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UTILIZING NET TRAPS TO MANAGE PYRALID INSECT POPULATION IN POND ECOSYSTEMS: INVESTIGATING SEASONAL ABUNDANCE AND THEIR ASSOCIATION WITH DUCKWEEDS

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Abstract

A one-year (May to April) study was done about the seasonal abundance of pyralid insect (*Synclita occidentalis*: Pyralidae), its association with the duckweed (*Spirodela* sp.), and the effectiveness of emergent trap as a control measure of pyralid insect in mini ponds ecosystem. The adult insects were non-feeding and selected duckweeds for oviposition and larval development. The larvae of different instars were used duckweed fronds as a trophic source (food). For this, the insect attains pest status in its larval stage. The duckweed production is highly hampered due to the attack of this pyralid insect in pond ecosystem. During experiment, two seasonal peaks were noted, one in summer and another in autumn (larvae and adults). The highest relative seasonal abundance of the adults was recorded in June (0.2) and larvae was in August (0.23). The lowest abundance of the adults and larvae was found 0.001 and 0.01, respectively during winter season. In this experiment, it was found that larvae used duckweed fronds as food in maximum 18.86 ± 0.86 and minimum 13.33 ± 0.70. The larva also built protective cases in duckweed fronds. The highest length of the larval cases was 27.07 ± 1.7 mm and width was 14.8 ± 1.75 mm. The larval feeding habit and case-making adaptability give this insect pest status. From the experiment, it was also found that the length and width of the larval cases greatly varied in different seasons and not positively correlated ($P > 0.005$). The total seasonal abundance of larval cases was lower in treatment ponds (54) than control (103); and not varied significantly ($P > 0.005$) between the experimental ponds. In addition, the net trap of adult's emergent had an important role in suppressing pyralid pest population especially in summer. This situation indicated that it might be a key contribution as a control planning during the peak season of pyralid pest outbreak for the management of duckweed in aquatic ecosystems.

Key words: Duckweed; Pyralid insect; Emergent trap; Seasonal abundance; Pond ecosystem.

INTRODUCTION

Duckweeds are a small floating aquatic plant and received considerable empirical attention because of its high quality crude protein (35 to 43% in dry matter). It is regarded as a promising source of human food (Appenroth *et al*. 2017, Ziegler *et al.* 2015, Laird and Barks 2018, Beukelaar *et al.* 2019). This aquatic plant is considered highly invasive in many countries due to its high vegetative growth rate (Ceschin *et al.* 2018, Ceschin *et al*. 2016). It covers quickly as a blanket on entire water bodies (Driscoll *et al*. 2016). In Bangladesh, it appears to be a suitable food for a wide range of fish species. Cui and Cheng (2015) reported that duckweeds are also used as bioremediation, agricultural feed and biofuel production. Herbivores (insect) adult's preference depends on which larvae developed properly (Cahenzli and Erhardt 2013, Thöming *et al.* 2013). Furthermore, insects rapidly interact with duckweed and the impact can be significant (Subramanian and Turcotte 2020). The *Cataclysta lemnata* L.

(Lepidoptera: Crambidae: Acentropinae) feeds on duckweed (*Lemna minuta*) reported by Mariani *et al.* (2020a,b). Haghani *et al.* (2017) observed that *C. lemnata* mainly infested *Azolla* sp. of duckweed. *C. lemnata* used duckweed as material for construction of protective cases at larval stages (Mariani *et al.* 2021). In Bangladesh, the productions of duckweeds (*Spirodella* sp.) are highly hampered due to the attack of a pyralid insect (*Synclita occidentalis*). This insect attains its pest status by larval feeding habit and case-making adaptability at larval stage reported by Parven *et al.* (2012). The infestation intensity of pyralid insect increased by the availability of suitable leaf sheath during the growing season of duckweed, adult egg laying and larval development (Bashar *et al.* 2008). Although duckweed is economically and ecologically important, interactions with insect's pest at developmental stages were studied in previous studies but unfortunately the impact of adult associations remain poorly understood. The impacts of this association on duckweed productivity, seasonal abundance and effective control measures is necessary to investigate. It is very difficult to control the pest at developmental stages by using pesticides due to them being well protected by cases. Therefore, innovation of effective control measures is highly essential for successful control of this insect and sustainable management of duckweed. The aims of the present study are to investigate the seasonal association of *S. occidentalis* with duckweed alone with innovation of adult emergent net traps for an augmentative biological control for pyralid insects.

MATERIAL AND METHODS

Experiments were performed at duckweed production farm in Mirzapur Kumudini Hospital complex Tangail, Bangladesh (24°5' 52" N, 90°5' 36" E) for one year duration. Sampling was made at 15 days of intervals from the selected mini pond ecosystem with inorganic fertilizer (cow dung, decomposed materials and inorganic fertilizer) used as duckweed nutrients. The seasonal abundance of adults and association with duckweed was investigated by the use of emergence traps. The emergency trap was made by bamboo, iron rod covered with mosquito net for tapping the adults. The trap consists of three parts; a basal part (50×50 cm^2), cylindrical body (22.86 cm×7.62 cm) with an opening chain (12.7 cm), and a circle opening (7.63 cm); all parts were covered by mosquito net (Fig. 1a). The adult emergent net traps (25) were positioned with a minimum distance (Fig. 1b) to prevent interference between traps and placed on duckweed biomass at the parallel position (Fig. 1c). The position of traps was changed within the ponds during the entire study period (Fig. 1d) according to the methods of Infusino *et al*. (2017). Naturally, adults were aggregated into the prolongation parts and collected by hands through opening the opening chain in laboratory for further analysis (Fig. 1e). Date-wise trapped adults were recorded to examine the seasonal abundance according to the methods of Adams *et al.* (2017).

The larval cases with duckweed biomass were collected from the selected sites of control and treatment ponds by metallic sieve (6.35 cm×6.35 cm). Larval cases were stored in (11.43 cm×8.89 cm) plastic containers by following the methods of Parven *et al*. (2012); along with the seasonal abundance of larvae and its association with duckweed and morphometric characteristics were investigated according to the methods of Mariani *et al*. (2020a) (Fig. 1f and g).

Newly emerged collected adults from emergent net traps were sexed and paired according to their dimorphic features (Fig.1h and i) combined into couples and three pairs were placed in a separate transparent, cylindrical mating glass container (18.5 cm×17 cm), filled with 125 ml of tap water and a thin monolayer of duckweed (2 g fresh weight). To prevent adults from flying away, all mating boxes were covered with mosquito nets to allow air flow (Fig.1j and k). Fresh duckweed fronds were supplied whenever necessary. Mating, oviposition behaviuor and association were observed around one hour and recorded at 24 hours of interval. Incubation was observed under a SKT microscope (Fig.1l) following the methods described by Mariani *et al.* (2021), Hu *et al.* (2018) and Haghani *et al.* (2017).

Fig.1. **a.** Different parts of adult emergent trap; **b.** Distance between traps; **c.** Placement of traps on duckweed; **d.** Change the position within ponds; **e.** Trapped adults; **f.** Larval cases build with duckweed fronds; **g.** Case making adaptability at the final developmental stage; **h.** Tapped female adults; **i.** Adults swarming on duckweed; **j.** Mating with male and female at lab; **k.** Container with duckweed biomass and adults oviposition behavior; and **l.** Egg hatching under 50X SKT microscope.

Finally, the effectiveness of emergent traps as a control measure (effects of mass adult trapping) was clarified by comparing the seasonal abundance of larval cases between the ponds (with trap and without emergent traps). Results were analyzed by Microsoft Office Excel programme. The collected data of larval cases for morphometric characteristics were summarized statistically to obtain mean, standard deviations and error. Values of collected adults and larval cases are presented as means of replications (three ponds). Seasonal abundance of pyralid insects at adult and larval stage was analyzed by relative frequency of collected data. Mean abundance of larvae, larval cases length, width and used duckweed fronds number were compared by one-way Analysis of Variance (ANOVA) test at the confidence level of 95%.

RESULTS AND DISCUSSION

A total of 507 adults were recorded during the study period. They were abundant primarily in the summer with the highest relative frequency (0.2 to 0.15). The highest abundance was recorded in the month of June and continued up to September. The adults were observed in swarms at night over the duckweed cover. A similar result was obtained by Belal (2015) who showed that adult abundance was significantly higher in summer and lower in winter in the mini pond ecosystem of the experimental duckweed production farm. At day time they were seen to fly on the peripheral herbs, shrubs, and on grass. The larvae of the experimental moths live entirely underwater during the developmental stages, while winged adults have a subaerial life (Pabis 2018). Abundance decreased from October to March and during winter the abundance was found very poor (0.009 to 0.001) (Fig. 2). During winter severe aphid infestation was noticed. It might be that, these two major pests of duckweeds caused a dynamic balance by lower pyralid infestation. *Cataclysta lemnata* adults (Lepidoptera: Crambidae: Acentropinae), on duckweed were reported in February, May, and October in a year suggesting the species is multivoltine, and therefore has multiple generations throughout the year (Mariani *et al.* 2020a).

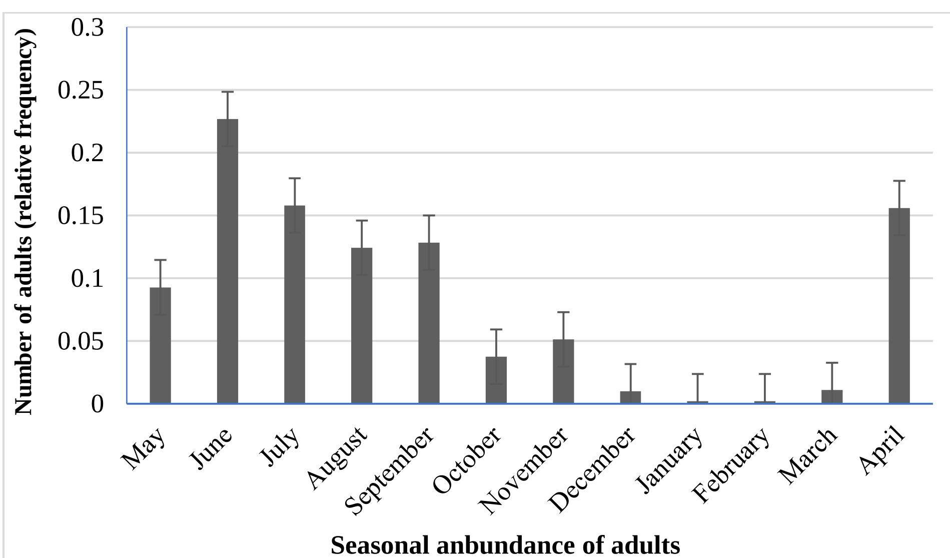

Fig. 2. Seasonal abundance of adults tapped by emergent traps in different seasons during the study period.

The adult stage of *S. occidentalis* was terrestrial and at this stage, it was not a pest itself on the duckweed (*S. polyrrhiza*). The adult was non-feeding and the lifespan was 2-3 days. Length of the body was 7.5-8 mm, light brown in colour, a female moth with a stout abdomen and a long ovipositor exhibited marked sexual dimorphism. Twenty hours after mating the female started to oviposite (335 to 156) eggs for two days. Whitish, oval, flattened eggs were laid near the edges of submersed duckweed fronds deposited either singly or slightly overlapping and scattered by curving the tip of the abdomen (Fig.1l). The newly hatched caterpillars were observed to live in the minute whole fronds utilized this for the life outside the eggshell. Adult's preference for a host plant depends on where eggs were properly developed as larvae (Cahenzli and Erhardt 2013, Thöming *et al.* 2013). Seasonal relative abundance of larvae also varied along with seasonal abundance of adults (Fig. 3). The highest relative seasonal abundance was 0.20 in July and continued up to August (0.21). The lowest presence was observed during the winter season (November to February) (0.01 to 0.009) when very few adults were oviposited. Belal (2015) reported that the lowest pyralid larval infestation and abundance were observed in winter season because the egg hatching rate is lower in winter.

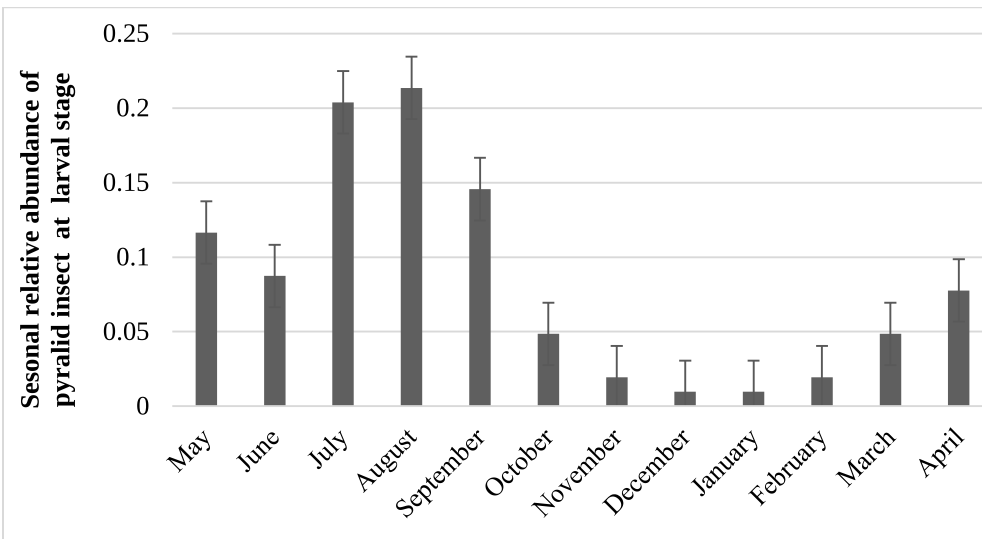

Fig. 3. Seasonal abundance of pyralid larvae in different seasons during the study period.

The result of this study has consistency with the abundance of *Diaphania hyalinata* larval abundance. The minimum abundance was in December (1.3 ± 0.0) and maximum in September 2014 (6.6 ± 0.1) when temperatures was relatively low (15-20°C) Panthi *et al.* (2017). The larvae consumed duckweed fresh fronds; used fronds failed to multiply further, causing rapid infestation by microbial infections. The infestation intensity varied along with larval abundance. Larval case-making is itself a special type of adaptability for this pest causing duckweed frond damage because used fronds failed to multiply. The number of associated and used duckweed fronds varied among collected cases (13.33 ± 0.70 to 17.69 ± 0.83). The highest number of used duckweed fronds in the larval cases was reported in the summer when the duckweed growth was good. The average length among cases varied 22.4 ± 1.55 mm to 24.34 ± 0.70 mm (Table 1).

Table 1. Host plant association of pyralid insect at larval stages and their morphic status.

Seasonal months	Measurement of the larval cases		No. of duckweed fronds used in larval case-making
	Length (mm)	Width (mm)	
March (n= 5)	Min. 11 Max.18 Av.23 Std.2.77 SE±1.24	Min. 5 Max.9 Av.11.66 Std.1.98 SE±0.70	Min.6 Max.10 Av.13.33 Std.1.58 SE±0.70
April (n= 8)	Min. 7 Max.20 Av.22.88 Std.3.97 SE±0.09	Min. 3 Max.10 Av.11.11 Std.1.98 SE±0.70	Min. 5 Max.12 Av.15.77 Std.2.74 SE±0.97
May (n= 12)	Min.11 Max. 20 Av.24.07 Std.3.14 SE±0.09	Min. 5 Max.9 Av.12.46 Std.1.81 SE±0.52	Min.7 Max.15 Av.17.69 Std.2.90 SE±0.83
June (n= 9)	Min. 11 Max 20 Av.22.4 Std.4.66 SE±1.5	Min. 2 Max.18 Av.14.8 Std.5.26 SE±1.75	Min. 2 Max.12 Av.17.2 Std.3.0 SE±1.0
July (n= 21)	Min.6 Max.18 Av.24 Std.4.17 SE±1.2	Min. 2 Max.10 Av.11.9 Std.2.39 SE±0.69	Min. 2 Max.13 Av. 15.18 Std.2.90 SE ±0.83
August (n= 22)	Min.8 Max.19 Av.24.34 Std.2.45 SE±0.7	Min. 4 Max.10 Av.11.91 Std.1.54 SE±0.44	Min. 4 Max.15 Av.18.8 Std.2.9 SE±0.86
September (n= 15)	Min.7 Max.22 Av. 23.62 Std.4.48 SE±1.29	Min. 4 Max.10 Av.11.5 Std.1.9 SE±0.5	Min. 4 Max.17 Av.15.75 Std.3.74 SE±1.08
October (n= 5)	Min.11 Max.20 Av.27 Std.3.96 SE±1.77	Min. 6 Max.10 Av.14 Std.1.8 SE±0.81	Min. 8 Max.10 Av.16.6 Std.1.41 SE±0.63

The highest length of cases was recorded in the month of October (27 ± 1.7 mm). The results of ANOVA indicated no significant relation between the length and width of collected cases and numbers of used duckweed fronds ($P > 0.005$). In 1ate spring, on1y 1arge 1arvae of final instars were found. Except in size and number of used fronds very little morphological differences were observed among different instar larval cases presented in the Table 1. Panthi *et al.* (2017) reported that the abundance of small larvae (2.4 ± 0.1 mm) was greater than medium and large sized larvae (7.1 ± 0.3 mm) throughout the year in *Diaphania hyalinata* (Lepidoptera: Crambidae). Furthermore, body size increased from May to June (Gross *et al.* 2002). The larval size variation in the *Cataclysta lemnata* larvae (242 µm to 1051.82 µm) was reported by Mariani *et al.* 2021. Larvae were preferred native duckweeds as food and material to build protective cases in water (Mariani *et al.* 2020b). The duckweed small spongy fronds are very easily edible and suitable for manageable construction material of protective cases of *C. lemnata* larvae (Ceschin *et al.* 2016). In addition, high nitrogen content helped in larval and adult growth rates (Grutters *et al.* 2016).

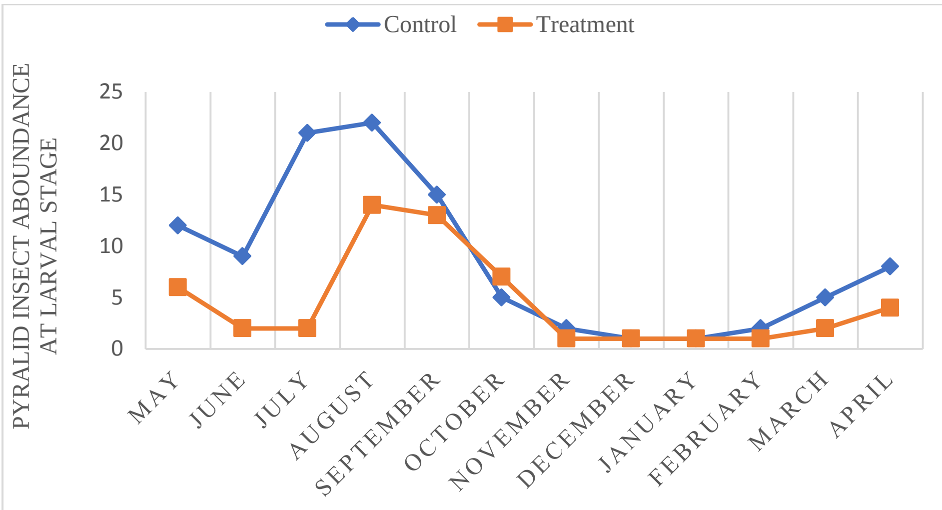

Fig. 4. Seasonal larval abundance in control and treatment ponds during the study period.

The larval case is water proof internally and contains a pocket of air. The inner layer of the case makes a close association with duckweed (Fig. 1g and h). It is difficult to control the insect due to protective case-building adaptability (Parven *et al.* 2012). The adaptability strengthens the insect to establish plant-insect association for the successful control of this insect pest utilization and innovation an effective control measure is very important. Maximum adult trapping efficiency was observed from June to July (100 to 83). The highest relative frequency of trapped adults gradually decreased from August (63) to October (26) (Fig. 2). The total collected larval cases of treatment ponds were lower (54) than control (103) during the entire study period. However, the abundance of pyalid insects was not significantly varied ($P > 0.005$). The emergent trap could be an effective control measure for this pest only in the peak season (Fig. 4). The present finding showed consistency with the seasonal threshold variation of three codling moth adult generations. A maximum of 12 adults per trap per season were captured and reported by Adams *et al.* (2017). Pyralid and duckweed association offers a good opportunity to clarify plant-herbivore interactions in mini pond ecosystem. The seasonal variation of adult related to the life cycle provides valuable information for the suitable management of this insect. Further, emergent traps as a control measure may provide a solution of duckweed problem.

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