

Comparative Evaluation of Sampling Methods for Insect Diversity and Guild Composition during Rice Reproductive Stage

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ABSTRACT

Paddy fields are complex agroecosystems that host diverse insect communities, including pests, natural enemies, and decomposers. Monitoring this diversity is vital for effective integrated pest management (IPM), but it remains challenging due to habitat complexity and heterogeneity. Although various sampling methods are available, few studies have systematically compared their efficiency in capturing insect diversity. Thus, this study aims to evaluate the effectiveness of different sampling methods- bucket-light trap, sticky trap, and sweep net- in assessing insect diversity in paddy field agroecosystems. The study was conducted during the reproductive stage of a single paddy cultivation season in Pekan Darat, Butterworth, Penang, Malaysia. A total of 86,742 insect individuals from 10 orders and 36 families were captured during the rice reproductive stage. The bucket-light trap method recorded the highest number of captured species, comprising 10 orders and 31 families, followed by the sticky trap (seven orders, 18 families) and sweep net (six orders, 15 families). The family Micronectidae was the most abundant in bucket-light traps, while Cicadellidae and Chironomidae were most prevalent in the sticky traps and sweep nets, respectively. The sticky trap method yielded the highest Shannon-Wiener diversity index (2.248) and evenness index (0.778), whereas the bucket-light trap method recorded the highest species richness (Margalef Index: 2.64). These findings highlight the significance of employing multiple sampling techniques to capture a comprehensive representation of insect community structure in agricultural ecosystems, which can inform effective management strategies and biodiversity monitoring efforts.

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1. INTRODUCTION

Paddy field ecosystems are vital agricultural landscapes that play a central role in food security, particularly in rice-dependent countries including Malaysia. These ecosystems are characterised by a unique combination of aquatic and terrestrial habitats, which create a dynamic and biodiverse environment. Spiders and insects are among the most abundant arthropods, which serve as natural enemies including predators and parasitoids, decomposers, and also herbivorous pests (Ali et al., 2022; Ohwaki, 2015). Their ecological roles are integral to maintain the health of the ecosystems, supporting ecological processes, and influencing crop productivity.

Insects contribute to ecosystem services such as pest population, nutrient cycling, and pollination, which are important for maintaining balance in agroecosystems (Rupali et al., 2024). Research indicates that 27 insect species have been identified as predators, while 14 soil-dwelling species function as decomposers (Raut et al., 2023; Sumah &

Kusumadinata, 2024). Conversely, approximately 70 insect species are recognized as pests, with 20 of these categorized as being of significant importance due to their substantial contribution to economic losses in rice production (Poolprasert & Jongjitvimol, 2014). Effective pest management strategies require detailed knowledge of insect communities, including their diversity, abundance, and ecological guilds (Umeh et al., 2023). Accurate monitoring of these communities can provide valuable insights into the health and stability of the ecosystem and support decision-making processes in integrated pest management (IPM) programs.

Monitoring insect diversity in paddy fields is a complex task that depends heavily on the choice of sampling techniques. The heterogeneity of paddy fields, influenced by factors such as crop phenology, water levels, and microhabitat variability, necessitates the use of diverse sampling methods to capture the full spectrum of insect communities. Common techniques include sweep nets, sticky traps, light traps, pitfall traps, and aquatic nets, each of which targets specific insect groups based on their behavior, activity periods, and habitat

preferences. For instance, light traps are highly effective at capturing nocturnal insects such as moths, true bugs, and beetles (Ramli, 2018; Rashid et al., 2022), while sweep nets are ideal for collecting foliage-dwelling insects during the day. The efficiency and limitations of these methods vary widely, making it essential to evaluate their comparative performance in capturing insect diversity.

Despite the availability of various sampling techniques, few studies have systematically compared their efficiency in paddy field ecosystems. This lack of information creates a challenge for researchers and field practitioners, as using unsuitable or relying on just one sampling tool might result in biased or incomplete data of insect communities. Without a clear understanding of how each method performs in actual field conditions, it is difficult to create standardized and reliable monitoring protocols for long-term biodiversity studies. Furthermore, the lack of method-specific data makes it harder to understand the roles of different insects, whether harmful pests or beneficial species, especially during important growth stages such as the rice reproductive phase, when insect activity is typically highest.

Therefore, this study addresses the problem by comparatively evaluating the performance of various insect sampling techniques in capturing insect diversity and guild composition in a paddy field during the reproductive stage of rice growth. The findings aim to inform more effective and standardized protocols for ecological monitoring and integrated pest management in rice agroecosystems.

2. MATERIALS AND METHODS

2.1. Ethical statement

This study involved field sampling of insect fauna and did not include any endangered or protected species. All insect collection methods adhered to ethical standards for scientific research and were conducted with minimal disturbance to the local environment. Permission to access and conduct sampling at the paddy field in Pekan Darat, Butterworth, Penang, was obtained from the landowner.

2.2. Study site

The study was conducted in a 2.5-acre paddy field located in Pekan Darat, Butterworth, Penang, Malaysia (5°28'46.7"N, 100°24'19.4"E). This area is within the designated granary area, where surrounding land use is dominated entirely by paddy cultivation and no other major crops or plantations are present in the vicinity. The field was cultivated with the MR297 paddy variety, a commonly used cultivar in Malaysia, under conventional agricultural practices. Sampling was carried out during the reproductive stage (55 to 70 days after sowing) of the paddy plants due to its high insect

activity, as this stage of growth provides abundant resources for both pests and beneficial insects. The sampling process was carried out twice, covering two intervals within the reproductive stage, from 21 to 23 December 2023 and from 27 to 29 December 2023. The timing of the study coincided with the peak period of insect presence, ensuring that the sampling methods would capture a representative sample of the insect community. During the study period, the area experienced typical northeast monsoon conditions, with an average monthly precipitation of approximately 250–300 mm, based on general regional meteorological data for December.

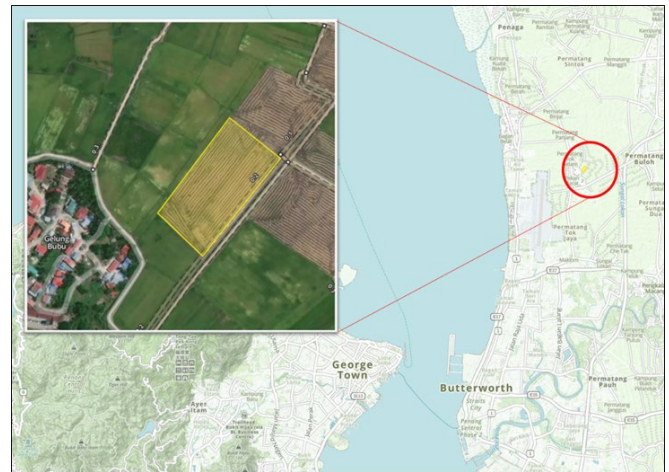


Figure 1: Map of sampling site in Pekan Darat, Butterworth, Penang.

2.3. Insect sampling

Insect sampling was conducted using three commonly employed methods: bucket-light traps, sticky traps, and sweep nets. Each sampling method was selected to capture a broad spectrum of insect species while minimizing bias in data collection. Bucket-light traps were used to collect nocturnal and flying insects. Sticky traps were effective in passively capturing small flying insects, especially during daylight hours, while sweep nets were employed to actively sample foliage-dwelling insects, including pests and their natural enemies, within the plant canopy. The combination of active and passive, as well as diurnal and nocturnal, sampling techniques was intended to reduce methodological bias and provide a more representative assessment of the insect community in the paddy field ecosystem.

2.3.1 Bucket light trap

Two bucket light traps were utilised for this study in order to capture nocturnal and light-attracted insect species. The traps were designed using a specific light source optimised for the insect's visual sensitivity. Each trap consisted of a 5-liter white plastic bucket with dimensions of 95 cm in height and 30 cm in diameter, equipped with an actinic fluorescent black light sourced from FSL Lamp (Figure 2A). The light emits a fluorescent ultraviolet (light blue) glow

with a wavelength range of 350-370 nm. The light was powered using a portable power inverter, operating within a voltage range of 10-15V and connected to a rechargeable lead-acid battery (Figure 3A). To ensure the effective capture and preservation of insects, ethyl acetate was used as a killing agent. Sponges soaked with ethyl acetate were placed inside the bucket, releasing fumes that quickly anesthetised and killed the insects upon entry. The light traps were set up at dusk (7.30 PM) and operated until 10.00 PM. This time frame was selected to standardize sampling across days while reducing logistical challenges associated with later hours. The captured insects were then transferred from the bucket into labeled plastic bags before being transported to the laboratory under controlled conditions for further sorting and identification. The traps were deployed at random locations across the paddy field, and the sampling was repeated twice during the growth stage of the paddy crop.

2.3.2 Sweep net

A sweep net was utilised to sample insects during daytime hours, targeting species that inhabit the paddy canopy and surrounding vegetation. The sweep net had a 40 cm diameter opening, an 80 cm deep net cloth, and a 120 cm handle to facilitate effective sampling in the paddy field (Figure 2C). The sampling method followed the protocol described by Nasiruddin & Roy (2012). The sweep net was swung in a 180° arc, with the rim of the net striking the top 15 to 20 cm of the paddy plants (Figure 3B). Each complete 180° swing was counted as one sweep. A single sample consisted of 10 random sweeps, taken at intervals of 10 steps across the field to ensure spatial coverage. Ten such samples were collected on each sampling day. Sampling was conducted during the early hours of the day, between 8:00 AM and 10:00 AM, when insect activity is typically high. This procedure was repeated twice during the rice growth stage. After collection, all insects were killed using ethyl acetate, which was applied via soaked cotton placed in a zip-lock plastic bag before being transported to the laboratory for further analysis.

2.3.3 Sticky trap

For the sticky traps, the sampling site was first divided into four subplots (or strata), each measuring approximately 0.63 acres, to ensure adequate spatial coverage of the study area. In each plot, four yellow sticky traps, which have the dimension of 25 cm x 20.5 cm (Figure 2B), were deployed resulting in a total of sixteen traps per sampling session. Each trap was affixed to one-meter-long pole, which was placed securely between the paddy plants (Figure 3C). The traps were positioned at the top of the paddy plants, ensuring they were in direct contact with the canopy where insect activity is concentrated. This setup maximised the capture efficiency of the traps by targeting insects that rest

or move along the upper portions of the paddy plants. The traps were installed in the morning and left for two days. After two days, the traps were carefully removed from the pole and brought back to the laboratory for the identification.

2.4. Insect identification and guild classification

The collected insect samples were identified to the family level using standard entomological identification keys by Johnson & Triplehorn (2004). Following identification, the insects were categorised into functional guilds based on the classification system proposed by Olivier et al., (2014). The guilds were classified according to their trophic roles, encompassing categories including herbivorous (plant feeders), parasitoids (organisms that develop in or on a host), predators (insect-consuming organisms), detritivores/saprophagous (decomposers feeding on organic matter), and other organisms contributing to ecosystem functions, such as visitors or pollinators.

2.5. Data analysis

The diversity indices, including the Shannon-Weiner Index, Evenness Index, and Margalef Index were used to determine the insect's diversity, evenness and richness for each of the sampling methods. In addition to diversity analysis, a comparison of the natural enemy-to-pest ratio was conducted to assess the ecological balance within the insect community captured by each sampling technique. This analysis aimed to provide insights into the functional role of insect assemblages and to evaluate which sampling technique best reflects the predator-prey dynamics.



Figure 2: Sampling tools for the study; (A) bucket-light trap, (B) sticky trap and (C) sweep net.



Figure 3: Sampling conducted for different methods in paddy field; (A) bucket-light trap, (B) sweep net, and (C) sticky trap.

3. RESULT AND DISCUSSION

During the reproductive stage of paddy growth, a total of 86,742 insect individuals were captured, representing 10 orders and 36 families. Among these, the bucket light traps yielded the highest capture, comprising 10 orders, 31 families, and 85,666 individuals (Table 1). The sticky traps captured seven orders, 18 families, and 795 individuals (Table 2), while the sweep net method accounted for six orders, 15 families, and 281 individuals (Table 3).

The paddy reproductive stage provides a more conducive environment for various organisms, including insects. During this phase, paddy plants undergo significant vegetative development, producing flowers and grains that serve as essential food sources for herbivorous pests (Nawaz & Farooq, 2017). Paddy stem borers (order: Lepidoptera, family: Crambidae) infest the paddy plants from the vegetative to reproductive stage, causing dead hearts and whiteheads symptoms (Shamik, 2020). Besides, brown planthoppers (order: Hemiptera, family: Delphacidae) exhibit peak infestation during the booting stage, which occurs within the reproductive phase of the paddy plant development (Iamba & Dono, 2021). The increased abundance of herbivores in turn attracts natural enemies such as predatory and parasitoid insects. This will promote a complex ecological interaction within the agroecosystem. Furthermore, the management practice of maintaining water in paddy fields during the reproductive stage of paddy cultivation to support plant growth also influences insect diversity. This practice creates a favorable habitat for both aquatic and semi-aquatic insect species (Che Salmah et al., 2017). This combination of abundant vegetation, food availability, and stable water environment enhances insect diversity. In contrast, during the vegetative stage, although water is also present, the paddy plants are still less developed, which offers limited food and habitat availability for certain insects that rely on mature plant structures. Similarly, in the ripening stage, water levels are gradually reduced or removed from the fields to facilitate crop harvesting (Mathew & Livingstone, 2022). This condition further limits the habitat and reduces the insect populations.

This study recorded a total of 10 orders, 36 families, and 86,742 insect individuals, the majority of which were

collected using the bucket-light trap method. This number is significantly higher compared to previous studies by Hashim et al., (2017), which also employed a light trap for insect sampling. The increased capture efficiency from this study may be due to the design features of the bucket-light trap. Unlike traditional light traps that are suspended with a white curtain at a higher setup, the bucket-light trap was positioned closer to the ground, which is effective in attracting ground-dwelling and flying insects (Bhandari et al., 2018). Besides, the trap was also equipped with a collection bucket that prevents the insects from escaping after being attracted to the light. The use of ethyl acetate as a killing agent furthered the trap's efficiency by ensuring that the captured insects were immobilised upon entry. This setup simplified the collection process as compared to the conventional light trap that requires manual collection, which is more labor-intensive and prone to insect escape.

The bucket-light trap recorded the highest number of insect orders and families, with 10 orders, 31 families, as compared to the sweep net and sticky trap methods. This can be due to the unique mechanism of light traps, which utilize specific wavelengths of light that are known to be highly attractive to many insect species. Studies indicate that fluorescent-UV light with wavelengths below 400 nm is particularly effective in attracting insects such as flies and moths (Hogsette, 2019; Wilson et al., 2021). In contrast, sticky traps depend on passive capture through adhesive surfaces, which do not actively attract insects but merely capture those that come into contact with them. Moreover, light traps can cover a larger area and attract insects from a wider radius compared to sticky traps and sweep nets. This broader attraction range allows for a higher overall catch rate (Wilson et al., 2021).

The bucket-light trap method recorded the highest number of insects from the family Micronectidae (Order: Hemiptera), with 83,225 individuals captured (Table 1). Micronectidae are semi-aquatic insects known for their positive phototactic behavior. Similar observations were reported where a large number of Micronectidae were drawn to artificial lights inside residential buildings (Lee et al., 2021). These insects can hop on the ground and fly up to human knee-level, making them susceptible to being trapped by bucket-light traps positioned at ground level. In terms of trophic guild composition, predators were the most dominant group, with 12 insect families represented (Figure 4). The comparison of natural enemies to pests yielded a ratio of 14:8/7:4, indicating a higher capture rate of natural enemies compared to pests (Figure 5). This finding contrasts with the study by Hashim et al., (2017), which recorded more pest species. The predominance of predators in this study was primarily from the Coleoptera group, such as Staphylinidae

and Carabidae. The ground-level setup of the bucket-light trap likely enhanced its effectiveness in capturing predatory beetles, which are capable flyers attracted to light emitted by the trap. Besides, predators such as Staphylinidae are also more mobile and exhibit active foraging behavior, preying on the brown planthopper, *Nilaparvata lugens*, which increases the likelihood of being trapped (Vinothkumar, 2014). Their ability to fly long distances toward light makes them highly susceptible to capture.

Table 1: List of insects captured in paddy field using bucket-light trap method.

Order	Family	Guild	Total no. captured
Odonata	Libellulidae	Predator	1
	Coenagrionidae	Predator	10
Hemiptera	Belostomatidae	Predator	16
	Delphacidae	Herbivores (pest)	55
	Cicadellidae	Herbivores (pest)	34
	Micronectidae	Detritivores	83225
	Reduviidae	Predator	2
	Miridae	Herbivores (pest)	110
	Gerridae	Predator	1
	Pentatomidae	Herbivores (pest)	1
	Notonectidae	Predator	92
Coleoptera	Hydrophilidae	Detritivores	291
	Scarabaeidae	Herbivores (pest)	9
	Staphylinidae	Predator	298
	Coccinellidae	Predator	1
	Carabidae	Predator	105
	Noteridae	Predator	79
	Dytiscidae	Predator	38
Hymenoptera	Formicidae	Others	1220
	Braconidae	Parasitoid	12
Lepidoptera	Crambidae	Herbivores (pest)	13
	Hesperiidae	Herbivores (pest)	1
	Noctuidae	Herbivores (pest)	6
Orthoptera	Gryllidae	Others	5
Blattodea	Termitidae	Detritivores	1
Diptera	Tipulidae	Detritivores	5
	Ephydriidae	Detritivores	3
	Chironomidae	Detritivores	14
	Tachinidae	Parasitoid	1
Dermoptera	Anisolabididae	Predator	15
Ephemeroptera	Baetidae	Detritivores	2
10 orders	31 families		Total: 85666

The sticky trap method recorded the highest number of insects from the family Cicadellidae (order: Hemiptera), with 168 individuals captured (Table 2). The dominance of this family aligns with the ecological behavior of Cicadellidae, as they are highly mobile and frequently land on surfaces while feeding or resting. This makes them more susceptible to being captured by sticky traps, which were placed among the vegetation of the paddy plants. Santi et al., (2023) similarly reported that yellow sticky traps captured the highest number of *Nephotettix virescens* (green leafhoppers) and *Nilaparvata lugens* (brown planthoppers) compared to other trapping methods. In terms of trophic guild composition, herbivores (pests) and detritivores were the most dominant groups, comprising six insect families (Figure 4). A comparison of the

proportion of natural enemies to pests revealed a ratio of 4:6, or 2:3, indicating a higher capture rate of pests relative to natural enemies (Figure 5). Many insects are particularly attracted to the yellow colour due to its association with food sources like flowers or stressed plants, which serve as visual cues (Hodgson, 2018). Yellow sticky traps are commonly used in gardens and agricultural fields for pest control and monitoring (Rodriguez-Saona et al., 2012; Wilson & Shade, 1967). Previous research has also confirmed the high efficiency of yellow sticky traps in capturing paddy pests, including *Hydrellia* sp., *Leptocorisa oratorius*, *N. virescens*, and *N. lugens* (Santi et al., 2023). However, sticky traps are less effective at attracting predatory insects, as these insects rely on active hunting strategies rather than passive contact.

Table 2: List of insects captured in paddy field using sticky trap method.

Order	Family	Trophic	Total no. captured
Hemiptera	Delphacidae	Herbivores (pest)	99
	Cicadellidae	Herbivores (pest)	168
	Miridae	Herbivores (pest)	13
	Micronectidae	Detritivores	13
Hymenoptera	Braconidae	Parasitoid	93
	Formicidae	Others	6
Diptera	Chironomidae	Detritivores	120
	Phoridae	Detritivores	32
	Chloropidae	Herbivores (pest)	136
	Drosophilidae	Detritivores	28
	Tachinidae	Parasitoid	44
	Tipulidae	Detritivores	3
	Anthomyiidae	Herbivores (pest)	17
	Culicidae	Others	12
Lepidoptera	Crambidae	Herbivores (pest)	4
Odonata	Coenagrionidae	Predator	4
Coleoptera	Coccinellidae	Predator	2
Ephemeroptera	Baetidae	Detritivores	1
7 orders	18 families		Total: 795

The sweep net method captured 281 insect individuals comprising six orders and 15 families (Table 3). This number is slightly lower compared to previous studies by Hashim et al., (2017) and Nurul Farisa et al., (2022), which reported seven orders, 19 families, and seven orders, 36 families, respectively. The lower count in this study could be due to limited sampling occasions, as only two sampling sessions were conducted over a two-week period during the rice growth stage. Sweep net also recorded the least number of insects as compared to the two others sampling methods. This finding aligns with previous research by Hendawy & Abdel-Hamid (2016), which documented that sweep nets are often less efficient as compared to water pan traps and pitfall traps. Although sweep nets remain one of the most commonly used tools for sampling insect populations, their effectiveness depends on various factors, including environmental conditions and sampling methods.

Table 3: List of insects captured in paddy field using sweep net method.

Order	Family	Guild	Total no. captured
Odonata	Coenagrionidae	Predator	37
	Libellulidae	Predator	2
Hymenoptera	Braconidae	Parasitoid	6
	Formicidae	Others	1
Lepidoptera	Crambidae	Herbivores (pest)	5
Hemiptera	Cicadellidae	Herbivores (pest)	23
	Delphacidae	Herbivores (pest)	22
	Miridae	Herbivores (pest)	11
Diptera	Chironomidae	Detritivores	139
	Tachinidae	Parasitoid	16
	Anthomyiidae	Herbivores (pest)	3
	Tipulidae	Detritivores	2
	Drosophilidae	Detritivores	7
Coleoptera	Coccinellidae	Predator	5
	Carabidae	Predator	2
6 orders	15 families		Total: 281

The sweep net method yielded the highest number of insects from the family Chironomidae (order: Diptera), with 139 individuals collected. This was followed by the families Coenagrionidae (Order: Odonata) and Cicadellidae (Order: Hemiptera), with 37 and 23 individuals, respectively. These insects are commonly found flying or resting within the paddy canopy, making them highly susceptible to capture using a sweep net (Ikhsan et al., 2021). In terms of trophic guild composition, herbivores (pests) represented the most dominant group captured using the sweep net method, comprising five insect families (Figure 4). This is because most of the rice pests, including brown planthoppers, green leafhoppers, and rice stink bugs, are typically active within the canopy of paddy plants (Bhavanam et al., 2021; Nasrullah & Rafsanjani, 2022; Zakqy & Wiyatiningsih, 2023). Duman (2019) documented that the sweep nets show higher efficiency in capturing certain insect families, such as Phloeothripidae, during specific growth stages of paddy. A comparison of the proportion of natural enemies (predators + parasitoids) to pests revealed a ratio of 6:5, indicating a higher capture rate of natural enemies compared to pests (Figure 5). These results are not significantly different due to the fact that the sweep net method performance can be inconsistent, which can vary based on several factors, including technique variability, environmental conditions, and vegetation characteristics.

The calculated diversity indices revealed distinct patterns among sampling methods. The sticky trap method recorded the highest Shannon-Wiener Index (2.248) and Evenness Index (0.778), indicating a well-balanced and diverse insect community. In contrast, the bucket-light trap exhibited the lowest Shannon-Wiener Index (0.182) and Evenness Index (0.053), despite recording the highest species richness value (2.64) based on the Margalef Index. This inconsistency is due to the bucket-light trap's capture of an overwhelmingly large number of Micronectidae individuals

(over 80,000), while other families contributed only 1-1000 individuals each. This extreme dominance skewed the evenness component, drastically reducing the overall Shannon-Wiener Index despite the high species richness. Since evenness has a greater influence than richness on the Shannon-Wiener Index, the metric becomes a less accurate representation of true diversity, effectively serving as a biased measure of evenness (Strong, 2016). Light traps are particularly effective in attracting specific insect taxa due to their phototactic behavior, resulting in disproportionate captures (Merckx & Slade, 2014). While the bucket-light trap captured a wide range of insect families and orders, the uneven distribution caused by the dominance of a single family lowered its diversity score.

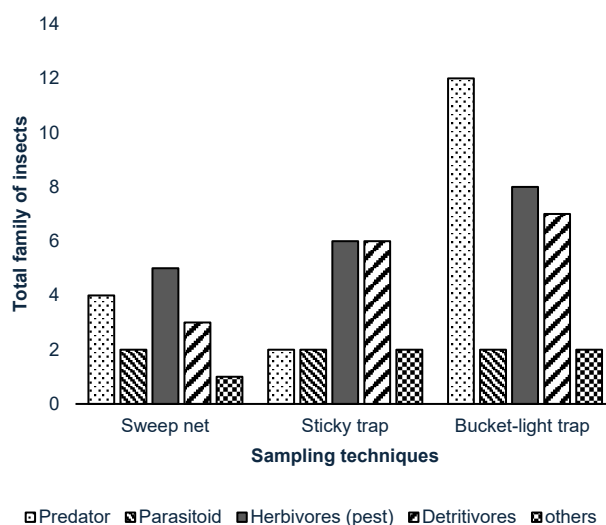


Figure 4: Composition of insect guilds captured in paddy field for the different sampling techniques

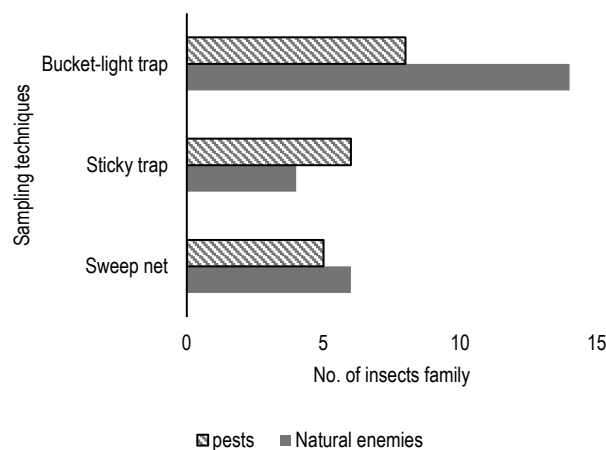


Figure 5: Proportion of natural enemies to pests for each of the sampling methods

4. CONCLUSION

In conclusion, this study demonstrates the relative effectiveness of different sampling techniques in assessing insect diversity in paddy agroecosystems. The bucket light trap was particularly effective in capturing a high number of insect orders and families, especially among nocturnal and predatory groups. The sticky trap yielded high insect diversity and evenness, effectively sampling herbivores and detritivores. Meanwhile, the sweep net proved valuable in collecting canopy-dwelling pests and their natural enemies during the day. These findings highlight that each method has specific strengths and sampling biases based on insect behavior and activity periods. Therefore, relying on a single technique may not provide a complete representation of the insect community. The observed differences in diversity indices across sampling methods underscore the importance of employing a combination of techniques to achieve a more comprehensive assessment of insect diversity and guild composition. These insights contribute to more effective pest management and improved ecological monitoring strategies in rice-based agricultural landscapes.

REFERENCES

- Ali, M. P., Biswas, M., Clemente-Orta, G., Kabir, M. M. M., Datta, J., Haque, S. S., Qin, X., Landis, D., Kaur, P., Pittendrigh, B. R., & Howlader, M. T. H. (2022). Landscape diversity influences the arthropod species diversity in the rice field. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.740287>
- Bhandari, G., Jha, S. K., Giri, Y. P., Manandhar, H. K., Jha, P. K., Devkota, N., Thapa, P., & Thapa, R. B. (2018). Performance evaluation of locally developed black light trap for maize insects monitoring in Chitwan, Nepal. *Journal of Maize Research and Development*, 3(1), 98–107. <https://doi.org/10.3126/jmr.v3i1.18926>
- Bhavanam, S., Wilson, B., Blackman, B., & Stout, M. (2021). Biology and Management of the Rice Stink Bug (Hemiptera: Pentatomidae) in Rice, *Oryza sativa* (Poales: Poaceae). *Journal of Integrated Pest Management*, 12(1). <https://doi.org/10.1093/jipm/obab014>
- Che Salmah, M. R., Siregar, A. Z., Abu Hassan, A., & Nasution, Z. (2017). Dynamics of aquatic organisms in a rice field ecosystem: effects of seasons and cultivation phases on abundance and predator-prey interactions. *Tropical Ecology*, 58(1), 177–191.
- Duman, M. (2019). Efficacy of different sampling methods in pest monitoring of direct seeded rice at different growth stages. *Applied Ecology and Environmental Research*, 17(4). https://doi.org/10.15666/aeer/1704_1020710220
- Hashim, N. A., Abd Aziz, M., Basari, N., Saad, K., Jasmi, A. H., & Ab Hamid, S. (2017). Diversity and guild structure of insects during rice flowering stage at a selected rice field in Penang, Malaysia. *Malaysian Applied Biology*, 46(3), 161–169.
- Hendawy, A. S., & Abdel-Hamid, G. M. (2016). Efficiency of Sampling Techniques for Collecting Hymenopterous Insects Inhabiting Rice Nurseries. In *J. Plant Prot. and Path.*, Mansoura Univ (Vol. 7, Issue 6).
- Hodgson, L. (2018, April 21). *When Insects See Yellow*. *Laidback Gardener*. <https://laidbackgardener.blog/2018/04/21/when-insects-see-yellow/>
- Hogsette, J. A. (2019). Turning Ultraviolet Light Traps On and Off Increases Their Attraction to House Flies (Diptera: Muscidae). *Journal of Insect Science*, 19(1). <https://doi.org/10.1093/jisesa/iev126>
- Iamba, K., & Dono, D. (2021). A Review on Brown Planthopper (*Nilaparvata lugens* Stål), a Major Pest of Rice in Asia and Pacific. *Asian Journal of Research in Crop Science*, 7–19. <https://doi.org/10.9734/ajrcs/2021/v6i430122>
- Iksan, Z., Hidrayani, H., Yaherwandi, Y., & Hamid, H. (2021). Effectiveness of sweep net, yellow pan trap and malaise trap for sampling parasitic hymenoptera on tidal swamp rice. *Aceh Journal of Animal Science*, 6(2), 62–68.
- Johnson, N., & Triplehorn, C. A. (2004). *Borror and DeLong's introduction to the study of insects* (7th ed.). Brooks/Cole.
- Lee, L., Foo, M., & Oh, S. (2021). Biodiversity Record: A swarm of pygmy water boatman, *Micronecta haliploides*. *Nature in Singapore*, e2021099.
- Mathew, V., & Livingstone, A. R. (2022). Diversity of Insects in The Paddy Fields of Mundakam Vayal, Kannur District. *Uttar Pradesh Journal of Zoology*, 11–16. <https://doi.org/10.56557/upjz/2022/v43i32906>
- Merckx, T., & Slade, E. M. (2014). Macro-moth families differ in their attraction to light: implications for light-trap monitoring programmes. *Insect Conservation and Diversity*, 7(5), 453–461. <https://doi.org/10.1111/icad.12068>
- Nasiruddin, M., & Roy, R. C. (2012). Rice Field Insect Pests During the Rice Growing Seasons in Two Areas of Hathazari, Chittagong. *Bangladesh Journal of Zoology*, 40(1), 89–100. <https://doi.org/10.3329/bjz.v40i1.12898>
- Nasrullah, M. K., & Rafsanjani, A. (2022). Distribution of Rice Plant Pests (*Oryza sativa* L.) in Vegetative and Generative Phases: analytical study. *AGRICULTURE: Advances Agriculture Science & Farming*, 1(3), 123–126.
- Nawaz, A., & Farooq, M. (2017). Rice Physiology. In *Rice Production Worldwide* (pp. 455–485). Springer International Publishing. https://doi.org/10.1007/978-3-319-47516-5_17
- Nurul Farisa, R., Muhammad Muzammil, M. N., Zulidzham, M. S., & Mohd Fahimee, J. (2022). Insect Diversity at Glutinous Paddy Field, Telok Chengai, Alor Setar, Kedah, Malaysia. *Transactions of the Malaysian Society of Plant Physiology*, 29, 105–108.
- Ohwaki, A. (2015). Ground arthropod communities in paddy fields during the dry period: Comparison between different farming methods. *Journal of Asia-Pacific Entomology*, 18(3), 413–419. <https://doi.org/10.1016/j.aspen.2015.05.001>
- Olivier, R. S., Aranda, R., Godoi, M. N., & Gracioll, G. (2014). Effects of environmental heterogeneity on the composition of insect trophic guilds. *Applied Ecology and Environmental Research*, 12(1), 209–220. https://doi.org/10.15666/aeer/1201_209220
- Poolprasert, P., & Jongjitvicol, T. (2014, July 3). *Arthropod Communities Inhabiting Organic Rice Agro-ecosystem*. International Conference on Agricultural, Ecological and Medical Sciences (AEMS-2014) July 3-4, 2014 London (United Kingdom). <https://doi.org/10.15242/IICBE.C714014>
- Ramli, M. R. (2018). *The effectiveness of the various light trap colour to attract and control the insect pests population in paddy field* [Unpublished Final Year Project Thesis]. Universiti Teknologi MARA.
- Rashid, M., Ridoy, M. K., Rahman, M. M., Rahman, M. M., & Mondal, M. F. (2022). Does solar light trap reduce the cost of pesticides used in rice field? *SAARC Journal of Agriculture*, 20(1), 171–183. <https://doi.org/10.3329/sja.v20i1.60615>
- Raut, A. M., Banu, A. N., Akram, W., Nain, R. S., Singh, K., Wahengabam, J., Shankar, C., & Shah, M. A. (2023). Impact of Pesticides on Diversity and Abundance of Predatory Arthropods in Rice Ecosystem. *Applied and Environmental Soil Science*, 2023, 1–10. <https://doi.org/10.1155/2023/8891070>
- Rodriguez-Saona, C. R., Byers, J. A., & Schiffhauer, D. (2012). Effect of trap color and height on captures of blunt-nosed and sharp-nosed leafhoppers (Hemiptera: Cicadellidae) and non-target arthropods in cranberry bogs. *Crop Protection*, 40, 132–144. <https://doi.org/10.1016/j.cropro.2012.05.005>
- Rupali, J. S., Hadimani, B. N., Vidya Madhuri, E., Bharath Kumar, B. M., Karthick Mani Bharathi, B., & Raikwar, S. (2024). A study to access the significant role of insects in decomposition and nutrient recycling. *International Journal of Advanced Biochemistry Research*, 8(9S), 110–114. <https://doi.org/10.33545/26174693.2024.v8.i9Sb.2065>
- Santi, I. S., Firmansyah, E., Febrian, B. M., & Listianto, H. (2023). The Effectiveness of Trap Colors Against the Catch of Rice Plant Pests. *Tropical Plantation Journal*, 2(1), 28–33. <https://doi.org/10.56125/tpj.v2i1.17>
- Shamik, D. (2020). Stem borers, an important yield reducing insect pest complex of rice in India: A review. *Journal of Entomology and Zoology Studies*, 8(5), 786–789.
- Strong, W. L. (2016). Biased richness and evenness relationships within Shannon–Wiener index values. *Ecological Indicators*, 67, 703–713. <https://doi.org/10.1016/j.ecolind.2016.03.043>
- Sumah, A. S. W., & Kusumadinata, A. A. (2024). The diversity of soil insects in rice field ecosystems. *Jurnal Biologi*, 6(2), 121. <https://doi.org/10.30821/biologi.v6i2.3054>
- Umeh, B. C., Avicor, S., Quartey, J. K., Kyerematen, R., & Dankyi, E. (2023). Insect Abundance and Diversity Under Different Pest-Managed Cocoa Agroecosystems. <https://doi.org/10.2139/ssrn.4635061>

- Vinothkumar, B. (2014). Status of Insect Pests and Natural Enemies in MID Hill Rainfed Rice Agroecosystem. *Madras Agriculture*, 101(9), 273–279. <https://cabidigitallibrary.org>
- Wilson, C. M., & Shade, R. E. (1967). Relative Attractiveness of Various Luminescent Colors to the Cereal Leaf Beetle and the Meadow Spittlebug. *Journal of Economic Entomology*, 60(2), 578–580. <https://doi.org/10.1093/jee/60.2.578>
- Wilson, R., Wakefield, A., Roberts, N., & Jones, G. (2021). Artificial light and biting flies: the parallel development of attractive light traps and unattractive domestic lights. *Parasites Vectors*, 14(28).
- Zakqy, N., & Wiyatiningsih, S. (2023, May 1). Diversity of Important Pests and Natural Enemies in Rice Plants. *Nusantara Science and Technology Proceedings*. <https://doi.org/10.11594/nstp.2023.3117>