Assessment of Microplastics Presence on Firefly (Coleoptera: Lampyridae) from Tumpat Mangrove, Kelantan.

By

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A report submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (Natural Resource Science) with Honours

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DECLARATION

I declare that this thesis entitled "Assessment of Microplastics Presence on Firefly (Coleoptera: Lampyridae) from Tumpat Mangrove, Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ______________________

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Date : ______________________

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Assessment of Microplastics Presence on Firefly (Coleoptera: Lampyridae) from Tumpat Mangrove, Kelantan.

ABSTRACT

Microplastics (MPs), defined as plastics equal or smaller than 5 mm in size, are an emerging contaminant that can affect both aquatic and terrestrial ecosystems. This study assessed the level of contamination of microplastics on the surface of fireflies (Coleoptera: Lampyridae) from Tumpat mangrove in Kelantan. There were 89 firefly specimens collected, consisting of 62 larvae and 27 adults. Each specimen were observed closely under a dissecting microscope and confirmed the results through a hot needle test. In total, 35 specimens had microplastic contamination, with 31 of 35 of the contaminated specimens being larvae and only 4 adults with microplastic contamination. The most common microplastic found on the fireflies were transparent strands followed by dark blue and yellow strands. Our results confirm that fireflies are exposed to environmental microplastics and are potential bioindicators of surface-level plastic pollution in mangrove ecosystems. These findings provide a robust baseline and emphasize the need for future studies of insect–microplastic interactions in coastal environment.

Penilaian Kehadiran Mikroplastik pada Kelip-kelip (Coleoptera: Lampyridae) dari Kawasan Paya Bakau Tumpat, Kelantan.

ABSTRAK

Mikroplastik (MP), yang ditakrifkan sebagai plastik yang sama atau lebih kecil daripada saiz 5 mm, ialah bahan cemar yang muncul yang boleh menjejaskan ekosistem akuatik dan daratan. Kajian ini menilai tahap pencemaran mikroplastik pada permukaan kelip-kelip (Coleoptera: Lampyridae) daripada paya bakau Tumpat, Kelantan. Terdapat 89 spesimen kelip-kelip yang dikumpul terdiri daripada 62 larva dan 27 ekor dewasa. Setiap spesimen diperhatikan dengan teliti di bawah mikroskop membedah dan mengesahkan keputusan melalui ujian jarum panas. Secara keseluruhan, 35 spesimen mempunyai pencemaran mikroplastik, dengan 31 daripada 35 spesimen yang tercemar adalah larva dan hanya 4 dewasa dengan pencemaran mikroplastik. Mikroplastik yang paling biasa ditemui pada kelip-kelip adalah helai lutsinar diikuti helai biru tua dan kuning. Keputusan kami mengesahkan bahawa kelip-kelip terdedah kepada mikroplastik alam sekitar dan merupakan bioindikator berpotensi bagi pencemaran plastik peringkat permukaan dalam ekosistem bakau. Penemuan ini memberikan garis dasar yang teguh dan menekankan keperluan untuk kajian masa depan tentang interaksi serangga-mikroplastik dalam persekitaran pantai.

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LIST OF ABREVIATIONS

MPs	Microplastics
FTIR	Fourier transform infrared Spectroscopy

CHAPTER 1

INTRODUCTION

1.0 Background of Study

Microplastics are plastic particles with a length of less than five millimeters. The conservation of environmental quality and its accompanying problems has become a major priority. Microplastics can be classified as primary or secondary based on their origins. Primary microplastics are manufactured intentionally with dimensions in the millimeter or sub-millimeter range, whereas secondary microplastics are the breakdown of larger plastic products through exposure to natural elements, physical forces, and biological or chemical processes. These compounds may originate from a variety of sources that are not properly handled. Industrial, household, and personal care goods are some of the sources of these plastics, which lead to microplastic development.

Microplastics have been found in several environments, including air, soil, fresh water, drinking water, seas, aquatic and terrestrial biota, food items, and human placenta and feces. Because of their small size, microplastics are easily carried by wind, water, and human activity, allowing them to reach even the most isolated and ecologically fragile areas, such as mangrove ecosystems (Koelmans et al, 2022). Malaysia has been acknowledged as a country with the greatest diversity of mangrove species (Idris et al., 2025). Mangroves provide essential habitat for terrestrial, marine, and aquatic animals, as well as food, medicine, fuel, and building materials for local populations. Mangrove trees provide lumber for building, fuel, charcoal, fishing poles, and pulp. Mangrove ecosystems are very well known for their dense root systems, which effectively trap sediments and pollutants, like microplastics. River currents and tidal actions will cause the microplastics to be transported towards the mangrove area.

Fireflies (Coleoptera: Lampyridae) live in a variety of settings, especially mangroves, rivers, and mountains. Fireflies are found in several settings, including mangroves, where their larvae feed on snails in the intertidal zone. *Pteroptyx* spp. are commonly found on trees and plants in estuary mangrove wetlands. *Pteroptyx tener* Olivier has been seen feeding on many mangrove plants, including *Sonneratia* spp., in Peninsular Malaysian forests (Jusoh et al., 2011). The presence of vegetation in mangrove areas offers a suitable habitat, hides them during the day, and boosts their chances of finding a mate (Seri et al., 2024).

The mangrove ecosystem has been recognized as a potential source for microplastics brought in by both marine and terrestrial activities (Deng et al, 2021). Despite global concerns about microplastic pollution, research in Malaysia, particularly in mangrove regions, remains restricted. Fireflies, which live in mangroves and rely on healthy ecosystems for reproduction and feeding, may be indirectly harmed by microplastics by consumption of contaminated prey or contact with polluted soil. Fireflies are regarded bioindicators of environmental health and have cultural and ecological value. In response to these gaps, this study aims to identify the microplastics presence on firefly (Coleoptera : Lampyridae), thus providing insights into the potential pathways of microplastic transfer within ecosystem and ways to conserve water quality and ecosystem in Tumpat Mangrove, Kelantan.

1.2 Problem Statement

Though fireflies are both predatory and prey in the food chain and therefore play an important role in mangrove biodiversity, as larvae they regulate the food web through invertebrate consumption, while the adult life stage are pollinators and provide a food source for birds, amphibians, and reptiles. Fireflies are well known as bioindicators of ecosystem health because their presence is heavily influenced by changes in the environment. No research has examined whether fireflies in Malaysian mangroves are being exposed to microplastics, through the consumption of microplastics from drifting contaminated plant, soil, or water surfaces. The lack of information restricts our understanding of how microplastics behave when in contact with insect exoskeletons and how microplastics attached to insect exoskeletons through external exposure may accumulate to form a projection of environmental pollution levels. Documenting microplastics outside of firefly exoskeletons could be a novel indicator of microbial levels in the mangrove ecosystem. This novel bioindicator could potentially reaffirm known but unexamined contamination pathways that may impact insect biodiversity.

1.3 Objective

1. To determine the presence of microplastics on the external surfaces of fireflies (Coleoptera: Lampyridae) collected from the Tumpat mangrove, Kelantan

1.4 Scope of Study

This study aims to identify any microplastics present on the external surfaces of fireflies (Coleoptera: Lampyridae) from the Tumpat mangrove ecosystem in Kelantan, Malaysia, more specifically, the Delta Tumpat mangrove ecosystem. Both adult and larval fireflies were hand-collected from the Delta mangrove using an aerial net during their active hours, and the coordinates for each sampling site were recorded. The fireflies were then taken to the laboratory. Once in the laboratory, each firefly was examined under a microscope to determine if any microplastics were attached to their external body parts, such as wings, thorax, abdomen, and legs. Microplastics were classified based on their visible characteristics, namely, type, shape, and colour. This study is an important attempt to create baseline data on the external contamination of fireflies via microplastics in a mangrove environment.

1.5 Significance of Study

This study presents significant baseline data on the occurrence of microplastics on the external surfaces of fireflies from a mangrove setting, a topic that has received very little research focus thus far. The project studied fireflies from the mangrove area of Tumpat in Kelantan and demonstrates the potential exposure of terrestrial insects to microplastic pollution from coastal systems. Fireflies are often considered sensitive bioindicators of the health of the ecosystem. Microplastics present on the fireflies' bodies may reflect the level of surface contamination across their habitat. The results from this study can be used as a baseline for similar ecological studies, as well as microplastics pollution monitoring involving terrestrial and semi-aquatic settings. Notably, this study raises scientific awareness of the problem plastic pollution causes to marine life, insects, and other less-studied taxa within the food web. It may also help inform local conservation initiatives and potentially contribute to the environmental management associated with planning for the protection of biodiversity in the mangrove systems of Malaysia.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Microplastics (MPs)

Plastics are synthetic organic polymers formed by the polymerization of monomers taken from oil or gas. Since the first modern plastic innovation in 1907, several low-cost manufacturing processes have been perfected, enabling the mass manufacture of a wide range of lightweight, durable, inert, and corrosion-resistant polymers (Rillig et al,2020). Although the earliest synthetic polymers, such as Bakelite, were developed in the early twentieth century, widespread usage of plastics outside of the military did not begin until after World War II. The resulting fast rise in plastics manufacturing is unprecedented, outperforming most other man-made materials (Geyer et al., 2017). Microplastics are microscopic pieces of plastic that are less than 5 mm in diameter. Due to their small size, microplastics can rapidly spread into the environment (Mohamed et al., 2023). Thus, it is crucial to view MPs as a complex group of pollutants (Smith M et al., 2018). To further complicate things, MPs that organisms may come into contact with come in a variety of sizes, shapes, polymer types, concentrations, and forms, such as fragments, foams, films, pellets, and most frequently fibers (Campanale et al., 2020). The Philippines is the third largest producer of plastic litter to the ocean and the leading emitter of plastic trash from river sources. Recent studies in the nation have found that plastic waste is common in estuaries, seagrass meadows, and beaches (Navarro et al., 2022).

Microplastics, or tiny pieces of plastic, were described by Thompson et al. (2004) in their study as being present in the sediments of the sea in European waters. Microplastic's variety is increased by the pollutants it contains. This multifaceted diversity, together with the likelihood that it will be consumed and absorbed by a wide variety of animals, has fueled worries that microplastics could pose a threat to both the environment and human health (Koelmans et al., 2022).

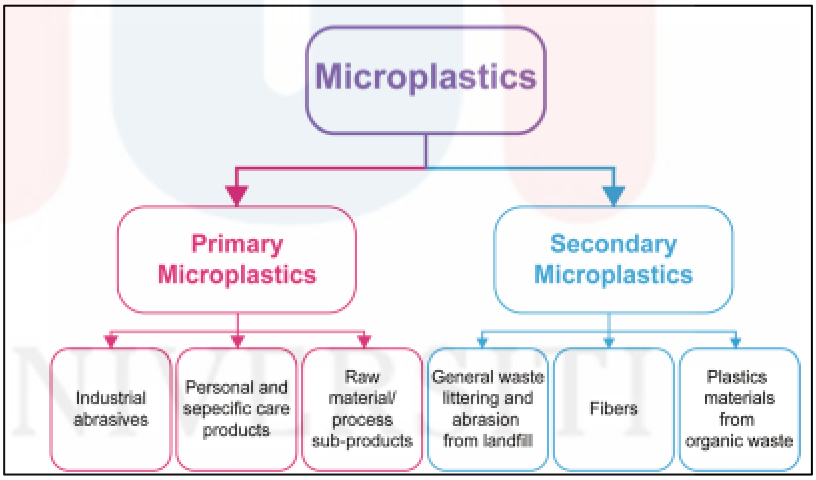

Figure 2.1: Primary and Secondary sources of microplastics (MPs) (Chia et al., 2021).

Plastics break down into microplastics when they are exposed to natural factors such as wind, exposure to sunshine, wave action, weathering, temperature, irradiation, pH, other severe environmental conditions, and physical stress (Navarro et al., 2022). The main sources of environmental microplastics (MPs) include plastic pellets, paint, sewage sludge, washing wastewater, artificial grass, rubber roads in cities, plastic running tracks in schools, and personal care products that contain microbeads. In the meantime, secondary sources include fishing waste, farming film, and other large-scale plastic wastes, as well as municipal garbage such plastic bottles and bags (An et al., 2020).

2.2 Microplastics (MPs) as Threats to Pollution

In 2019, MP pollution in terrestrial environments was 4 to 23 times greater than in marine habitats (Horton et al., 2017).Although plastic has been commonly used for a long time, its by-product microplastics have lately been a major issue of controversy worldwide (Kim & Lee, 2020). Microplastic emissions to the environment are projected to be between 10 and 40 million tons per year, and under business-as-usual scenarios, this figure might triple by 2040. Even if emissions could be rapidly reduced, they would continue to rise due to the fragmentation of legacy products (Thompson et al., 2024). Additionally, due to their small size, microplastics are easily swallowed by a variety of marine organisms, including zooplankton, fish, shellfish, and shrimp. The major issues regarding microplastics are connected with harmful compounds such as heavy metals and persistent organic pollutants, which result in marine creatures being exposed to these chemicals and passing them on to higher trophic levels (Mohamed et al., 2023b).

According to Iannilli et al. (2020), freshwater is a source of microplastics (MPs) that end up in the oceans. Rivers are the primary transit routes for plastic trash from land. Microplastics function as a transporter for heavy metals and organics, resulting in complex contaminants. These novel combinations of contaminants, once swallowed by aquatic creatures, are magnified up the food chain and can have unanticipated consequences for both aquatic organisms and humans (Tang et al., 2021). Large-scale and long-term trip investigations using trawls have also determined the amounts of microplastic contamination in the open ocean (Luo et al., 2019). MPs have been found at depths ranging from deep-sea bottoms to microlayers on sea surfaces (Song et al., 2014; Van Cauwenberghe et al., 2013). The geographical distribution of MPs contamination, particularly its high abundance in near-shore seawater, reveals a strong link between pollution sources from land and marine microplastic abundance (Luo et al., 2019).

2.3 Microplastics (MPs) and Mangrove Ecosystems

A mangrove forest is an ecosystem of plants and shrubs that are typically found around coastlines. A mangrove is a connecting point between land and water that is critical to the ecology, particularly for the aquatic population (Pradit et al., 2022). Mangroves are extremely productive wetlands that may protect land against coastal erosion, hurricanes, and tsunamis (Gjisman et al., 2021). Mangroves are also a home for animals and provide nursery grounds for numerous fish and shellfish, as well as trap sediments and suspended materials in the water column (Powell et al., 2019). Furthermore, it has been shown that the aerial roots of mangrove trees play an essential role in trapping marine plastic because of their complex root systems, which may filter and impede the flow of water, resulting in the buildup of microplastics in sediments (Martin et al., 2019).

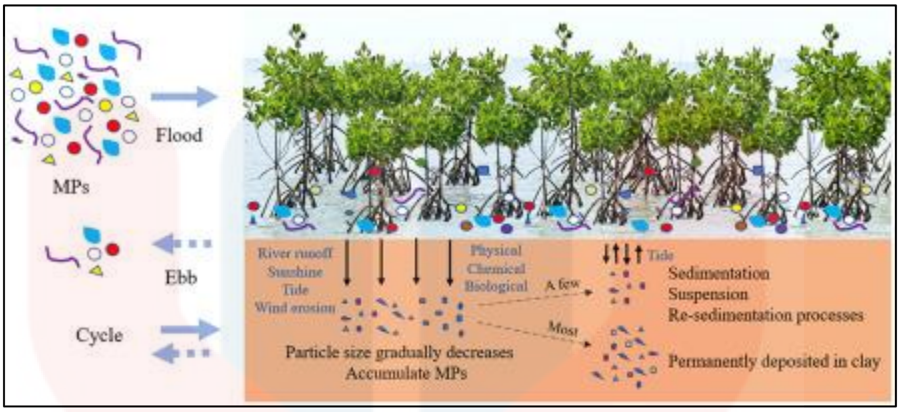

Figure 2.2 : Microplastic formation in the mangrove area (Liu et al., 2021).

Mangrove forests in Malaysia are extremely affected to plastic pollution because of their position at the confluence of land and ocean, where rubbish from surrounding industrial regions is occasionally disposed of, whether purposefully or unintentionally (Ibrahim et al., 2022). In recent years, pushed by industry and urbanization, a huge amount of land-based pollutants has made its way into mangrove forests (Bolivar-Anillo et al., 2023). Some indoor simulation experiments have revealed that seawater intrusion transports marine plastics to coastal groundwater, and some plastic particles attach to the surfaces of porous media. Microplastics are discharged back into the ocean during the groundwater and seawater replenishment process (Liu et al., 2022).

2.4 Description of Firefly (Coleoptera: Lampyridae)

Fireflies (Coleoptera: Lampyridae) are among our most charismatic insects, with unique bioluminescent courting displays that make them a good model for invertebrate conservation efforts. Firefly beetles, with over 2200 species worldwide, exhibit surprisingly diverse behaviors and life history traits, including nonluminous day-active adults with pheromone-based courtship, glow-worm fireflies with flightless females, and flashing fireflies whose courtship relies on exchanging bright, species-specific signals (Ohba, N, 2004) .The genus *Pteroptyx*, for example, includes species whose synchronized flashing has made them famous inhabitants of Southeast Asian mangroves (Fuzi et al., 2021)

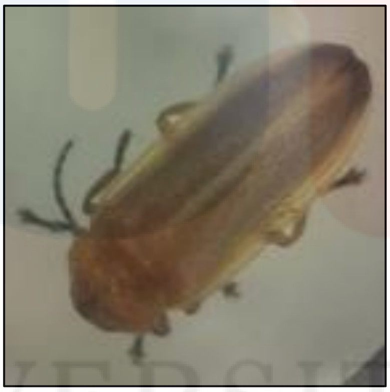

Figure 2.3: Firefly (Coleoptera: Lampyridae)

Firefly species are generally semelparous, which means they spend the majority of their life as larvae. Adults live for only a few weeks before reproducing and dispersing. In reality, most species' adults do not feed except for the occasional nectaring, therefore, they must absorb whatever they require to survive the larval stage (Riley et al., 2021). Fireflies are classified into five subfamilies: Amydetinae Olivier, Lampyrinae Rafinesque, Luciolinae Lacordaire, Photurinae Lacordaire, and Psilocladinae McDermott. There are around 2000 firefly species worldwide (Bousquet

1991). Firefly is classified as an insect species with high diversity (Sumruayphol et al.,. 2019). Firefly larvae have distinct environmental preferences, including aquatic (freshwater, marine, or brackish), semi-aquatic (marshes, ponds, or bromeliads), and terrestrial (leaf litter or soil) settings (Souto et al., 2024). Many Asian fireflies inhabit coastal or riparian woods. For example, *Pteroptyx* fireflies "live in mangrove swamps or riverbank areas to be able to get their food sources easily" (Fuzi et al., 2021Firefly larvae, whether aquatic, semi-aquatic, or terrestrial, feed on soft-bodied food for months or years. Adult fireflies, on the other hand, have limited lifespans and rarely eat. Some taxa are ecological generalists, whereas others have particular habitat and food needs (Lewis et al., 2024). There are several Lampyrid species in Southeast Asia. There are at least 13 Pteroptyx species known to exist in Malaysia alone with 9 species in Peninsular Malaysia and others in Borneo (Swatdipong et al., 2018).

2.5 Past studies on Microplastics in Insects (2020-2025)

Table 2.1: Previous Study on microplastics in insects

Year	Author(s)	Title
2020	Malafaia et al.	Effects of polyethylene microplastics on *Culex quinquefasciatus* larvae: Developmental and biochemical impairments
2021	Romano & Fischer	Exposure to microplastics reduces growth and survival in black soldier fly larvae (*Hermetia illucens*)
2021	Wang et al.	Gut microbiota and polystyrene microplastics co-exposure in honey bees (*Apis mellifera*): Toxicity and resilience
2022	Mat Zain et al.	Microplastic pollution in freshwater macroinvertebrates from Gua Musang, Kelantan, Malaysia
2023	Shen et al.	Hormesis of microplastics on terrestrial and aquatic insects: A review of recent evidence
2023	Lievens et al.	Ingestion and gut retention of microplastics in black soldier fly larvae (*Hermetia illucens*) under lab conditions
2024	Li et al.	Developmental and transmission effects of microplastics on mosquitoes (*Culex quinquefasciatus*)
2024	Jones et al.	Mosquitoes and microplastics: A growing concern for vector-borne disease ecology (Review)

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

The sampling study was conducted at Delta Tumpat which is a mangrove area located 3.24 km from Jeti Kuala Besar, in the Tumpat district, Kelantan. The study site can only be accessed by water and all sampling trips were made in a boat with the average estimated travel time from the jetty to the site of 7 minutes directly through the natural waterways surrounded by mangrove vegetation as shown in **Figure 3.1**. The sampling coordinates are 6°12'41"N, 102°12'33"E, located in an estuarine environment that is biologically productive. The Delta Tumpat area is characterized by small islands and estuarine partly surrounded by mangrove forest area creating a physical ecological niche that may be suitable for fireflies. **Figure 3.2** shows our study area, Tumpat inside the Kelantan state boundary

Figure 3.1: Maps of sampling site from Jeti Kuala Besar (Source: Google Earth)

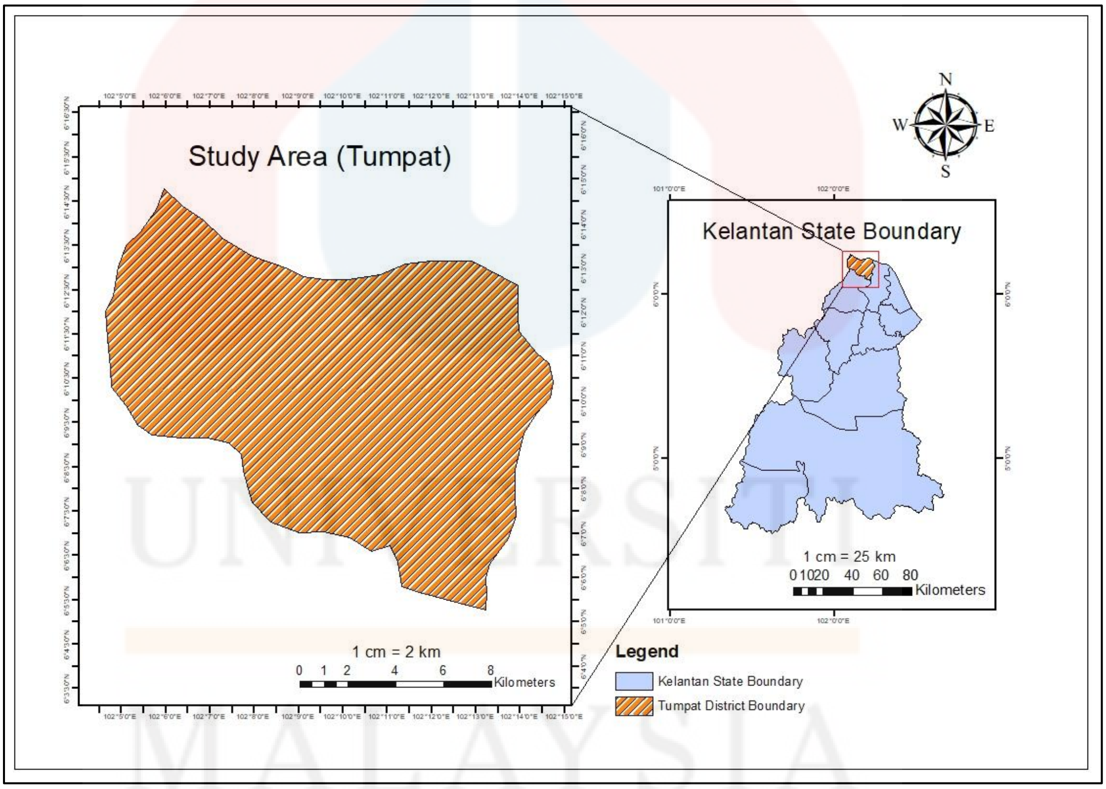

Figure 3.2: Map of study area Tumpat

. The presence of mature mangrove along the travel route to the sampling position suggests a healthy site which is stable and typically provides habitat for fireflies. The habitat provides physical shelter, food/host plants and breeding for numerous firefly species.

Aside from the geographic, climatic, and physical characteristics, the presence of local human settlements, such as a residential housing development and the nearby Kuala Besar Floating Market, which is an intersection of local culture and economic activity that are anthropogenic aspects which could introduce potential detrimental environmental factors for example, plastic materials and general pollution, marking it as an important area for understanding microplastic contamination in firefly surroundings. The combination of the rich mangrove system, along with anthropogenic features, makes Delta Tumpat an ideal and valuable site for evaluating the occurrence of microplastics on fireflies, as it is both a natural and anthropogenically impacted environment.

3.2 Materials

The study focused on both capturing samples and examining microplastics on the external body of both adult and larval fireflies obtained from Delta Tumpat. Table 3 displays the following equipment that were used throughout the research studies:

Table 3.1: Materials and equipment used in the laboratory and field work

Locations	Materials & Apparatus
Field materials	Field materials Aerial net Life jacket Seal bag Rubber gloves Torchlight GPS Universal jar
Laboratory materials & apparatus	Lab materials Glass petri dishes Forcep Pin Lighter Insect Pin Stage Chemical substance: Ethanol (95%) Lab Instrument Disecting Microscope Oven

Figure 3.3: Dissecting microscope brand RaxVision used to observe microplastics on firefly

3.3 Methods

3.3.1 Sample Handling

To ensure the integrity of collected samples, precautions are taken in conducting the laboratory to avoid any potential contamination from plastic polymers. We had to ensure no exposure of the fireflies to any plastic surface that could create false positives. This meant that in the lab, all instruments and containers used throughout the study were non-plastic and small glass containers. The adult and larval fireflies were all transferred to glass universal jars, directly after collection in the field, and at no point was contamination accepted and left to chance by using plastic containers as we wanted to avoid synthetic polymers contaminating the firefly samples. The universal jars are tightly sealed and returned to the lab with as little disruption to the specimens as possible.

Figure 3.4: A sample of larvae collected from Delta Tumpat, kept in the glass universal jar

After the specimens arrived in the lab, each specimen was transferred from the universal jar to a glass petri dish using stainless steel forceps. These tools were meant to avoid plastic surfaces and keep the sample intact. The specimens were then placed under a compound microscope, where visible particles of foreign material on their external body surfaces were noted. Specimens were observed under dissection microscope to look for any fine fibers, fragments, or films present on the specimens to determine their microplastic presence.

3.3.2 Hot needle test

The hot needle test is a simple, low-cost way of distinguishing plastic from nonplastic particles when examined under a microscope. A heated metal needle (or soldering iron) is lightly touched to a suspected particle. Plastics (thermoplastics) will soften, melt or curl when heated, whereas natural materials (wood, plant fibers, mineral grains) typically do not change shape (Beckingham et al, 2023). Prata et al. (2023), for instance, describe contacting particles with a needle tip that is about 130°C; melted or deformed fragments were categorized as plastics.

Figure 3.5: Microplastics after hot needle test (denatured)

3.3.3 Scanning Electron Microscope (SEM)

In addition to the microscopic observations and hot needle test, a small selection of specimens was separated and sent for Scanning Electron Microscope (SEM) analysis. Only specimens that had a visible suspected microplastic attached to their body were selected for this analysis. Several samples of adult and larval fireflies were selected. The specimens were examined using SEM analysis to provide clearer, higher-resolution images of the microplastic particles on external surfaces. This step was added to provide supplemental evidence to support the initial visual identification by allowing the researcher to examine the particle texture, shape, and surface structure detail at a magnification of 1000x. SEM imaging provided the best confirmation of the presence of microplastics while differentiating the shape of microplastic particles present on the external surface of the fireflies collected.

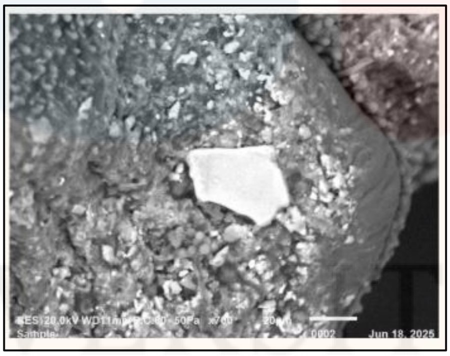

Figure 3.6: Larvae contaminated by MPs (fragment) under SEM

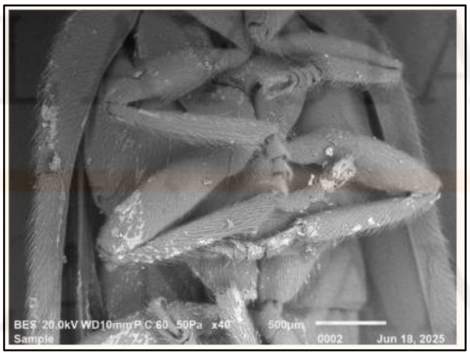

Figure 3.7: Adult contaminated by MPs (fragment) under SEM

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Sample Collected

All sampling was carried out only from the mangrove habitat within Delta Tumpat, Kelantan from 7.30 pm until 9.00 pm. Using a microscope, the samples were examined meticulously, focusing on their morphology, including the head, thoracic, and abdomen, to observe the presence of microplastics on their external surface.

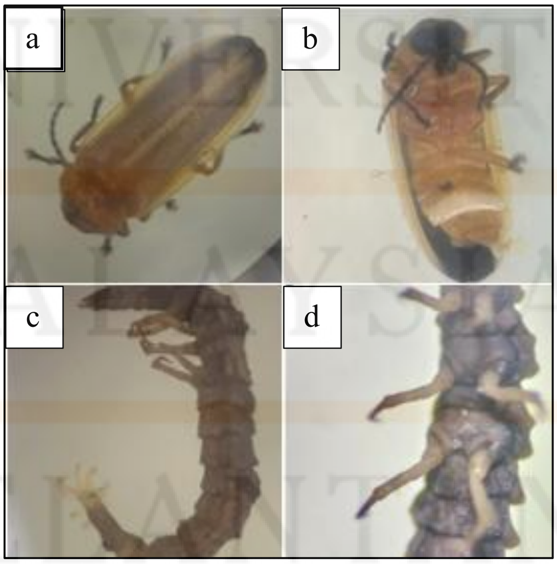

Figure 4.1: A different view of *Colophotia cf. praeusta* from both larva and adult stages captured during sampling. a) Dorsal view of female adult b) Ventral view of female adult c) Lateral view of larvae d) Ventral view of larvae.

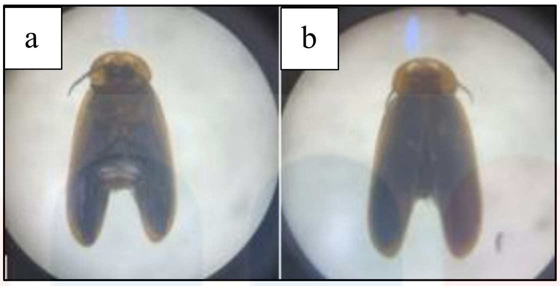

Figure 4.2: A different view of *Asymmetricata circumdata* from adult stages captured during sampling..a) Ventral view of a male adult b) Dorsal view of female adult

Table 4.1: Comparison number of fireflies adults and larvae collected

Stage	Number of Individuals	Percentage (%)
Larvae	62	69.66
Adults	27	30.34

A total of 89 firefly specimens were taken during our sampling process at Delta Tumpat. The sampling dataset revealed only *Colophotia cf. praeusta* and *Asymmetricata circumdata* species found in our study area. The identification of *Asymmetricata circumdata*, although only identified later in the study, contributes to the biodiversity profile of the locality and reinforces the evidence that these species are distributed throughout the mangrove habitats of Southeast Asia. They were both observed concurrently, and this could imply that they are among the dominant taxa in the mangrove ecosystem of the Delta Tumpat locality. 69.66% of the specimens collected are larvae, and 30.34% are adults, which will allow for comparative analysis of both life stages from a microplastic exposure perspective. Given that both life stages were in the same habitat will allow for speculation and comparative analysis of potential differences between each developmental stage concerning surface contamination, behaviour, micro-habitat, or exposure time.

Based on Table 3.2, it is clear that larvae outnumbered adults on most sampling days. In total, larvae made up around 70% of all specimens collected. The abundance results may indicate a population skew towards early developmental stages. Additionally, the larvae were more easily detectable during sampling at the site compared to the adult stage. Potential environmental factors such as humidity, temperature, tides, and moon phase also likely played a role. The rain on the final day of sampling suggests that this factor also had a direct impact on firefly activity. Unlike adults, larvae mainly live in the soil, among vegetation, or entrenched among mangrove roots. Adult firefly abundance is not consistently stable, as it may be influenced by a continuous cycle of reproduction throughout the season or by peak seasonal densities of adult insects.

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4.3 Presence of Microplastic in Larva and Adult stage

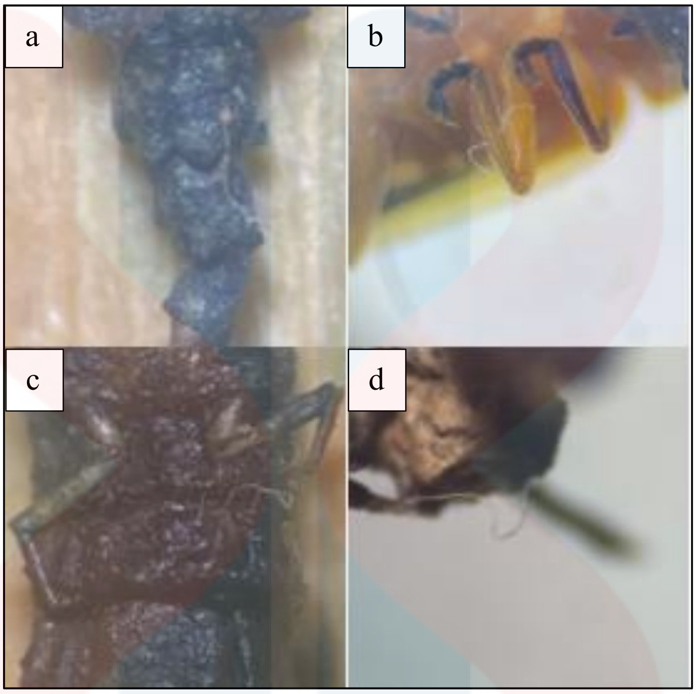

Figure 4.3: Microplastics on different part of the firefly and its larvae. a) tail, b) Leg, c) Thorax. and d) Mouth.

Table 4.2: Comparison of the presence of microplastics on adult and larval stages

Stage	Total of Samples Contaminated by Microplastics	Percentage (%)
Larva	31	50.00
Adult	4	14.81

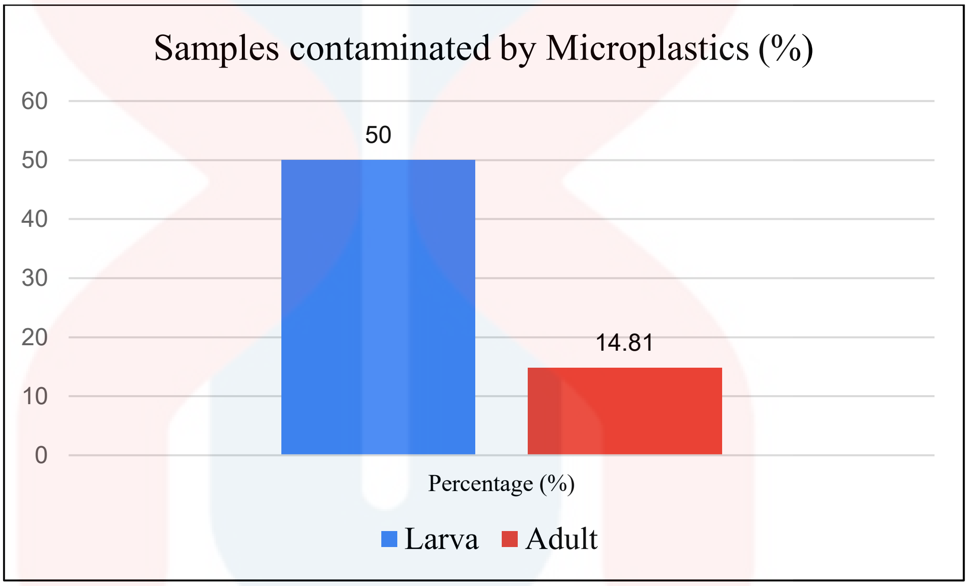

Figure 4.4: Bar graph comparing the presence of microplastics in adult and larval stages

Based on Figure 8, comparing adult and larval fireflies revealed a clear difference in the frequency of microplastic presence on their external body parts, with 38.64% of fireflies testing positive for microplastics. From the pie chart, we can see that the total number of microplastic-contaminated larvae and adults shows that larvae had a proportionally higher number of specimens with microplastics, at 50% among 62 samples collected, compared to adults at 14.81% out of 27 were observed to be contaminated with microplastics. This difference may be due to exposure or vulnerability to attachment in the environment.

Larvae occupy the lower parts of the ecosystem, such as the soil surface, decaying plant materials, and mangrove root zones, where microplastic fibers ultimately settle due to gravity and tidal range. These surfaces can serve as sink sites for small synthetic particles, increasing the probability of contact and attachment. Adults, while equally susceptible to contamination, are more aerial and mobile, residing on leaves and branches as well as flying around. Consequently, adults interact with the sediment and ground-level materials, which may account for the reduced rate of observed microplastic contamination. Additionally, the smooth and waxy exoskeleton of adults may contribute to fewer fiber attachments compared to the more textured larval form.

4.3 Colour Variation of Microplastics

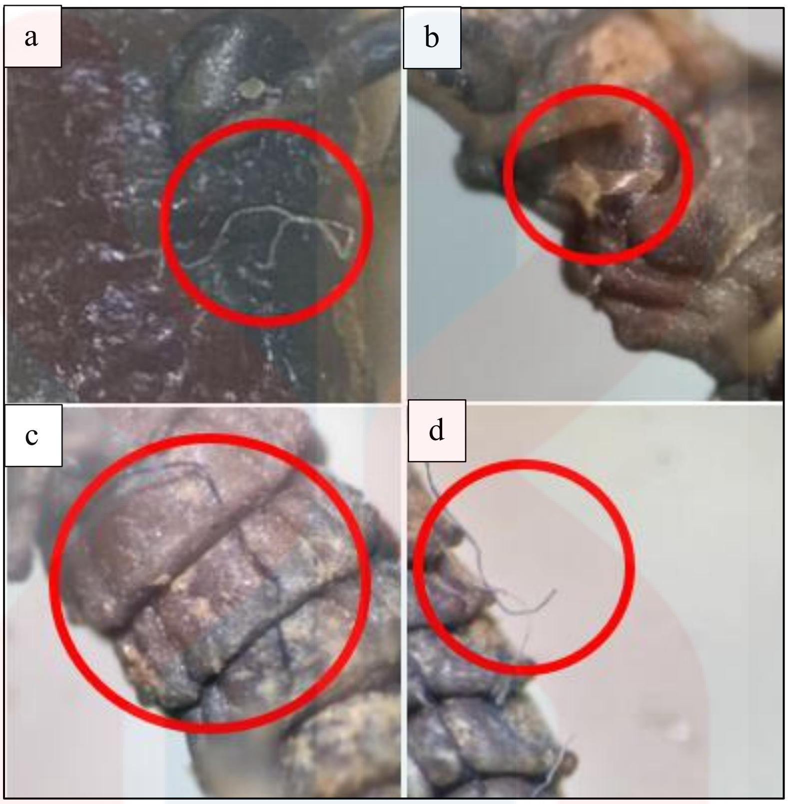

Figure 4.5: Colour types of microplastics detected in firefly larvae. a) Transparent strand b) Transparent yellow strand c) Dark-blue strand d) Dark-blue transparent strand

MPs Colour	No of MPs	Percentage (%)
Transparent strand	35	92.10
Dark-blue strand	2	5.26
Yellow Strand	1	2.63
Total	38	100%

Table 4.3: Colour of microplastics

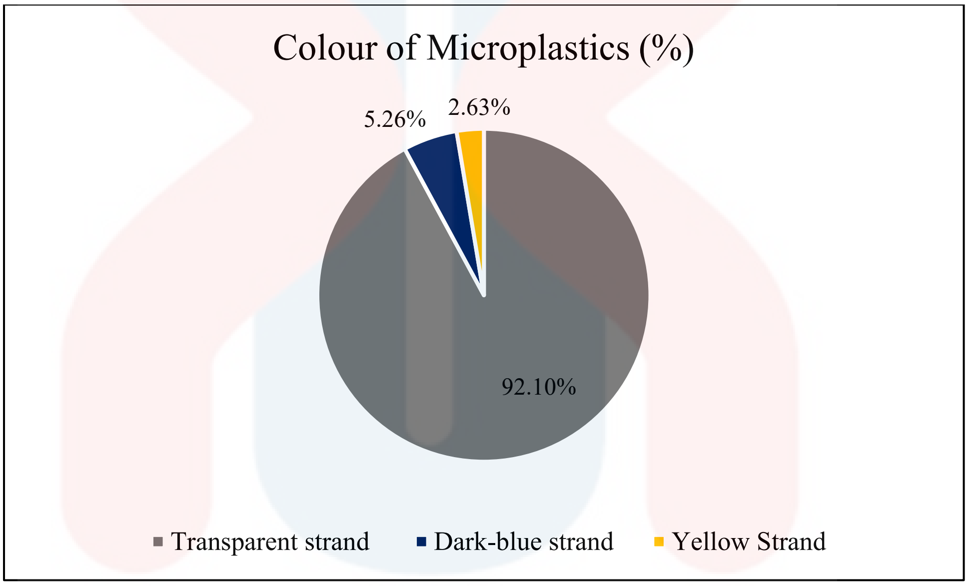

Figure 4.6: Pie chart comparison between the colour of microplastics present

From this study, microplastics are classified by the exterior surfaces of fireflies into three colors: transparent, dark blue, and yellow, with transparent fibers being the most common. The observation of transparent microplastic strands on the external of the firefly legs, thoracic, wings, abdomen, and head suggested that the transparent fibers were most likely derived from ordinary discarded plastic items of nearby area such as fishing net, synthetic threads, or plastic bags. Transparent microplastics are frequently the most difficult sort of microplastic to locate in the environment because of their non-obtrusive character, contributing significantly to a persistent and imperceptible contaminant.

Dark blue was the second most documented color, most likely due to cloth, fishing nets, or colored plastic containers. Dark blue threads may be the consequence of pollution from fishing activity. Delta Tumpat is located on the shore, near the Kuala Besar Floating Market and residential areas, where residents may contribute to the misallocation of synthetic garbage. Thus, dark blue fibrous residues are visible to the naked eye and under a microscope. This is one possible explanation for why dark blue fibers appeared despite being the second least detected color after transparent strands.

Only a few yellow strands of microplastic were discovered, which might mean one of two things, they were found less frequently than other colours in the surrounding environment of Delta Tumpat, or they disintegrate or fragment faster than other colours. Yellow fibers can also be formed by comparable plastic products like ropes or brushes, as well as different household items. The existence of numerous color types, while in smaller numbers than the other colors, indicates that fireflies in the Tumpat mangrove may be influenced by various sources of plastic pollution caused by various human activities in the surrounding region.

The color variations in microplastics may potentially have ecological effects. Colored microplastics may be more visually attractive and mistaken for prey by some organisms. Alternatively, color may impact heat absorption or microbiomes, altering the interaction of microplastics with the environment and the insect's body. Overall, the discovery of multi-colored microplastics on fireflies exemplifies the complex and heterogeneous nature of plastic pollution in mangrove systems, as well as the need to monitor both the presence of microplastics and their physical characteristics in order to assess pollution source characteristics and potential ecological hazards.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

This study documents the presence of microplastics on the external surfaces of fireflies (*Colophotia cf. praeusta)* collected from the Delta Tumpat mangrove ecosystem in Kelantan, Malaysia. The results revealed that both adult and larval fireflies were externally contaminated by microplastic particles, with a strong bias toward the larval stage. Larvae, which are in closer contact with soil and sediment surfaces, exhibited higher levels of contamination compared to the more mobile adult specimens. This finding underscores the importance of considering developmental stages in pollution studies and highlights larvae as a more sensitive indicator of surface-level microplastic exposure.

The types of microplastics observed were primarily fine, strand-like fibers in three distinct colors: transparent, dark blue, and yellow. Transparent strands were the most dominant, indicating the potential contribution of synthetic fishing lines, packaging materials, and domestic waste to microplastic pollution in the study area. These fibers were found adhered to various external body parts such as legs, thorax, abdomen, and wings. The use of the hot needle test allowed for effective, low-cost confirmation of microplastic identity by observing melting reactions, thus strengthening the reliability of visual detection under the microscope.

The presence of microplastics on fireflies in a mangrove environment raises ecological concerns. Fireflies are not only bioindicators but also culturally and economically valuable insects that contribute to ecotourism and ecological balance. Their exposure to pollutants, especially in protected and biodiversity-rich habitats like Delta Tumpat, signals the broader environmental threat posed by plastic pollution. This study contributes valuable baseline data to a field with limited literature, particularly within Malaysian contexts, and serves as a foundation for further research into the interactions between terrestrial insects and microplastics in coastal environments.

5.2 Recommendations

To build upon the findings of this study, future research should include both external and internal analyses of microplastic contamination in fireflies. While this study focused solely on particles attached to the external surface, it is important to explore whether fireflies, especially larvae, ingest microplastics through prey or direct contact with contaminated substrates. Internal microplastic detection may be conducted by dissecting the digestive system and using advanced imaging techniques such as FTIR (Fourier-Transform Infrared Spectroscopy) or Raman spectroscopy to identify polymer types with high specificity.

In addition, expanding the temporal and spatial scope of sampling is crucial. Seasonal studies can help determine whether microplastic contamination fluctuates throughout the year, influenced by factors such as monsoon cycles, tourism, or changes in water flow and human activity. Comparative studies between different mangrove sites with varying degrees of human influence would provide more comprehensive insight into the sources, transport, and deposition of microplastics in these sensitive environments. In particular, correlating microplastic types and colors with specific anthropogenic activities, for example fishing, domestic discharge, and market operations would support more targeted waste management interventions.

Finally, environmental education and community engagement should be prioritized in regions surrounding mangrove ecosystems like Delta Tumpat. Raising awareness among local residents, fishers, and market vendors about the ecological effects of plastic waste can lead to improved behavior regarding plastic disposal. Authorities and stakeholders are encouraged to implement stricter policies on plastic usage and support community-led conservation initiatives. Reducing plastic pollution at the source is essential to safeguarding the health of mangrove ecosystems and the many species, including fireflies, that rely on them for survival.

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APENDIX A

Process of collecting samples of fireflies' larvae on the soil at the study area, Delta Tumpat.

On the way to the study area by using boat from Jeti Kuala Besar

APENDIX B

Observation process of microplastics on the external of samples of fireflies larvae and adult.

APENDIX C

Order	Family	Genus	Species	Stage	Types of Microplastic	No. of Microplastic
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (abdomen)	1
					Transparent strand (thorax)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand	1
					Transparent strand	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand	1
					Transparent strand	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand	1
					Transparent strand	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (tail)	1
					Transparent strand (abdomen)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (thorax)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (head)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (thorax)	2
					Transparent strand (abdomen)	1
					Transparent strand (leg)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (tail)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (leg)	1
Coleoptera	Lampyridae	Colophotia	Praeusta		Transparent strand (leg)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	adult	Transparent strand (leg)	2
Coleoptera	Lampyridae	Colophotia	Praeusta		Transparent strand (wing)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (leg)	2
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (thorax)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (thorax)	2
					Dark blue strand (abdomen)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Dark blue strand (leg)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	adult	transparent strand (leg)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (leg)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	adult	Transparent strand (wings)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (thorax)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (leg)	1
					Transparent strand (mouth)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Yellow transparent strand (abdomen)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (leg)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (head)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (leg)	1
					Transparent strand (thorax)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (leg)	1
					Transparent strand (thorax)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (abdomen)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (abdomen)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (thorax)	1
					Transparent strand (tail)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (leg)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (head)	1
Coleoptera	Lampyridae	Colophotia	Praeusta	larvae	Transparent strand (leg)	1

Data of the types and number of microplastics from the samples collected at Delta Tumpat.

Date U7	Location	Coordinate		Finder	Stage	Order	Family	Genus	Species
11/4/2025	Delta Tumpat	N 06˚12'42.1"	E 102˚12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
11/4/2025	Delta Tumpat	N 06˚12'43.0"	E 102˚12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
11/4/2025	Delta Tumpat	N 06˚12'42.6"	E 102˚12'33.2"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
11/4/2025	Delta Tumpat	N 06˚12'42.5"	E 102˚12'33.3"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
11/4/2025	Delta Tumpat	N 06˚12'42.6"	E 102˚12'33.4"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
11/4/2025	Delta Tumpat	N 06˚12'43.0"	E 102˚12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
11/4/2025	Delta Tumpat	N 06˚12'43.2"	E 102˚12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
11/4/2025	Delta Tumpat	N 06˚12'43.4"	E 102˚12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
11/4/2025	Delta Tumpat	N 06˚12'41.3"	E 102˚12'33.9"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
11/4/2025	Delta Tumpat	N 06˚12'56.9"	E 102˚12'48.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
11/4/2025	Delta Tumpat	N 06˚12'44.8"	E 102˚12'41.8"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
12/4/2025	Delta Tumpat	N 06˚12'41.9"	E 102˚12'33.6"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
12/4/2025	Delta Tumpat	N 06˚12'42.8"	E 102˚12'33.5"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
12/4/2025	Delta Tumpat	N 06˚12'44.3"	E 102˚12'33.4"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
12/4/2025	Delta Tumpat	N 06˚12'44.7"	E 102˚12'34.9"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
17/4/2025	Delta Tumpat	N 06˚12'41.6"	E 102˚12'33.0"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
17/4/2025	Delta Tumpat	N 06˚12'44.0"	E 102˚12'34.2"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
17/4/2025	Delta Tumpat	N 06˚12'43.7"	E 102˚12'33.9"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
17/4/2025	Delta Tumpat	N 06˚12'43.5"	E 102˚12'33.7"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
17/4/2025	Delta Tumpat	N 06˚12'43.5"	E 102˚12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
17/4/2025	Delta Tumpat	N 06˚12'41.9"	E 102˚12'34.0"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
25/4/2025	Delta Tumpat	N 06˚12'42.1"	E 102˚12'36.3"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
25/4/2025	Delta Tumpat	N 06˚12'44.8"	E 102˚12'41.8"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
25/4/2025	Delta Tumpat	N 06˚12'42.4"	E 102˚12'32.9"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
25/4/2025	Delta Tumpat	N 06˚12'42.7"	E 102˚12'33.4"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
25/4/2025	Delta Tumpat	N 06˚12'43.0"	E 102˚12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
25/4/2025	Delta Tumpat	N 06˚12'43.2"	E 102˚12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
25/4/2025	Delta Tumpat	N 06˚12'43.4"	E 102˚12'33.4"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
25/4/2025	Delta Tumpat	N 06˚12'43.5"	E 102˚12'33.4"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
25/4/2025	Delta Tumpat	N 06˚12'43.5"	E 102˚12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
25/4/2025	Delta Tumpat	N 06˚12'43.7"	E 102˚12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
25/4/2025	Delta Tumpat	N 06˚12'43.6"	E 102˚12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06˚12'42.5"	E 102˚12'33.0"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06˚12'43.3"	E 102˚12'33.7"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06˚12'43.4"	E 102˚12'33.5"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06˚12'43.4"	E 102˚12'33.7"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06˚12'42.5"	E 102˚12'33.9"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06˚12'42.1"	E 102˚12'33.4"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06˚12'43.2"	E 102˚12'33.5"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06˚12'43.4"	E 102˚12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06˚12'43.7"	E 102˚12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*

26/4/2025	Delta Tumpat	N 06°12'43.7"	E 102°12'33.7"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06°12'42.9"	E 102°12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06°12'43.1"	E 102°12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06°12'43.3"	E 102°12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06°12'43.4"	E 102°12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06°12'42.5"	E 102°12'33.0"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06°12'41.8"	E 102°12'33.7"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
26/4/2025	Delta Tumpat	N 06°12'41.7"	E 102°12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
1/5/2025	Delta Tumpat	N 06°12'19.3"	E 102°12'04.4"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
1/5/2025	Delta Tumpat	N 06°12'41.3"	E 102°12'33.9"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
1/5/2025	Delta Tumpat	N 06°12'42.0"	E 102°12'33.1"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
1/5/2025	Delta Tumpat	N 06°12'41.8"	E 102°12'33.7"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
1/5/2025	Delta Tumpat	N 06°12'43.3"	E 102°12'33.7"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
1/5/2025	Delta Tumpat	N 06°12'42.8"	E 102°12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
1/5/2025	Delta Tumpat	N 06°12'43.3"	E 102°12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
3/5/2025	Delta Tumpat	N 06°12'41.7"	E 102°12'33.7"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
3/5/2025	Delta Tumpat	N 06°12'42.2"	E 102°12'33.9"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'42.1"	E 102°12'34.0"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'41.9"	E 102°12'32.5"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'42.5"	E 102°12'33.3"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'44.3"	E 102°12'33.8"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'42.6"	E 102°12'33.5"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'42.2"	E 102°12'33.6"	Syawal	Adult	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'43.6"	E 102°12'33.4"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'43.6"	E 102°12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'43.4"	E 102°12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'42.6"	E 102°12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'42.0"	E 102°12'33.8"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
5/5/2025	Delta Tumpat	N 06°12'41.8"	E 102°12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'43.0"	E 102°12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'42.9"	E 102°12'34.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'43.4"	E 102°12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'43.4"	E 102°12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'43.5"	E 102°12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'43.6"	E 102°12'33.7"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'43.6"	E 102°12'33.8"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'43.7"	E 102°12'33.7"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'43.4"	E 102°12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'42.0"	E 102°12'35.1"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'41.9"	E 102°12'33.7"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'42.1"	E 102°12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06°12'42.1"	E 102°12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*

6/5/2025	Delta Tumpat	N 06˚12'42.0"	E 102˚12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06˚12'42.0"	E 102˚12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06˚12'41.8"	E 102˚12'33.6"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06˚12'42.0"	E 102˚12'33.5"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
6/5/2025	Delta Tumpat	N 06˚12'42.1"	E 102˚12'33.4"	Amin	Larvae	Coleoptera	Lampyridae	*Colophotia*	*Praeusta*
11/5/2025	Delta Tumpat	N 06˚12'42.0"	E 102˚12'33.5"	Syawal	Adult	Coleoptera	Lampyridae	*Asymmetricata*	*Circumdata*

Data of the coordinates, finder, family, genus, and species of fireflies larvae and adults collected at Delta Tumpat