup bervariasi tergantung jenis mangsa dan musim tanam. Kelimpahan keong, jumlah keong, kelimpahan ikan dan kelimpahan *Oreochromis niloticus* berbeda nyata pada tahap budidaya ($P<0{,}05$) menurut hasil uji ANOVA. Sistem sawah asinkron cocok untuk memberi berang-berang mangsa yang melimpah sepanjang tahun. Oleh karena itu akan digunakan untuk membuat lanskap sawah ramah berang-berang.