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# Research Article
# Food Compositions of Two Commercial Fairy Shrimps, *Branchinella thailandensis* and *Streptocephalus sirindhornae* (Crustacea: Branchiopoda: Anostraca)

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## Abstract

**Background and Objective:** Aquaculture production of fairy shrimps has recently attracted growing interest with increasing evidence supporting close interaction between natural food compositions and fairy shrimp growth performance. The aim of this study was to examine the diversity of fairy shrimp gut biota and the nearby environment. **Materials and Methods:** Two species of fairy shrimps, *Streptocephalus sirindhornae* and *Branchinella thailandensis* were collected from different localities in the northeast of Thailand. Their gut contents were analyzed and determined for food compositions. **Results:** The amount and number of food items found in the guts of fairy shrimps related with their natural habitats. Number of food items found in *B. thailandensis* (46 taxa) was significantly higher than items recorded from *S. sirindhornae* (36 taxa) ($p<0.05$). The major food component appeared to be phytoplankton. Chlorophytes were the most abundant natural foods in the guts of *B. thailandensis* (57.4%) and *S. sirindhornae* (69.3%). The green algae *Chlorella* sp. represented the major food component in the guts of both species. **Conclusion:** *Streptocephalus sirindhornae* and *B. thailandensis* were both omnivorous species that consumed phytoplankton, small zooplankton and inert particles.

Key words: *Chlorella* sp., gut analysis, omnivorous, natural food, fairy shrimp, *Streptocephalus sirindhornae*, *Branchinella thailandensis*

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Fairy shrimps comprise a group of microcrustaceans in the order Anostraca; class Branchiopoda that usually occur in temporary wetlands or shallow seasonally-flooded ponds. They are well-adapted to live in arid areas where water is present only during rainy seasons[1]. Their eggs can survive drought for a few years and hatch about 24 h after rains fill the ponds where their parent's spawned[2]. In humid tropical areas of Asia, fairy shrimps inhabit temporary ponds, roadside ditches, rice paddies and water buffalo wallows[3]. These water bodies dry out periodically and water levels in such habitats are fluctuating widely[4]. Fairy shrimps are regarded as suspension feeders[5], except for some large species that are known to be raptorial feeders[6-7]. Fairy shrimps eat algae and detritus foods by the mechanism of particle filtration[8-9]. Both suspended particles and ingested live prey are found in fairy shrimp guts[9-11]. Food is filtered from the water bodies, scraped by sets of appendages and eaten using a mandible mouth. In nature, fairy shrimps feed on various types of foods which largely depend on the sources available in the water body[11].

In Thailand, 3 species of fairy shrimps have been recorded[12]. The 2 most common species in the country are *Streptocephalus sirindhornae*[13] and *Branchinella thailandensis*[3]. These 2 species are considered as a new live food for aquaculture[14-16]. They have been extensively cultured for commercial applications because of their rapid growth, high fecundity and as a valuable source of protein and carotenoid[1,14,17,18]. Due to the economically important role of fairy shrimps, many studies have attempted to improve cultivation methods. However, one of the main problems impacting on fairy shrimp farming is production loss due to the low survival rate. Countless efforts have been made to increase yield in fairy shrimp farming through varied nutrition and feeds. Culturing of fairy shrimps has so far concentrated on using live algae alone[14,17,19] which may not be sufficient for fairy shrimp nutrition requirements. Previous attempts have focused on investigating other food sources to replace live algae which are the monopoly feedstock for the Thai fairy shrimps. Hence, increased knowledge of natural foods and feeding habits of fairy shrimps are essential for formulating the dietary needs of these animals.

Gut content analysis provides important information on feeding patterns, habitat preferences and prey selection. An investigation of feeding habits was undertaken to establish the most frequently consumed prey and determine the relative importance of different food types to fairy shrimp nutrition. This is an important aspect for aqua cultural management[20]. Knowledge regarding the feeding habits of Thai fairy shrimps is lacking. Therefore, this study was undertaken to examine gut contents of 2 fairy shrimp species, *S. sirindhornae* and *B. thailandensis* to obtain information on their natural foods and feeding habits.

## MATERIALS AND METHODS

**Fairy shrimp collection:** Two fairy shrimp species, *Streptocephalus sirindhornae*[13] and *Branchinella thailandensis*[3] were collected qualitatively from 30 localities of temporary water habitats in Northeast Thailand from May to June, 2017 (Table 1 and 2) using a 30 µm mesh size plankton net. The samples were immediately preserved in 4% formalin. At each sample locality, water temperature, pH, conductivity, salinity, turbidity and dissolved oxygen (DO) were measured using a Horiba Water Quality Checker (U-10) and 3 adult fairy shrimps were randomly selected for gut analysis and measured for body length. Specimens were measured from the anterior tip to the tip of the caudal furca using a Vernier caliper. The average body length of *B. thailandensis* and *S. sirindhornae* were 2.89±0.19 and 2.53±0.21 cm, respectively. At each sample locality, water samples were also taken for 5 replicates to determine food availability in fairy shrimp water habitats.

**Preparation and analysis of gut contents:** The alimentary canal was carefully dissected from the specimens. Each gut was placed on a counting slide with a few drops of distilled water and the different items were teased out and counted. Food items were identified to the nearest possible taxonomic level under compound and stereo microscopes according to Velu and Munuswamy[11] and Ali *et al.*[20] using keys and publications[21-24].

**Data analysis:** The percentage composition method was used for diet analysis to calculate the amount of different food items. Number of individuals of each food type in the gut was counted and expressed as a percentage of the total number of food items. Percentage composition of food items was calculated using the method described by Mahesh *et al.*[25] as follows:

$$Ni\ (\%) = \frac{Ni}{Nt} \times 100$$

where, Ni (%) is the percentage of food item i, Ni is the number of particular food item i, Nt is the total number of food (gut content) items.

Table 1: Environmental variables at each sampling site of *Streptocephalus sirindhornae*

| Localities | Altitude (m) | Temp. (°C) | pH | Cond. (μS $cm^{-1}$) | Salinity (psu) | Turb. (NTU) | DO (mg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| **Maha Sarakham province** | | | | | | | |
| Roadside canal in Chiang Yun district | 157 | 27.7 | 6.59 | 249 | 0.00 | 7.27 | 2.00 |
| Rice field in Chiang Yun district | 169 | 32.9 | 6.65 | 115 | 0.00 | 114.00 | 4.50 |
| Rice field in Chiang Yun district | 170 | 34.4 | 7.20 | 434 | 0.01 | 37.00 | 4.80 |
| Rice field in Chiang Yun district | 169 | 32.9 | 6.65 | 115 | 0.00 | 115.00 | 4.50 |
| **Roi Et province** | | | | | | | |
| Roadside canal in Thawat Buri district | 136 | 33.1 | 7.71 | 780 | 0.05 | 28.50 | 30.70 |
| Rice field in Kaset Wisai district | 124 | 36.6 | 7.30 | 178 | 0.00 | 24.00 | 4.05 |
| Rice field in Kaset Wisai district | 121 | 36.2 | 6.80 | 476 | 0.01 | 40.00 | 3.30 |
| Canal in Suwannaphum district | 126 | 33.4 | 7.40 | 113 | 0.00 | 707.00 | 1.14 |
| **Khon Kaen province** | | | | | | | |
| Roadside canal in Muang district | 135 | 29.4 | 6.90 | 180 | 0.00 | 180.00 | 2.56 |
| Rice field in Muang district | 181 | 33.4 | 7.80 | 274 | 0.01 | 53.00 | 5.60 |
| Rice field in Nong Ruea district | 209 | 35.7 | 7.10 | 190 | 0.00 | 455.00 | 4.48 |
| Temporary pond in Muang district | 185 | 35.0 | 7.80 | 64 | 0.00 | 165.00 | 3.75 |
| **Buriram province** | | | | | | | |
| Roadside canal in Phutthaisong district | 151 | 32.3 | 9.24 | 158 | 0.00 | 106.00 | 9.24 |
| Rice field in Khu Muang district | 151 | 32.3 | 7.20 | 62 | 0.00 | 65.00 | 8.86 |
| Rice field in Muang district | 173 | 32.8 | 8.07 | 104 | 0.00 | 110.00 | 6.33 |

Temp.: Temperature, Cond.: Conductance, Turb.: Turbidity, DO: Dissolve oxygen

Table 2: Environmental variables at each sampling site of *Branchinella thailandensis*

| Localities | Altitude (m) | Temp. (°C) | pH | Cond. (μS $cm^{-1}$) | Salinity (psu) | Turb. (NTU) | DO (mg $L^{-1}$) |
|---|---|---|---|---|---|---|---|
| **Khon Kaen province** | | | | | | | |
| Roadside canal in Muang district | 175 | 27.8 | 7.50 | 175 | 0.00 | 36 | 3.51 |
| Rice field in Muang district | 173 | 30.1 | 7.20 | 88 | 0.00 | 90 | 4.66 |
| Temporary pond in Muang district | 157 | 35.0 | 7.80 | 64 | 0.00 | 165 | 3.75 |
| Temporary pond in Muang district | 152 | 35.0 | 7.60 | 68 | 0.00 | 160 | 3.72 |
| Rice field in Phu Wiang district | 165 | 35.2 | 7.10 | 99 | 0.00 | 155 | 4.32 |
| **Buriram province** | | | | | | | |
| Roadside canal in Phutthaisong district | 151 | 31.9 | 6.97 | 236 | 0.00 | 177 | 8.23 |
| Temporary pond in Prakhon Chai district | 163 | 38.1 | 8.04 | 162 | 0.00 | 92 | 6.40 |
| Rice field in Lam Plai Mat district | 167 | 31.6 | 6.96 | 229 | 0.00 | 99 | 8.10 |
| **Nakhon Ratchasima province** | | | | | | | |
| Rice field in Phimai district | 155 | 36.3 | 8.83 | 406 | 0.00 | 340 | 7.90 |
| Rice field in Chum Phuang district | 136 | 31.1 | 7.31 | 366 | 0.01 | 125 | 9.30 |
| Rice field in Prathai district | 140 | 30.9 | 7.53 | 170 | 0.00 | 508 | 5.45 |
| **Surin province** | | | | | | | |
| Rice field in Muang district | 154 | 30.0 | 7.47 | 300 | 0.01 | 183 | 5.83 |
| Roadside canal in Sang Kha district | 171 | 34.3 | 7.80 | 375 | 0.01 | 110 | 9.85 |
| Rice field in Muang district | 174 | 27.2 | 9.04 | 194 | 0.00 | 165 | 9.04 |
| Roadside canal in Muang district | 156 | 34.0 | 6.96 | 104 | 0.00 | 150 | 9.50 |

Temp.: Temperature, Cond.: Conductance, Turb.: Turbidity, DO: Dissolve oxygen

**Statistical analysis:** Statistical analysis was performed using SPSS program for Windows, version 13. Differences in food composition between *S. sirindhornae* and *B. thailandensis* were defined using Levene's test for equality of variances and the t-test for equality of means. Differences were considered significant at $p<0.05$ level.

## RESULTS

**Habitats and water quality variables:** *Streptocephalus sirindhornae* and *B. thailandensis* were recorded in temporary ponds, roadside ditches, rice paddies and water buffalo wallows. Water quality variables of their habitats (range and mean) are shown in Table 3. Body length of *B. thailandensis* (28.9±0.1.9 mm) was significantly longer than *S. sirindhornae* (25.3±02.1 mm) ($p<0.05$).

**Number taxa of food items:** Gut contents of *B. thailandensis* and *S. sirindhornae* presented as a greenish-brown mass of recognizable planktonic organisms and mud's. Numbers of organisms found in the guts of *B. thailandensis* were significantly higher than in *S. sirindhornae* ($p<0.05$). Forty-six taxa of organisms belonging to 10 groups were found in the guts of *B. thailandensis*, while 36 taxa belonging to 11 groups were recorded in *S. sirindhornae* (Table 4). The major food component appeared to be phytoplankton which

Table 3: Water quality variables at the sampling sites

| Water variables | *B. thailandensis* | *S. sirindhornae* |
|---|---|---|
| Altitude (m) | 136-175 | 121-209 |
| Temperature (°C) | 27.2-38.1 | 27.7-36.6 |
| pH | 6.97-9.04 | 6.59-9.24 |
| Conductivity (μS $cm^{-1}$) | 68-406 | 62-780 |
| Dissolve oxygen (mg $L^{-1}$) | 3.51-9.85 | 1.14-9.24 |
| Turbidity (NTU) | 36-508 | 40-707 |
| Salinity (psu) | 0-0.01 | 0-0.05 |

Table 4: Number of taxa of food items found in the gut of *Branchinella thailandensis* and *Streptocephalus sirindhornae*

| Categories | *B. thailandensis* | *S. sirindhornae* |
|---|---|---|
| Chlorophyta | 16 | 13 |
| Bacillariophyta | 6 | 6 |
| Cyanophyta | 4 | 5 |
| Euglenophyta | 3 | 3 |
| Chrysophyta | 1 | 1 |
| Rotifera | 11 | 3 |
| Copepoda | 2 | 1 |
| Protozoa | 1 | 1 |
| Nauplius of crustacean | 1 | 1 |
| Cladocera | 1 | 1 |
| Microworm | - | 1 |
| Total | 46 | 36 |

formed 91.75% of the food component in *B. thailandensis* and 96.16% in *S. sirindhornae*. Thirty taxa of phytoplankton were found in the guts of *B. thailandensis*, while 28 taxa were recorded in *S. sirindhornae*.

**Percentage composition of food items:** Different components comprising the major food items are illustrated in Table 5. Food items found in the guts of *B. thailandensis* consisted mainly of chlorophytes (57.4%) followed by bacillariophytes (23.8%), euglenophytes (7.2%), protozoan's (5.4%), chrysophytes (1.8%), cyanophytes (1.5%), crustacean nauplii (1.1%), rotifers (1.0%), copepods (0.7%) and cladocerans (0.1%). Similarly, *S. sirindhornae* consumed miscellaneous items mainly composed of chlorophytes (69.3%), bacillariophytes (13.5%), cyanophytes (10%), protozoan's (3.3%), chrysophytes (2.1%), euglenophytes (1.2%), crustacean nauplii (0.4%), rotifers (0.1%), copepods (0.05%), cladocerans (0.02%) and microworms (0.02%). Results demonstrated that chlorophytes showed the highest percentage abundance and also represented highest species diversity in the guts of the 2 fairy shrimp species. The most encountered taxon was *Chlorella* sp. in both species

**Zooplankton found in the gut contents:** *Branchinella thailandensis* and *S. sirindhornae* comprised 8.25 and 3.84% zooplankton, respectively and were mainly composed of protozoa, crustacean nauplii, rotifers, copepods, cladocerans and microworms (Table 4). Sixteen taxa of zooplankton were observed in gut contents of *B. thailandensis*, whereas 8 taxa were recorded in guts of *S. sirindhornae.* Protozoa were the most encountered zooplankton, while the rotifers represented the most diverse species found in the guts of both fairy shrimps.

**Analysis of food availability:** Fifty-four taxa of food items were observed in the water bodies of *B. thailandensis*, whereas 48 taxa of food items were recorded in the water habitats of *S. sirindhornae* (Table 6). Chlorophyta represented the most diverse species of phytoplankton found in the water bodies. Similar to the gut analysis, chlorophyta represented the most diverse food found in the guts of *B. thailandensis* and *S. sirindhornae*.

## DISCUSSION

Gut contents of *B. thailandensis* and *S. sirindhornae* recorded phytoplankton, zooplankton (including protozoa, crustacean nauplii and microworms) and inert particles. The major food item of *B. thailandensis* and *S. sirindhornae* appeared to be phytoplankton, while chlorophytes represented abundant natural food occurring in the guts of both species. Similar findings were reported by Bernice[10] and Selvarani[26] who analyzed food items of *S. dichotomus* and determined that its diet largely consisted of phytoplankton. In addition, microorganisms such as bacteria, yeast and fungi were found in the gut of the fairy shrimp, *Branchinella spinosa* (Milne Edward, 1840)[27] as important foods[10]. However, in this study, these microorganisms were not investigated. The occurrence of phytoplankton, zooplankton, crustacean appendages, fecal pellets and mud in the gut indicated that *B. thailandensis* and *S. sirindhornae* are non-selective filter feeders. They showed no appreciable ability to discriminate between different types of organisms presented in their water bodies. These fairy shrimps consumed all particles which passed from their filtering appendages into the mid-ventral groove. Amounts and species of organisms found in the guts of fairy shrimps related with their environmental habitats. This finding concurred with the conclusions drawn by Velu and Munuswamy[11], Selvarani[26] and Starkweather[28].

A non-selective feeding habit was also demonstrated in *S. proboscideus*[6] and *S. dichotomus*[10,26] in agreement with Reeve[29] who reported that *Artemia salina* was not able to discriminate between plant cells and other inert particles. The thoracic appendages of fairy shrimp are multifunctional phyllopods. These are used not only for locomotion but also for food collection. Particle filtration is regarded as the feeding habit of most anostracans[6,10]. The thoracic limbs play an

Table 5: Food items (%) found in the guts of *Branchinella thailandensis* and *Streptocephalus sirindhornae*

| | | *B. thailandensis* | | *S. sirindhornae* | |
|---|---|---|---|---|---|
| Categories | Food items | Number | Percentage | Number | Percentage |
| Chlorophyta | *Chlorella* sp. | 34.69 | 57.4 | 37.25 | 69.3 |
| | *Monoraphiduim* sp. | 10.74 | | 8.52 | |
| | *Cosmarium* sp. | 3.83 | | 18.84 | |
| | *Crucigeniella* sp. | 2.32 | | 0.03 | |
| | *Dictyosphaerium* sp. | 2.01 | | 0.11 | |
| | *Tetrahedron* sp. | 1.74 | | 1.08 | |
| | *Closterium* sp. | 1.03 | | 0.14 | |
| | *Volvox* sp. | 0.49 | | - | |
| | *Oedogonium* sp. | 0.18 | | 0.03 | |
| | *Scenedesmus* sp. | 0.13 | | 3.04 | |
| | *Gonatozygon* sp. | 0.09 | | 0.03 | |
| | *Eudorina* sp. | 0.04 | | - | |
| | *Pediastrum* sp. | 0.04 | | 0.02 | |
| | *Pleurotenium* sp. | 0.04 | | - | |
| | *Pleurotenium* sp. | 0.04 | | - | |
| | *Spirogyra* sp. | 0.04 | | 0.02 | |
| | *Crucigenia* sp. | - | | 0.20 | |
| Bacillariophyta | *Navicula* sp. | 18.72 | 23.8 | 1.33 | 13.5 |
| | *Pinnularia* sp. | 3.79 | | 0.21 | |
| | *Fragilaria* sp. | 1.07 | | 0.11 | |
| | *Gomphonema* sp. | 0.09 | | - | |
| | *Cymbella* sp. | 0.09 | | - | |
| | *Hantzschia* sp. | 0.04 | | 0.02 | |
| | *Nizschia* sp. | - | | 11.79 | |
| | *Amphora* sp. | - | | 0.08 | |
| Euglenophyta | *Euglena* sp.1 | 0.18 | 7.2 | 0.32 | 1.2 |
| | *Phacus* sp. | 0.67 | | 0.56 | |
| | *Euglena* sp.2 | 6.38 | | 0.36 | |
| Chrysophyta | *Centitractus* sp. | 1.78 | 1.8 | 2.14 | 2.1 |
| Cyanophyta | *Microcystis* sp. | 1.16 | 1.5 | 9.14 | 10 |
| | *Spirulina* sp. | 0.22 | | 0.06 | |
| | *Oscillatoria* sp. | 0.09 | | 0.44 | |
| | *Oocystis* sp. | 0.04 | | 0.06 | |
| | *Nostoc* sp. | - | | 0.27 | |
| Protozoa | Protozoa | 5.39 | 5.4 | 3.34 | 3.3 |
| Nauplius of crustacean | Nauplius | 1.07 | 1.1 | 0.36 | 0.4 |
| Rotifera | *Lecane papuana* | 0.22 | 1.0 | - | 0.1 |
| | *Polyarthra* sp. | 0.18 | | 0.03 | |
| | *Brachionus rubens* | 0.09 | | 0.02 | |
| | *Brachionus falcatus* | 0.09 | | - | |
| | *Lacane* sp. | 0.09 | | - | |
| | *Filinia longiseta* | 0.09 | | - | |
| | *Brachionus* sp. | 0.04 | | 0.02 | |
| | *Anuraeopsis coelata* | 0.04 | | - | |
| | *Lecane bulla* | 0.04 | | - | |
| | *Leppadella patellus* | 0.04 | | - | |
| | *Hexarthra* sp. | 0.04 | | - | |
| Copepoda | Cyclopoid | 0.58 | 0.7 | 0.05 | 0.05 |
| | Calanoid | 0.09 | | - | |
| Cladocera | *Diaphanosoma* sp. | 0.13 | 0.1 | - | 0.02 |
| | *Ceriodaphnia cornuta* | - | | 0.02 | |
| Microworm | Microworm | - | - | 0.02 | 0.02 |

important role by producing feeding currents and filtering the food particles. Food is swept forward by these appendages to the food groove mechanically and not propelled by water currents[10]. The presence of a backwardly directed mouth rules out the possibility of a carnivorous habit and the occurrence of animal remains in the gut is not a result of active predation[10]. However, some large species as *Branchinecta gigas*, *Branchinecta ferox* and *Branchinecta mackini* are described as true predators[6,27].

Table 6: Miscellaneous items collected from natural habitats

| Categories | Miscellaneous items | *B. thailandensis* | *S. sirindhornae* |
|---|---|---|---|
| Chlorophyta | *Chlorella* sp. | + | + |
| | *Monoraphiduim* sp. | + | + |
| | *Cosmarium* sp. | + | + |
| | *Crucigeniella* sp. | + | + |
| | *Dictyosphaerium* sp. | + | + |
| | *Tetrahedron* sp. | + | + |
| | *Closterium* sp. | + | + |
| | *Volvox* sp. | + | - |
| | *Oedogonium* sp. | + | + |
| | *Scenedesmus* sp. | + | + |
| | *Gonatozygon* sp. | + | + |
| | *Eudorina* sp. | + | - |
| | *Pediastrum* sp. | + | + |
| | *Pleurotenium* sp. | + | - |
| | *Spirogyra* sp. | + | + |
| | *Crucigenia* sp. | - | + |
| Bacillariophyta | *Navicula* sp. | + | + |
| | *Pinnularia* sp. | + | + |
| | *Fragilaria* sp. | + | + |
| | *Gomphonema* sp. | + | - |
| | *Cymbella* sp. | + | - |
| | *Hantzschia* sp. | + | + |
| | *Nizschia* sp. | - | + |
| | *Amphora* sp. | - | + |
| Euglenophyta | *Euglena* sp.1 | + | + |
| | *Phacus* sp. | + | + |
| | *Euglena* sp.2 | + | + |
| Chrysophyta | *Centitractus* sp. | + | + |
| Cyanophyta | *Microcystis* sp. | + | + |
| | *Spirulina* sp. | + | + |
| | *Oscillatoria* sp. | + | + |
| | *Oocystis* sp. | + | + |
| | *Nostoc* sp. | - | + |
| | *Microcystis* sp. | - | + |
| | *Oscillatoria* sp. | + | + |
| Protozoa | Protozoa | + | + |
| Nauplius of crustacean | Nauplius | + | + |
| Rotifera | *Lecane papuana* | + | - |
| | *Polyarthra* sp. | + | + |
| | *Brachionus ruben* | + | + |
| | *Brachionus falcatus* | + | - |
| | *Lacane leontina* | + | - |
| | *Filinia longiseta* | + | - |
| | *Brachionus* sp. | + | + |
| | *Anuraeopsis coelata* | + | - |
| | *Lecane bulla* | + | - |
| | *Leppadella patellus* | + | - |
| | *Hexarthra* sp. | + | - |
| | *Brachionus forficula* | + | - |
| | *Testudinella patina* | + | - |
| | *Keratella tropica* | - | - |
| | *Trichocerca* sp. | - | + |
| | *Polyarthra vulgaris* | - | + |
| Copepoda | *Mesocyclops thermocyclopoides* | + | + |
| | *Mesocyclops aspericornis* | + | - |
| | *Vietodiaptomus blachei* | + | + |
| | *Mongolodiaptomus malaindosinensis* | + | + |
| | *Mongolodiaptomus botulifer* | + | + |
| | *Phyllodiaptomus christineae* | - | + |
| | *Eodiaptomus draconisignivomi* | - | + |
| Cladocera | *Diaphanosoma excisum* | + | - |
| | *Ceriodaphnia cornuta* | - | + |
| | *Bosmina meridionalis* | + | + |
| | *Bosminopsis deitersi* | + | + |
| | *Macrothrix flabelligera* | + | - |
| | *Simocephalus serrulatus* | - | + |
| Microworm | Microworm | - | + |

-: Absent in water habitats, +: Present in water habitats

The presence of inert particles such as crustacean appendages, fecal pellets and mud in the gut proved that *B. thailandensis* and *S. sirindhornae* are suspension feeders. Inert particles may be taken from the bottom of the ponds. Fairy shrimps sometimes lie on the bottom of the ponds with their appendages in constant movement. This behavior, results in the passage of mud containing inert particles into the mid-ventral groove and finally into the gut of fairy shrimps[10]. Mud particles were seen in the guts, supporting the idea that fairy shrimps burrow into the muddy bottoms of pools when they are disturbed[11].

*Branchinella thailandensis* and *S. sirindhornae* consumed both phytoplankton and zooplankton; therefore, they can be described as omnivorous animals. *Branchinella thailandensis* consumed more diverse food items than *S. sirindhornae*. Additionally, *B. thailandensis* consumed more diverse zooplankton taxa than *S. sirindhornae*. The explanation for this may relate to the larger size of *B. thailandensis* due to the larger mouth width which can consume larger prey than *S. sirindhornae*. These results concurred with Chaoruangrit *et al.*[5] who reported that *B. thailandensis* consumed larger particles than *S. sirindhornae*. The largest percentages of ingested food size in both immature and mature *B. thailandensis* were 5-30 µm and showed a relationship between the body length of fairy shrimps and food size capacity.

The two fairy shrimp species consumed higher numbers of rotifers than cladocerans and copepods. This finding concurred with Sarma and Nandini[30] who reported that *Chirocephalus diaphanus* consumed less large prey (cladocerans) and preferred smaller prey (rotifers). Ali *et al.*[20] also reported that rotifers were the most abundant zooplankton in the gut of *S. proboscideus*, while cladocerans were only consumed by adult fairy shrimps. Higher consumption of rotifers compared to cladocerans and copepods by fairy shrimps was related to the smaller size of rotifers and higher rotifer availability in the water bodies[28,30]. Besides, larger-sized zooplanktons normally move faster and cannot be wafted by food currents. They can swim away from the vortices produced by the food currents and are too large to go through the mid-ventral groove. Thus, these preys are not present in fairy shrimp guts[10].

This investigation recorded only phytoplankton and zooplankton as food preferences in the gut of 2 fairy shrimps. However, the natural food of fairy shrimps also comprised large numbers of microbiota such as bacteria. Gut microbiota perform the recognized role of beneficial microbes by promoting nutrient intake and conferring resistance against pathogens. Unfortunately, aquaculture-related microbiome studies are scarce. Therefore, gut composition of the bacterial community requires further study to identify future probiotic-approaches for more sustainable fairy shrimp farming practices.

## CONCLUSION

Phytoplankton are abundant microscopic algae occurring as natural food in the gut of *B. thailandensis* and *S. sirindhornae*. The most frequent food item in the gut of the 2 fairy shrimp species was the chlorophyte *Chlorella* sp. The presence of algae, small zooplankton and inert particles in the gut of fairy shrimps revealed that *B. thailandensis* and *S. sirindhornae* are omnivorous species as non-selective feeders.

## SIGNIFICANCE STATEMENT

This study discovered that natural foods of two fairy shrimp species can be beneficial for fairy shrimp aquaculture. Small zooplankton and inert diets could be used as alternative food sources to benefit fairy shrimp culture systems. These findings offer valuable information to optimize practical fairy shrimp farming production.


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