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EVALUATING BIODIVERSITY IN DEEP-WATER RICE FARMS DURING AUTUMN - WINTER CROP IN AN GIANG PROVINCE

Nguyen Thanh Hung[1], Pham Hong Phuc[1], Tran Ngoc Chau[1], Le Thanh Phong[1], Nguyen Duy Thanh[1]
[1]*An Giang University, VNU-HCM*

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ABSTRACT

The study was conducted in three ecological areas in An Giang province, where three models of deep-water rice cultivation were established during the autumn-winter crop in 2022. In this study, biodiversity was assessed through the presence of fish, insects and natural enemies in deep-water rice fields. The results of the study showed that the three ecological areas under deep-water rice cultivation, demonstrated greater diversity of fish, insects, and natural enemies compared to traditional rice farms. Fish were found in all three models, and the identified species were common in the canals of the study area. Moreover, the results also showed that the diversity of insects and natural enemies in deep-water rice fields was higher than in controlled fields. A total of 1,093 individuals were recorded in the three models across the three ecological areas, compared to 788 individuals in the controll fields. The biodiversity index showed higher values for the deep-water rice models than for control models (2.58:2.35 in Tri Ton; 2.45:2.35 in Cho Moi; 2.64:2.28 in Thoai Son, for the deep water and─controlled fields, respectively). The cultivation of deep-water rice has positive effects on biodiversity, contributing to environmental improvement and offering a sustainable farming solution for adapting to climate change.

1. INTRODUCTION

The Mekong Delta has long been known as the origin of various local rice varieties, including well-known such as Huong Lai, Nang Thom Cho Dao, Tai Nguyen, Mot Bui Do, Mot Bui Trang, Nang Nhen, and Huyet Rong. However, after a prolonged shift to high-yielding rice varieties with triple cropping systems, the area dedicated to seasonal rice has drastically diminished. This transition has led to soil and water pollution, ecosystem degradation, and a severe decline in natural fish resources.

Seasonal rice varieties exhibit three main growth patterns corresponding to their adaptability to different water levels: (1) upland rice, suited to conditions with minimal water and water depths ranging from 0 to 50 cm; (2) deep-water rice, capable of tolerating depths between 50 and 100 cm; and (3) floating rice, which can thrive in water depths exceeding 100 cm. These rice varieties typically require fewer fertilizers and pesticides, growing well on floodplain alluvial soils with yields ranging from 3.1 to 7 tons per hectare, depending on the variety (Le Thanh Phong, 2022).

By leveraging the biological characteristics of early-maturing, flood-tolerant rice varieties like Huong Lai, alongside hydrological conditions and the current cropping calendar, it is possible to cultivate a crop that begins during the flood season and is harvested at its end (around late November) without interfering with the local double cropping system. Currently, deep-water rice cultivation covers only around 220 hectares, concentrated mainly in floodplain areas of An Giang and Long An provinces (Le Thanh Phong et al., 2023).

Results from several studies conducted by the Center for Rural Research and Development and the Faculty of Agriculture and Natural Resources, at An Giang University, on traditional rice fields indicate that 43 species of natural fish were recorded, belonging to 20 families from 9 orders, distributed in flood-released traditional rice areas (Huynh Ngoc Đuc et al., 2014). Regarding insects, 86 insect species from 10 orders were identified (Nguyen Thanh Xuan and Nguyen Thi Thai Son, 2014). Additionally, 15 spider species in rice fields in An Giang were recorded (Dinh Minh Quang, 2019). A study by Nguyen Thi Thai Son and Tran Vinh Sang (2021) in the same region also found 86 insect species, including 19 beneficial species, present in flood-released traditional rice fields. However, these studies have not yet implemented a comparative model to determine the differences in fish and insect biodiversity between deep-water rice and high-yielding three-crop farming system.

Furthermore, the complete dike systems constructed in An Giang since the 1990s, after the historic flood in 2000, have enabled triple rice cropping, ensuring food security and economic growth. By 2019, An Giang had 341 enclosed dike areas spanning 1,920 km (Lam Thanh Si and Chau My Duyen, 2020). However, such systems have contributed to soil pollution and negatively impacted agricultural ecosystems. Therefore, the deep-water rice cropping model is a promising experimental approach to environmentally friendly farming. This model offers various economic, environmental, and social benefits while helping to adapt to climate change and fostering sustainable agricultural development in An Giang and the Mekong Delta region. Evaluating the environmental and ecological advantages of deep-water rice farming models and providing a solid scientific basis for scaling up these models is crucial for promoting sustainable agriculture. Therefore, the study titled "Evaluating Biodiversity in Deep-Water Rice Farming During the Autumn-Winter Crop in An Giang Province" is essential.

2. METHODOLOGY

2.1 Study area

The research was conducted during the Autumn-Winter rice crop of 2022, focusing on biodiversity in the rice fields, particularly in relation to insects, natural enemies, and fish. The study was carried out in three regions (sub-regions) as follows:

- **Region 1:** The area located between the Tien and Hau Rivers, is situated in Hoa Binh Commune, Cho Moi District.
- **Region 2:** The Long Xuyen Quadrangle is located in Binh Thanh Commune, Thoai Son District.
- **Region 3:** The Seven Mountains area is located in Tan Tuyen Commune, Tri Ton District.

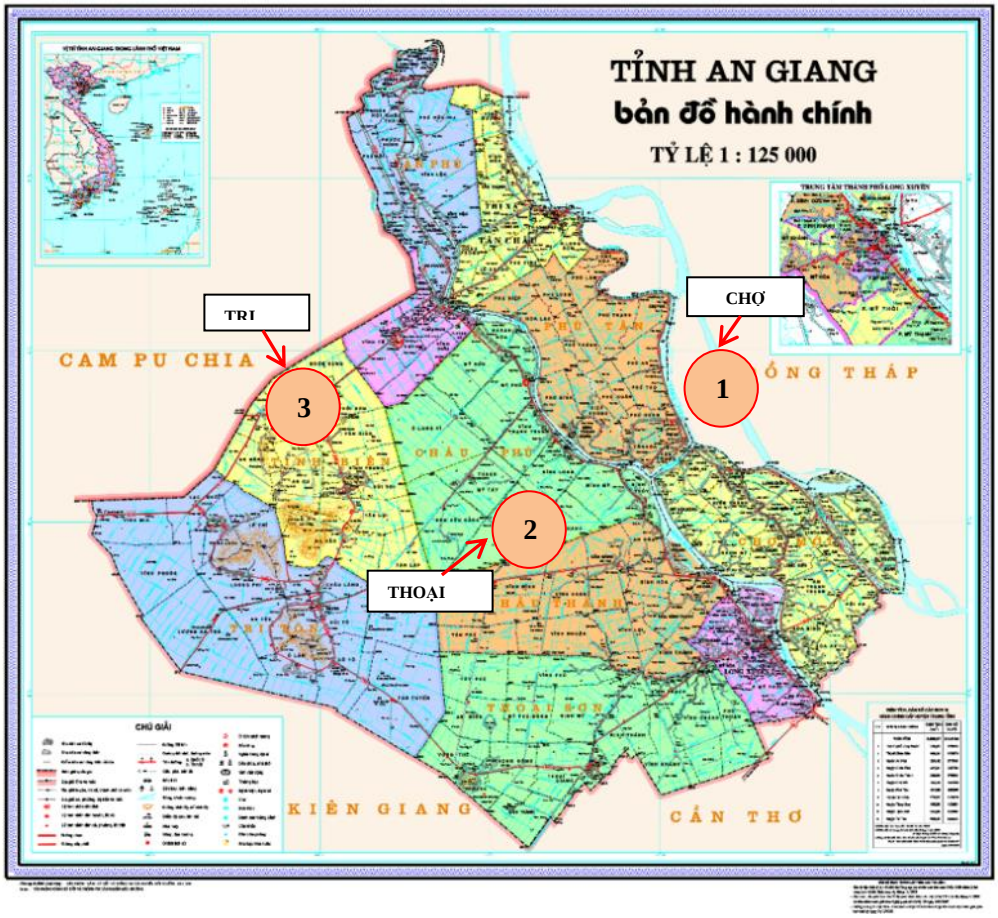

Figure 1. The Three Study Areas (Source: Department of Natural Resources and Environment of An Giang Province, 2010)

Each district will select one commune to represent it for household surveys and the implementation of a pilot model. The selected communes must meet the following criteria:

- A comprehensive dike system for three-crop rice production;
- Distinctive socio-economic characteristics of the district;
- Natural characteristics, soil quality, and climate representative of the district.

2.2 Deep-water rice cultivation model during the Autumn-Winter season in An Giang

The model replaced high-yielding rice with the Huong Lai variety, a deep-water rice variety collected and selected by the Agricultural Research and Development Center. This variety originates from Can Duoc District, Long An Province. The model combined with controlled flooding within enclosed dike systems and was implemented over an area of 4-5 hectares across three different ecological zones. The model includes one deep-water rice crop (Huong Lai) followed by two high-yielding rice crops, with flooding depths maintained below 100 cm, depending on local conditions.

2.3 Model locations

The deep-water rice cultivation model was implemented in Cho Moi, Thoai Son, and Tri Ton districts (Table 2).

Table 2. Locations of the study models

No.	Location	Position	Longitude	Latitude	Layout
1	Tan Tuyen Commune, Tri Ton District	Model	105.479885°	10.396141°	
		Base	105.480411°	10.396494°	
2	Binh Thanh Commune, Thoai Son District	Model	105.202564°	10.217194°	
		Base	105.200893°	10.215644°	
3	Hoa Binh Commune, Cho Moi District	Model	105.090350°	10.337177°	

2.4 Sampling collection method

2.4.1 Fish samples

Fish species were sampled directly from the deep-water rice fields during the Autumn-Winter crop of 2022 using various fishing tools, including traps (5 per model), nets (5 per model), and larger nets (15 per model). The tools were placed randomly, following the direction of water flow in the rice fields, across three sampling periods (from the time water entered the fields until it receded).

2.4.2 Insect samples

a. Field sampling method

Insects were collected from five diagonal points within each deep-water rice field model (Figure 2) using 2 to 5 sweeps of a net per point within an area of 1 m². The collected insects were preserved in 70% ethanol, placed in plastic containers, and transported to the lab for counting and species identification. In instances of low abundance, specimens were counted directly in the field without preservation. Additionally, visual observations were also conducted to assess pest situations.

- Sampling times: Samples were collected twice per field:

+ First collection: 30 days after sowing.

+ Second collection: 60 days after sowing, during the panicle initiation and flowering stages.

Figure 2. Layout of sampling points in the study models

b. Identification method

The insect species collected from the sampling points were classified and identified. The indentification of species collected during field investigations was identified using the classification key by Borror, D. J., Triplehorn, C. A., & Johnson, N. F. (1976).

3. RESULT AND DISCUSSION

3.1 Fish biodiversity

Through field surveys and species identification in the study models, 11 fish species were recorded, belonging to 4 orders: Cypriniformes (carp-like fish), Siluriformes (catfish), Anabantiformes (climbing perch), and Cichliformes (tilapia), as well as 8 families (Table 3). Most of these species are commonly found in local rice fields and canal systems, and they are regularly harvested by local residents for consumption. In the control fields, which often experienced drought conditions, no fish species were recorded.

Table 3. Summary of fish species in the models across three districts in An Giang Province

No.	Scientific Name	Order	Family	Tri Ton	Cho Moi	Thoai Son
1	*Esomus metallicus* (Ahl, 1923)	CYPRINIFORMES	Cyprinidae	+	+	+
2	*Barbonymus gonionotus* (Bleeker, 1849)	CYPRINIFORMES	Cyprinidae	+	+	+
3	*Puntioplites proctozystron* (Bleeker, 1865)	CYPRINIFORMES	Cyprinidae		+	
4	*Mystus mysticetus* (Roberts, 1992)	SILURIFORMES	Bagridae	+	+	+
5	*Clarias macrocephalus* (Günther, 1864)	SILURIFORMES	Clariidae	+		
6	*Pterygoplichthys disjunctivus* (Weber, 1991)	SILURIFORMES	Loricariidae	+	+	+
7	*Anabas testudineus* (Bloch, 1792)	ANABANTIFORMES	Anabantidae	+	+	+

8	*Trichopsis vittate* (Cuvier, 1831)	ANABANTIFORMES	Osphronemidae		+	+
9	*Trichogaster trichopterus* (Pallas, 1770)	ANABANTIFORMES	Osphronemidae	+	+	+
10	*Channa striata* (Bloch, 1793)	ANABANTIFORMES	Channidae	+	+	+
11	*Oreochromis niloticus* (Linnaeus, 1758)	CICHLIFORMES	Cichlidae	+	+	+
Total				**10**	**10**	**9**

In total, 10 species were recorded in both Tri Ton and Cho Moi, while 9 species were recorded in Thoai Son. Most of these species are classified as "Least Concern (LC)" according to the IUCN Red List, except for *Clarias macrocephalus* (Günther 1864), which is categorized as "Near Threatened (NT)."

Table 4. Number of fish species in the models across three districts in An Giang Province

No.	Family	Tri Ton			Cho Moi			Thoai Son		
		Batch 1	**Batch 2**	**Batch 3**	**Batch 1**	**Batch 2**	**Batch 3**	**Batch 1**	**Batch 2**	**Batch 3**
1	Cyprinidae	2	2	1	2	1	1	2	1	1
2	Bagridae	1	1	1	1	1	1	1	1	1
3	Clariidae		1	1	1				1	
4	Loricariidae	1	1			1		1		
5	Anabantidae		1	1			1		1	1
6	Osphronemidae		1		2	1		1	1	
7	Channidae	1	1	1		1	1	1	1	1
8	Cichlidae	1			1	2		1		

According to Table 3, some species such as Esomus metallicus, Barbonymus gonionotus, and Puntioplites proctozystron, were abundant during the first sampling period when water from the canal system was directed into the fields. Other species, like Channa striata and Mystus mysticetus, were present throughout the study in all areas. The most common species recorded was Anabas testudineus, while the least common were Clarias macrocephalus (found only in Tri Ton during the first sampling) and Puntioplites proctozystron (only recorded during the first sampling in Cho Moi).

The variation in species observed across different sampling periods is attributed to changing water levels and the growth stages of the rice. By the end of the rice-growing season, the water receded quickly, leading to a reduction in the fish population. Overall, fish diversity in the deep-water rice fields during the Autumn-Winter crop was lower compared to previous studies.

3.2 Insect and natural enemy diversity

Based on surveys and species identification conducted in the study areas, 66 species of natural enemy insects were recorded in the models.

Table 5. Composition of insects and spiders in the models across three districts in An Giang Province

No.	Type	Tri Ton		Cho Moi		Thoai Son	
		Species	Proportion (%)	Species	Proportion (%)	Species	Proportion (%)
1	Pets	42	71,2	43	75,4	40	74,1
2	Natural enemies	13	22,0	10	17,5	11	20,4
3	Unknown	4	6,8	4	7,0	3	5,6
	Total species	59	100	57	100	54	100

The total number of individuals recorded in the three field models was 1,093, which was higher than in the 788 recorded in the control fields. The data show that both the number of insect species and natural enemies were greater in the model fields compared in the control fields, particularly for spiders, which comprised the largest proportion with 13 species. Additionally, the total number of species in the model fields consistently exceeded that of the control fields across all study regions.

Table 6. Number of insects and spiders by functional groups

Functional group	Tri Ton		Cho Moi		Thoai Son		Total*
	Experimental	Control	Experimental	Control	Experimental	Control	
Planthoppers	6	6	5	5	6	6	8
Herbivores	6	7	6	7	5	6	9
Spiders	8	6	8	6	5	4	13
Parasites	12	10	11	9	11	8	16
Predators	11	8	9	7	9	8	12
Others	4	4	4	4	2	3	8
Total	47	41	43	38	38	35	66

*Notes: *The total number of species recorded across all three districts.*

In the experimental fields, the number of species collected varied across different growth stages. Predators, including both predatory and parasitic species, as well as spiders, exhibited greater diversity than pests, with spiders representing the highest number of species (13 species). Additionally, the total number of insects and spiders in the experimental fields consistently

surpassed that in the control fields, while the number of planthopper species was similar in both experimental and control fields. However, herbivorous species were more abundant in the control fields compared to the experimental fields (see Table 6).

4. CONCLUSION

The study was conducted in the districts of Cho Moi, Tri Ton, and Thoai Son, which represent three prominent ecological regions of An Giang province. Biodiversity in these study areas was assessed by evaluating the presence of fish, insects, and natural enemies in the fields. The results indicated the presence of 11 fish species belonging to 4 orders and 8 families, along with 66 beneficial insect species across the three study areas. During the different growth stages of the rice, a total of 1,039 insect individuals were observed in the experimental fields, compared to 788 individuals in the control fields.

Additionally, the diversity index of beneficial insects in the experimental fields was consistently higher than in the control fields, with values of 2.64, 2.58, and 2.45 for Thoai Son, Tri Ton, and Cho Moi, respectively. These findings demonstrate that the ecological regions where the deep-water rice model was implemented exhibited superior biodiversity of fish, insects, and natural enemies compared to the conventional farming methods used in control fields. Therefore, the application of the deep-water rice cultivation model not only reduces environmental impact but also enhances the diversity of insects and natural enemies in the fields, potentially providing an additional source of income from fish.

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