Effects of a Pyralid Pest on Productivity of Duckweeds in Pond Ecosystem

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DECLARATION

I do hereby declare that the thesis entitled '***Effects of a Pyralid Pest on Productivity of Duckweeds in Pond Ecosystem'*** submitted to the 'Department of Zoology' University of Dhaka for the awarding of the Degree of Doctor of Philosophy. The research work was based on my own investigation and carried out in Environmental Biology and Biodiversity Laboratory (EBBL), under the supervision of Professor Dr. M. A. Bashar, Department of Zoology, University of Dhaka. This research work as a whole or part has not been submitted in any form for another degree or diploma at any university or other institution. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references has given.

Shahnaz Imrana Belal

CERTIFICATE

This is to certify that the thesis entitled "***Effects of a Pyralid Pest on Productivity of Duckweeds in Pond Ecosystem***" is the record of basic research carried out in Environmental Biology and Biodiversity Laboratory (EBBL), Department of Zoology, University of Dhaka under my direct supervisions. Author recorded data on her own effort and practical exercise of experimentation very regularly. All the data, figures and parts presented in this thesis are based on her observations and no portion there of has been used in any publications.

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TO

MY BELOVED FATHER AND MOTHER

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ABSTRACT

There are numerous instances of plant-Animal relationships which are ecologically friendly and significantly useful to the humans. The aquatic plant Duckweed and its pest (The pyralid insect) bear of the same interactions. In this study different biotic aspects were examined to clarify critical interactions of this relationship. This was aimed to establish a technique to examine bioresources in pond ecosystem.

The objectives of the study were selected to evaluate biomass development of duckweed (*Spirodela Polyrhiza*). Life cycle and behavioural activities of its insect pest (*S occidentals*) was examined. Abundance of adults and abundance of larval and pupal stage was also examined. Record was maintained in nature of injury caused by the insect pest on the duckweed productivity.

Various procedures and the sampling methods were innovated by the EBBL were used to carry out the research work. The research stations was in the Mirzapur Kumudini Hospital Complex, in Tangail District (in PRISM farm). Some experiments have been conducted in the Zoological Garden, Carzon Hall, in Dhaka University campus.

In the experiment, Duckweed biomass growth development, the result was vary significantly in inorganic and organic pond, and biomass was doubled in eight days in both ponds. Duckweed Biomass growth development were followed by the method used by (Khondoker 1993)

Life cycle observation, incubation period for hatching varies form 4-7 days. Egg hatching was higher in summer and lower in winter. Larval period lasts twelve days to more than one month. Pupation occurred within a cocoon inside the case, pupation period lasted for 4-7 days. The adults emerge from the pupa (within 2-4 days).Life cycle observations were followed by the methods using by Tuskes (1977)

Adult abundance was significantly high in August and October and lower in January in Inorganic pond and an adult abundance were more in April and less in January in Organic pond. Adult distribution were followed by the methods of Lavery and Costa (1973)

Infestation was calculated both in the fronds and roots of the Duckweeds in both ponds. The infestation was significant on the roots but it was not significant on the fronds in Organic pond.

In loss assessment of Duckweed growth, it was found that; growth rate was highly affected, in the Inorganic and Organic pond. Larval/Pupal case making process had significant impact on duckweed productivity.

Measurements of the Duckweed infestation and loss estimation were followed by the method used by Denis. S. Hill (1997)

Finding of the research will also play a significant role in augmentation of rural economy of Bangladesh. But it needs awareness regarding the use of Duckweeds by taking scientific care of its association in the aquatic ecosystem.

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GENERAL INTRODUCTION

Chapter-1

1.1 Background Information

Duckweeds are small, fragile, free-floating flowering plants with enormous potential both for animals and environment. It grows ubiquitously on fresh or polluted water throughout the world. Duckweeds are monocotyledons belonging to the family, Lemnaceac. This family consists of four genera. *Lemna, spirodella, walfia* and *wolffiella*. All species occasionally produce tiny, almost invisible flowers and seeds, but what triggers flowering is unknown. Many species of duckweed cope with low temperatures by forming a special starchy "Survival" frond known as a turion.

Duckweed species have an inherent capability to exploit favorable ecological conditions by growing extremely rapidly. The Duckweeds are commonly found in still or sluggish water. They often form large floating mats in ponds, marshes, lakes and quite stream. Fresh Duckweed contain 92-94% water (Skillikorn *et al.* 1993) Their wide geographic distribution indicates a high probability of ample genetic diversity and good potential to improve their agronomic characteristics through selective breeding.

Duckweed fronds are not anchored in soil, but float freely on the surface of a body of water. They can be dispersed by fast currents or pushed toward a bank by wind and wave action.

The duckweed-biomass is highly resourceful as a feed resource for livestock (Skillicorn *et al*., Leng *et al.* 1994)

Duckweeds can complete in terms of biomass production like most rigorous photosynthetic terrestrial plants. They can make "doubling" their biomass production n between 16 hours and 2 days (Leng, 1999)

Duckweed grows on water with relatively high levels of N, P and K, concentrates the minerals and synthesizes protein. Its protein has higher concentrations of essential amino acids, lysine and methionine, than most plant proteins, and more closely resembles animal proteins in that respect (Skillikorn *et al.* 1993).

Duckweed species bio-accumulate as much as 99 percent of the nutrients contained in wastewater and produce valuable protein-rich biomass as a bi-product (Skillikorn *et al.,* 1993). It produces more protein per square meter than soybeans (Landesman *et al.,* 2005). When duckweed grows on water high in nutrients, such as that in an animal waste lagoon, the food value is much higher than when it grows in natural waters (Truax *et al.,* 1972). Duckweed is one of the floating plants with a high capability of ammonia uptake and assimilation rate into valuable protein.

Duckweed contains a lot of minerals. Landoit and Kandeler (1987) indicated that the K, Ca. Mg. C and N are rich in amount. Mainly it stores varying amounts of calcium oxalate crystals in the vacuole. The C and N ratio varies more modestly, in the range of 6.7 to 8.6.

The organic composition of duckweed is varying amounts of different organic matter. The carbohydrate and protein amounts are noticeable which has made it as valuable food source.(Landolt and Kandeler 1987)

Leaf protein concentrates (LPC) and the residual pulp fibers were extracted and analyzed by Faskin (1999). He reported that the duckweed LPC was 64% protein, while the residual pulp fiber contained 20% crude protein. The LPC from duckweed was low in lipid and fiber content. The protein content of duckweeds is one of the highest in the plant kingdom, but it is dependent on growth conditions. Typically duckweeds are rich in leucine, threonine, valine, isoleucine and phenylalanine. They tend to be low in cysteine, methtonine, and tyrosine.

Duckweeds can contain up to 2- 4 percent oxalic acid. .However, oxalate also is, found in a great many leafy and very nutritious vegetables, including spinach, Swiss chard and others. In these edible vegetables, calcium oxalate is found in at levels up to 0.5-1 percent. So, minimizing oxalate has the potential to make duckweeds more nutritious and digestible.

Duckweeds are high in protein and dietary minerals and low in fiber. They do not produce toxic alkaloids and are palatable to a wide variety of domestic animals, birds and fishes. They are suitable for animal production, and that the meat is tasty and nutritious for human consumption.

Khan *et al.* (2002) reported that in duckweed the crude protein degradability was 330g/kg, microbial protein formation at 24'h incubation ranged from 38.6-47.2 mg and in vitro rumen degradable nitrogen between 31.5 and 48.4 %. All species were very rich in K, Fe, Mg, Mn, Cu and Zn concentration.

Landolt and Kandeler (1987) reported that most species of duckweed have protein contents in the range of 15-45%, depending on the nitrogen supply, and the amino acid balance is favorable. The yearly protein yield/ha is up to ten fold higher with *Lemna* than with soybeans, and nearly as much better than for alfalfa (Said *et al.,* 1979).

Mibagwu and Adeniji (1988) reported an especially high nutritional value of *Lemna paucicostata.* They showed a crude protein ranging from 26.3-45.5% of dry weight.

The amino acid content compared (Mibagwu and Adeniji. 1988) favorably with that of blood, soybean and. cottonseed meals and considerably exceeded that of groundnut meal. The levels of .the essential amino acids surpassed the FAO reference pattern, except for metnionine, which met 61.4% of the recommended value. The levels of minerals were high but should not cause any toxicity problems if incorporated into animal feeds. The levels of nitrogen in the plant were comparable to those in commercial fertilizers.

The growth of hybrid (grass carp X bighead carp, 12 to 18 months old) carp was studied by Cassani and Caton (1983) to determine feeding preference and feed consumption and concluded, "The most preferred plant was *Lemna gibba* when in combination with six other species.

Gaigher *et al.* (1984) compared the growth of hybrid tilapia fish, on commercial pellets vs. duckweed. The fish were cultured at high densities in an experimental reticulating unit for 89 days with duckweed *(Lemna gibba)* or a combination of duckweed and commercial pellets. They conclude that a combination of pellets and *Lemna* gave the best performance.

They observed when fed on duckweed alone, intake rate was low, feed conversion ratio was good (1:1) and relative growth rate was poor (0.67% of bodyweight daily), Sixty-five percent of the duckweed consumed was assimilated and 26% converted to fish. When the fish were fed on pellets in addition to duckweed the rate of duckweed consumption decreased and growth rate of the fish doubled with feed conversion ratios between 1.2 and 1.8, Seventy percent of the mixed diet was assimilated but only 21% converted. Fish grown on the mixed diet performed similarly to fish, grown on pellets but had a better feed conversion ratio.

Porath *et al.* (1985) reported preliminary tests using duckweed to substitute for animal protein-rich feed in diets of young lambs and Awasi sheep Landoit, & Kandeler, (1987) summarize many other studies of this kind. They found duckweed as a potential protein source in their studies.

It need not be stressed that many waterfowl normally feed upon this plant. Chickens have also been prime candidates for this food source, since their high efficiency of feed conversion would further contribute to its economic viability, Work with laying hens has been particularly encouraging (Haustein, *et al.,*1990).

Duckweed is probably the fastest growing multi-cellular plant. It can double its weight in 24 hours, Culley *et al*., (1981) and Landolt & Khandeler (1987) summarized many earlier studies demonstrating the unusually high productivity of this aquatic plant. Dry weight increases of 10-20 tons/ha/yr were the normal. Doubling times in the range of 24 hr have been observed on many occasions, a rate of increase results in 64 g/g dry weight/week, or 73 tons/ha/yr. Under summer conditions in Louisiana with heavy fertilization, up to 44 tons/ha/yr have been obtained (Said *et al*., 1979).

Porath, *et al.* (1985) attempted to recycle the solid wastes of these fish as a fertilizer for *Lemna*, The duckweed *(Lemna gibba)* was grown in shallow ponds containing mineral nutrients. However, the tilapia waste was poor in free NH_3 and ammonium compounds. When separated and incubated at 38° C to allow anaerobic digestion to release mineral nutrients, prolonged digestion was necessary before it supported growth of the plant.

The *Lemna* Technologies of St. Paul, Minnesota has patented a new form of wastewater treatment. This technology combines conventional wastewater treatment lagoons with a pond covered by duckweed. This floating mat of duckweed effectively reduces the growth of phytoplankton (algae) and submerged aquatic plants by competing for nutrients dissolved in the wastewater and creating shade, which also prevents the growth of these plants. Furthermore this duckweed can be harvested and used as food for ducks and fish. This technology has the potential for recycling nutrients and producing useful products as well. Widespread use of this and similar technologies can kill 2 birds with one stone: treat wastewater and produce high protein feed materials. This technology should be particularly useful for developing countries. Moreover the potential duckweed has for wastewater treatment, an urgent concern all over the world.

The efficient absorption of heavy metals and other (organic) toxic compounds could be used for the extraction of such toxins from industrial wastewaters. The experiential results of Parven *et.al* (2009) indicated that persistence of heavy/essential metals (Pb, Cd, Cu, Co, Mn, Ni, Cr, Fe and Hg) occurred in successive tropic levels of pond ecosystem. It is, however, important that the biomass is harvested at regular intervals; otherwise, the toxins will settle the sediments with the decaying plants. The harvested plants should be burnt and/or disposed of in sealed landfills. Duckweed for food production should only be grown on wastewaters with extremely low toxin concentrations. Even low concentrations in the raw wastewater may become hazardous due to the manifold bioaccumulation in duckweed and, possibly, in the food chain. Separate collection of toxin containing domestic and industrial wastewaters is recommended. In practice, separation of critical industrial wastewaters is very difficult as the countries concerned dispose of only elementary or no wastewater collection systems.

Aquatic weed utilization as a feed for the monoculture and poly culture of carp fishes, poultry and cattle stands as the most important and vital in the economy of Bangladesh. The research is to bring the duckweeds from the states of 'weeds' to 'wealth' the wealthy bio-resource.

Duckweed based wastewater treatment system has demonstrated great efficiency in domestic wastewater. Duckweed wastewater treatment is potentially suitable for small scale application at rural level and for medium-sized facilities at community, urban and industrial levels. The duckweed treatment plants installed so far almost exclusively treat domestic or agricultural wastewaters. Duckweed-based wastewater treatment systems provide genuine solutions to the problems of urban and rural human waste management with simple infrastructure at low cost (Leng, 1999). Hardly any literature is available on the treatment of specific industrial wastewaters (Gijzen and Khondker, 1997). Potentially, duckweed may also be applied for the treatment of industrial wastewaters provided their nutrient content is relatively high. Effluents with both a high BOD and nutrient load may require adequate primary treatment to reduce the organic load.

A further interesting approach would be to create a market for duckweed locally, as is the case presently in Vietnam, in order to encourage duckweed agriculture as a cash crop. Undoubtedly a cash flow from such a market would than stimulate village people to clean up the huge number of pollute ponds. In this case duckweed collection centre may be established to either sell duckweed directly or after drying for cattle, duck, poultry or even ruminant production through local outlets or to blend duckweeds for use in compounded feed. The latter in Bangladesh is largely imported at great cost.

Creation of markets is essential if duckweed is realized as a potential commodity in all the countries in the subtropics and tropics that have large areas of ponds or swamps that are presently eutropic because of man's activities.

A typical one hectare duckweed wastewater treatment plant will yield up to one metric ton of harvest which will produce approximately 100 kg of fish, or 100 kg of dried high protein duckweed meal (Skillikorn *et al.,* 1993). The Mirzapur-experimental programme in Bangladesh represents the first effort to apply existing knowledge on duckweed growth and cultivation in developing a practical farming system. The Mirzapur experimental programme has shown that duckweed farming can be profitable.

The profitability of duckweed production is especially sensitive to two factors: (i) the cost of fertilizer and (2) the sale price of fresh duckweed. The projected rates of return of the Mirzapur experimental programme of Bangladesh on both investments (one hectare of duckweed-fed carp culture and 0.5 hectare of the unit of duckweed production) compare favorable with any alternative investments in the agricultural sector in Bangladesh.

Feeding trials reported in the literature and carried out recently in Peru have demonstrated that duckweed can be substituted for soy and fish meals in prepared poultry rations for broillars, layers and chicks. Cultured duckweeds can supply protein component in poultry diets. Acceptable levels of duckweed meal in the diets of layers range upto 40 percent of total feed. Duckweed fed layers produce more eggs of the same or higher quality as control birds fed with the recommended formulated diets.

It is found that small amounts (2-25) % of total dry matter fed) of duckweed in the diet stimulate the growth of chickens, while higher additions (> 40 %) of duckweed tend to decrease weight gain (Haustein *et al.* 1988). An increase in weight by 10 to 32 % for chicken fed with small amounts of duckweed (2-5 %) in Addition to their regular diet (Mueller and Lautner, 1954; Muzaffarov *et al.,* 1968; Naphade and Mithuji, 1969; Taubaev and Abdiev, 1973). Application of duckweed as feed for ducks is practiced at least to some extent in rural areas (Gijzen and Khondker, 1997). According to Hamid *et al.* (1993) *Lemna trisulaca* meal (LTM) could be considered as a protein feed supplement for growing ducklings without deleterious effect on performance.

The mosquito *Culex pipiens pipiens* L. never colonize in sewerage water covered with duckweed. The *Lemna minor* vegetations affected the identification of oviposition site by the females. The amputation of sensilla made the mosquito incapable of choosing the oviposition site. The immature stages of the mosquito are susceptible to the water borne synomones of the duckweed; the first instar larvae are most susceptible and have high mortality. *Lemna trisulca* appears to produce allelo chemicals that are active against algae (Crombae and Heavers, 1994).

In Vietnam duckweed production on nutrients from animal and human waste is given fresh with cassava waste to ducks. In Taiwan, it was traditional to produce duckweeds for sale to pig and poultry producers.

Duckweed is a promising new commercial agriculture crop. Prior to 1989 duckweed had been used only in commercial applications to treat wastewater in North America. In 1989 staff of a non-governmental organization based in Columbia, Meryland 'The PRISM Group' initiated a pilot project in Bangladesh to develop farming systems for duckweed and to test its value as a fish feed. An earlier project. in Peru investigated the nutritional value of dried duckweed meal in poultry rations. Although these pilot operations were located in South Asia and Latin America, the results suggested that the plant would be important as a source of fish and poultry feed and simultaneously as a wastewater treatments process in selected areas of the Middle East, in Egypt and Pakistan (Skillikorn *et al.,* 1993).

In Bangladesh duckweeds are used in different fields. Feed containing the duckweed was more effective than the feed containing water hyacinth or rice bran in the diet of *Oreochromis niloticus.* Duckweed can be used as an effective supplementary feed for the culture of phytophagus silver carb. Duckweed could be used as an effective protein supplement in poultry diet (Islam 2002). Duckweed can effectively be used as feed for polyculture of fish (Kabir *et al,* 2009).

Bangladesh could be termed genuinely the home of duckweed. Taking Bangladesh as an example, the organized production of duckweed could provide sufficient quantities to replace at a minimum 80% of the protein meals required by the small poultry producer. In this process a simple and economic system of collection sun drying and marketing could be put in place. There are thousand hectares of derelict ponds polluted to eutrophication levels in Bangladesh. These ponds could potentially be cleaned of their pollutants and resurrected for duckweed aqua-culture and fish farming at the family farm level. In these systems the objectives would be largely to provide protein of high biological value for the families of small farmers, who often have no animal protein in their diets.

This bioresource (duckweed) productivity is very high in terms of time but is severely affected by the insect pests. Bashar and Aslam (1999) and Aslam and Bashar (2001) found a pyralid pest and three aphid pests to attack duckweed and impede their production. Steinly *et al.* (1987), and Mansor and Buckingham (1989) reported some other insects that feed duckweeds. The degree of damage to duckweeds depends on many factors, such as temperature, relative humidity and insect species.

From the continuing studies it is evident that the insect pests on duckweeds have been developed some level of resistance to the insecticides applied in various duckweed farms in Bangladesh (Bashar and Aslam, 1998). It is found that insecticide application for the control of insect pests on duckweeds is not useful and environmental friendly. The caution of pesticide accumulation in the sequentially duckweed → fish → man in usual food chain needs to be considered in this case. Ecological pest management approaches in sound way methods thus be important in managing the duckweed populations.

Adaptation to an aquatic existence in the Lepidoptera is best exemplified by certain members of the family Pyralidae where the immature stages (egg.) larva, and pupa) undergo their entire development in the water. In one instance, the brachypterous form of the female of *Acentria nivea* (Olivier) spends her adult life in the water (Berg 1942; Buckingham and Ross 1981)

Larval habits include leaf mining, stem or root boring, foliage feeding, and feeding on flower or seed structures. Larvae of some species of the Hawaiian genus Hyposmocoma (Cosmopterigidae) construct Trichoptera-like cases and feed on lichens, algae, or mossess growing on the emergent portions of rocks in fast-flowing streams. The larvae are able to survive periodic submergence.

Among the pyralids, members of the subfamily Nymphulinae are the best suited for an aquatic existence. In the tribe Argyractini, the larvae and pupae occur in a variety of aquatic habitats, including lakes (*Eoparargyractis sp.)* deep and fast-flowing streams, hot springs, intermittent streams, and those receiving organic enrichment (*Petrophila jaliscalis*)(Lange 1956) .

The larvae of *Neargyractis slossonalis* (Dyar) feed on the roots of Pistia and other submerged plants (Habeck 1988). Forno (1983) reports the feeding of *Argyractis subornata* (Dyar) on the roots of water hyacinth (*Eichhornia crassipes*). An increased knowledge of the biology and ecology of plant-feeding nymphuline and related pyralid moths is being used as a basis for the suppression of several aquatic (submergent) weeds.

A western species (*Petrophila confusalis*) [Walker] is found is well-oxygenated water of streams and lakes. The adult female usually crawls down a rock into the water and deposits groups of eggs on the underside. After hatching, the gilled larva constructs a silken tent on the rock, under which it feeds on diatoms and other algae. The pupal cocoon is made of tightly woven silk with holes along the periphery that allow for water circulation. The pupa is located in inner cocoon, and prior to pupation the larva cuts an "escape slit" to assist in adult emergence. The emerging adult swims (using the mid and hind legs, and wings) or floats to the surface from the underwater cocoon.

Truskes (1981) reports that the larvae are most abundant in lakes and streams where the water velocity is between 0.4 and 1.4 m/sec. Other factors influencing numbers and distribution include water temperature, concentration of dissolved oxygen, substrate texture, and algal growth.

In addition to the rock-dwelling species of Nymphulinae (Argyractini), the Nymphulini are associated with vascular hydrophytes and also adapted to fresh water. Many first larval instars are nongilled. Following a molt to the second instar, members of the genus *Parapoynx* possess tracheal gills, whereas all instars of the other genera *(Munroessa, Synclita. Neocalaclyxia)* lack gills (Berg 1949, 1950). In the absence of gills, a plastron type of respiration has been suggested for *Munroessa, Synclita, Neocataclysta* (Walker) (Berg 1949, 1950a; Thorpe 1950).

The first two larval instars of *Pampoynx inaciilcilis* (Clemens) occur on the bottom and feed on submerged leaves of *Nymphaea,* whereas older larvae generally become surface feeders (Welch 1924).

Most of the other lepidopterous larvae associated with aquatic and semiaquatic ecosystems feed on cattail (Typhaspp), bulrush (Scirpus spp.) or other vascular hydrophytes. These include genera of several pyralids (Crambus and Chilo), a nepticulid (Nepticula), several coleophorids (Coleophora) (Ellison 1991).

Considering the valuable importance and needs of duckweed production and their pest management the present programme of research has been under taken.

Duckweed may be the most promising plant for the twenty first century for the following reasons.

- Duckweed produces more protein per square meter than soybeans UTA.
- Duckweed is easier to harvest than algae or other aquatic plants.
- Duckweed can be used to feed fish, poultry and cattle (PRISM, INC).
- Duckweed can purity and concentrate nutrients from wastewater (sewage effluent).
- Duckweed can make a balance aquatic ecosystem and can preserve the environment.

1.2 Objectives of the research work

This study is the part of nature conservation where the role of interrelationship between duckweed plants and pyralid insect has been envisaged as the main focus. It deals with the population abundance and larval pupal abundance of the insect and it causes the adverse effect on duckweed productivity. The principal objectives of the research programme have been stated as below-

- Determination of life cycle stages of the insect pest and duckweed.
- Observation on behavior and adaptability of the insect pests and the seasonal variation of the duckweed productivity.
- Observation of nature of injury and to estimate duckweed infestation intensity.

1.3 Organization of Thesis:

The thesis is organized in to ten chapters

Chapter1: Begins introducing about the general concept of duckweed and pyralid insect as well as objectives of the current research work.

Chapter-2: Describes reviewing of literature related to duckweed and pyralid insect.

Chapter- 3: Duckweed Biomass growth development in lab and field condition is documented in this chapter.

Chapter-4: Biology and some behaviour of the pyralid insects has been described, based on field work.

Chapter-5: Deals adult and larval/pupal abundance of the insect and emergence pattern of the insect in duckweed field and lab.

Chapter-6: Describes nature of injury caused by the pyralid insect in Duckweed roots and fronds.

Chapter-7: Deals with loss assessment of duckweed fronds and roots caused by the pyralid insect.

Chapter-8: Presents the importance of Research work in social aspect.

Chapter-9: Presents the conclusion of the whole research work.

Chapter-10: Deals with the citation of literature that has been used in the thesis.

Chapter-11: Presents raw data of research work in appendix.

CHAPTER 2

REVIEW OF LITERATURE

Chapter 2

Review of Literature

Various workers have made some excellent studies on other pyralid insects of different vegetations, but very few literature was available on the biology , nature of damage and pest management of duckweeds. Mainly the review of literature have been conducted here those pyralid and some related insects which are aquatic and as like as the insects of duckweeds. A brief account of some of the available pertinent literatures is cited below alphabetically.

Aslam (1987) reported *Nymphulct africalis* (Lepidoptera: Pyralidae) a pest of *Azolla* in Nigeria. He found *Azolla* in an irrigated rice field at Ibadan, Nigeria infested with the pyralid *N. africalis.* Newly hatched larvae fed on the leaf buds and after a few days concealed themselves in cases made from *Azolla* fronds, which they carried around with them in search of food. The fully-grown larva could consume 9-14 leaves/day. Cocoons were spun inside the cases for pupation. Adults emerged from the cocoons within a week.

Aslam and Bashar (2001) worked on aphid pest problems of duckweed in mini pond ecosystem. Severe aphid infestation on duckweed was recorded in some duckweed production farms in Bangladesh. Three species- *Aphis gossypii, A.fabae* and *Leapaphis erysimi* were found to attach to the duckweeds. The infested leaves were damaged due to the direct loss of sap and the injury to tissues of leaves when the aphids were feeding. The aphids caused wilting of the duckweed fronds by feeding and also acted as vectors of other diseases, which cause damage to the fronds. These prevented the fronds from doubling and then multiplying. Consequently duckweed production ceased rapidly. The aphid infestation was significantly lower in the wastewater treated ponds than in the inorganic fertilizer treated ponds. Among the various species of duckweeds examined, the *Spirodela* population was found to be attacked the most. The frequency of infestation ranged from 18.4 to 96% in the different ponds of the experimental station.

Bashar and Aslam (1998) evaluated the pest status of a pyralid insect *(Synlita occidentalis)* affecting duckweed productivity in a minipond ecosystem. They found a pyralid pest *(S. occidentalis)* that caused a continuous economic injury in the duckweed production farms of Bangladesh. The insect was treated as a key pest for the duckweed *(Spirodela* sp.) population in a mini pond ecosystem. This insect attained its pest status at the larval stage. The larvae of different instars make case with duckweed fronds and the larva of final instar constructs case for the pupa. Both the larval and pupal case making is the key technical stages for bringing the insect to its pest status. Both larval and pupal case fronds fail to multiply and ultimately die. The number of fronds used by larva to construct case (larval case) varied from 6 to 12; and in case of pupal case the number varied from 8 to 20. The larvae feed on fronds and roots. More than 60% of the total fronds of larval cases had no roots and in case of pupal cases more than 53% of the used fronds were rootless.

Bashar and Aslam (1999) a pyralid, *Snyclita* sp. has been recorded as a key pest on duckweed in the mini pond ecosystem from some duckweed production farms of Bangladesh. Larvae of different instars make cases (except first and second instars) with duckweeds and larvae of ultimate instars construct cases for their pupae. The fronds containing larval or pupal cases fail to multiply and finally die, causing impeding the production of duckweed. The abundances of larvae and pupae were also recorded. The case-making strategy has been treated as the characteristics nature of injury.

Bashar *et al.* (2007) examined the morphological and physiological adaptations of pyralid insect larva. Different appendicular and visceral organs of the larvae were considered for examination. Anatomical features of digestive, excretory and respiratory organs were found highly significant. The 1st thoracic and 1st, 2nd, 3rd, 4th, 5th, 6th abdominal segments bear spiracles. The 3rd to 6th and 10th abdominal segments bear prolegs on either side of the body. The alimentary canal was found developed and adapted to consume a large amount of leaf-biomass. The principal excretory organ composed of six malpighian tubules. The neural organs were highly developed. The tracheal system was found terrestrio-aquatic in adaptations. The larvae had no gills or additional structures. The larval case was a characteristic air chamber, in which the larva breathes through spiracles.

Bashar *et al.* (2007). Severe infestation caused by a pyralid insect pest on duckweeds was recorded from July 2004 to February 2005 in some duckweed farms of Bangladesh. In Mirzapur station-1, larval abundance was in the peak in September and October. Larval abundance was diminished to zero state in the month of January. Maximum number of pupa was recorded in September 2005. The pest population was virtually absent in the month of December and January.

Bock (1990) described the Australian species of *Hydrellia* Robineau- Desvoidy (Diptera: Ephydridae). According to him 15 species represented the ephydrid genus *Hydrellia* in Australia. One of the new species *Hydrellia administrate* was collected from the water weed *Myriophyllum aquaticum* in Victoria. One of the species *Hydrellia williamsi* was originally described from specimens collected on duckweed *(Lemna minor)* in Hawaii.

Buckingham (1989) worked on *Lemnaphila scotlandae* (Diptera: Ephydridae) and three of its parasites discovered in Florida. He reported that the ephydrid *Lemnaphila scotlandae* was found attacking the weed *Lemna vorldiviana* in water tanks in Florida in 1986. Additional host plants were *Lemna gibba* and *Lemna minor.* Three parasitoids of the ephydrid were reared from pupae. Larvae elude after two days and mine the leaves for about 10 days. One amber-coloured pupa was formed per leaf. The adults of *Lemnaphila scotlandae* fed on their host plant. They had strong spines in the labella with which they scrape the leaf surface.

Buckingham and Binnett (1989) studied the laboratory host range of *Parapoynx diminutalis* (Lepidoptera: Pyralidae) as Asian aquatic moth adventives in Florida (USA) and panama on *Hydrilla vertidllata* (Hydropottaceae). *Parapoynx diminutalis* Snellen had been accidentally introduced from Asia into Panama and Florida where the aquatic larvae fed on the leaves of *Hydrilla vertidllata* Royle, an important submersed weed from Asia. Larvae were developed in the laboratory on 14 plant species belonging to 13 genera. *Hydrilla* was usually preferred by larvae when paired with a test plant, but it was not preferred by ovipositing females in small cage tests.

Buckingham and Binnett (1996) studied the biology of an immigrant Asian moth, *Parapoynx diminutalis* (Lepi: Pyralidae) on *Hydrilla vertidllata* (Hydropottaceae) in

Laboratory. They observed that the Asian moth *Parapoynx diminutalis* Snellen is immigrant in Florida and Panama where it attacks *Hydrilla,Hydrilla verticillata* Royle, an immigrant submersed weed from Asia. Larvae build portable cases from which they feed on leaves and stems. In the laboratory at 26.7c, eggs develop in 4-6 days, larvae in 21-35days, pre pupae in1-2 days and pupae in 6-7 days. Adult lived 3-5 days at 24.4c.

Cheng and Stomp (2009) described that the wastewater grown duckweed can be a good resource of proteins and starch, and utilized for the production of value-added products such as animal feed and fuel ethanol. In the experiment it is observed that when there are nutrients Nitrogen (N) and Potassium (P) available in the wastewater, duckweed takes the nutrients from the wastewater to support its growth and to store the nutrients in its tissue. When the N and P are completely removed from the wastewater, duckweed can use its internally stored nutrients. Nutrient reserve in the duckweed biomass has been found the key to the kinetics of duckweed growth. Utilization of duckweed for value-added products has a good potential. Duckweed is also an alternative starch source for fuel ethanol production. *Spirodela polyrrhiza* grown on anaerobically treated swine wastewater was found to have a starch content of 45.8% (dry weight). Enzymatic hydrolysis of the duckweed biomass with amylases yielded a hydrolysate with a reducing sugar content corresponding to 50.9% of the original dry duckweed biomass. Fermentation of the hydrolysate using yeast gave an ethanol yield of 25.8% of the original dry duckweed biomass. Results of these experiments indicate that the duckweed biomass can produce significant quantities of starch that can be readily converted into ethanol.

Cigdem *et al*. (2012) Observed that olive pyralid moth (*p.unionalis*) was reared at 24 degree centigrade and 65% RH in the laboratory on leaves of its natural olive host, but at random in the adult cages. There were six instars on molts and head capsule measurements. Larval development was completed in the average of 23 days and the survival rate was 60%.

Chokehai *et al.* (2013) they observed that, Lemnaceous plants,namely *lemna minor* and *Landoltia punctata* ,have been used in various types of biological research. The effects of Murashige and Skoog(MS) and Hoagland media on vegetative growth rate of both species during in vitro and ex vitro cultivation were investigated. Under axenic conditions frond proliferation of *L.minor* and *L punctata* in Hoagland medium are 8 and 11.5% respectively faster than that in MS medium. Biomass production in Hoaglandm medium also increases 2.2-fold (*L.minor*) and 1.4 fold (*Lan punctata*) compared to MS medium. The roots of both species in MS medium are distinctly shorter than those in Hoagland medium. In contrast, ex vitro regeneration of frond colonies in MS medium is 22.2% for *L.minor* and 17.1% for *L.punctata* faster than in Hoagland medium. Similarly, ex-vitro biomass *production* of both species in MS increases 1.8 fold for *L minor* and 1.3 fold for *L.Punctata* compared to that in Hoagland medium. Root elongation of the frond colonies in MS and Hoagland medium is comparable. The distinct effects of MS and Hoagland medium on vegetative growth of both species and the pre-determination of pre-determination of ex-vitro growth rates in each medium are demonstrated.

Das (1974) described a new species *Heliodiaptomus latifin* (Copepoda: Calanoidea) with a brief note on its ecology from freshwater ponds of Dacca City.

Edwards *et al.* (1991) cultivated duckweeds in septage-loaded earthen ponds. A series of three experiments were conducted by them on the cultivation of duckweeds *(Spirodela polyrrhiza, Lemna perpusilla* and *Wolffia arrhiza)* in 200m^2 septage-fed earthen ponds. Mean short and long term (27 and 182 days) extrapolated yields of *Spirodela* were 21.4 and 9.2 t dry wt/ha/year in the experiments 1 and 2 respectively. In the 90 days of experiment 3, extrapolated yields *of Spirodela* and *Lemna* were 20.4 and 10.91 dry wt/ha/year respectively. Duckweed nitrogen and phosphorus contents increased significantly with an increase in nitrogen and phosphorus concentrations of pond water.

Eid *et al.* (1992) worked on the aquatic ecosystem, which includes specific aspect of duckweeds. According to the authors the duckweeds can play a role on mosquitos' control. They abstracted their work in the way that the mosquito *Culex pipiens pipiens* never colonize sewerage water covered with duckweed. The *Lemna minor* vegetations affected the identification of the oviposition site by the females. The amputation of sensilla made the mosquito incapable of choosing the oviposition site. The immature stages of the mosquito are susceptible to the water borne synomones of the duckweed; the first instar larvae are most susceptible and have high mortality.

Fagoonee (1980) reported the life cycle, bionomics and control of the cabbage webworm *Crocidolomia binotalis* (Lepidoptera: Pyralidae). She mentioned that the life cycle of C. *binotalis* lasts about 60 days, the mean incubation, larval and pupal periods being 6, 10 and 12 days, respectively. There are six larval instars determined by simultaneous sloughed head capsule width and body length measurements. She also observed that at higher temperatures (20-24°C) heavy rainfall might be the limiting factor for population growth and low rainfall not favour over breed at cooler temperatures.

Fannah (1987) worked on *Elophila africalis* Hampson (Lepidoptera: Pyralidae); a new pest of *Azolla* in Sierra Leone. He observed an outbreak of leaf feeding insect larvae on *Azolla pinnata* var, *imbricata* was observed by him. The insect was identified as a species of *Elophila,* possibly *Elophila africalis.* This was the first record of *Elophila* on *Azolla* in Sierra Leone. Preliminary studies on the biology of the insect showed that females laid eggs in batches of 16-165 on the adaxial side of the floating *Azolla* frond, and larvae hatched four days later.

Fiance and Moeller (1977) stated the immature stages and ecological observations of *Eoparargyractis plevie* Dyar (Pyralidae: Nymphulinae). They described the larvae of *E. plevie* for the 1st time. They cited that pupae possessed what may be a stridulatory apparatus; two series of ridges raised on the abdominal sternites near the heavily sclerotized teeth at the tip of the metathoracic tarsi and larvae were feed on submersed rosette plants. Young larvae were fed intensively during late August and early September before entering a quiescent phase in which they over winter. Feeding was resumed in the late spring before pupation in early summer. Pupation occurred under water on the host plants.

Forno (1983) stated the life history and biology of a water hyacinth moth, *Argyractis subornata* (Lepidoptera; Pyralidae, Numphulinae). The moth reared on the roots of water hyacinth *Eichhornia crassipes* (Martius). Developmental time at 25°C was 61 days for moths with five instars and 71 days for those with six instars. The more common host plant in the field was water hyacinth, but the moth also completed, its life cycle on water lettuce *Pistia stratiotes I.*

Habeck (1988) described the larvae of *Neargyractis slossonalis* (Lepidoptera: Pyralidae: Nymphulinae) and gave a biological note on it. He observed that the larvae of this southeastern United States species lived among the submerged roots of plants growing in or along streams and lakes. Larvae ingested young roots, but may also feed on periphyton. Pupation occurred under water among the roots.

Hamid *et al.* (1993) growing ducklings were fed diets containing an aquatic weed *Lemna trisulaca* meal (LTM) replacing, on a protein basis, either 40, 60 or 80 g kg"l of the fish meal (FM) from a control diet, which contained 120 g FM kg'l. Partial replacement of FM (40 and 60 g kg'l of the FM) by LTM on a protein basis showed good growth and low food consumption but food conversion efficiency was fond to be comparable. It was concluded that LTM could be considered as a protein feed supplement for growing ducklings without deleterious effect on performance.

Harper (1977) worked on the population biology of plants. He described vegetative growth of duckweeds. He divides development of a duckweed mat into three phases. Phase 1 is called exponential growth where the increase in population is a function of the amount of duckweed started with. It can be expressed as fronds per day or gram per day. Phase 2 called a steady decline of growth rate because of limiting environment (area and resources) where fronds become crowded. At this phase there is a constant addition of fronds per unit time and growth rate is determined by the size of the environment and not the amount of fronds present. The thickness of duckweed mat increases still steadily. Phase 3 called steady state phase where the new fronds which are formed at the top layer are balanced with the dying fronds at the dark underside of duckweed layer.

Herlong (1979) studied the aquatic Pyralidae (Lepidoptera: Nymphulinae) in South Carolina, U.S.A. They observed that lepidopterous larvae of the subfamily Nymphulinae (Pyralidae) are well adapted to the aquatic environment. They recorded twenty one species representing 11 genera. Larvae of only eight species all belonging to Nymphulinae, were collected and their host plants were noted. Nymphulinae larvae collected in South Carolina include *Munroessa gyralis, M. causalis, Parapoynx allionealis, P. macula I is, P. abscuralis, P. seminealis, Langessa nomophilalis* and *Synclita obliteralis.*

Huque *et al.* (1996) studied on the potentiality of duckweed as a feed for cattle. *Spirodela, Lemna* and *Wolffia,* the most available species of duckweeds were evaluated in terms of their chemical composition, the rate and extent of digestion of their dry matter (DM) and crude protein (CP) in the rumen and also their acceptability to the cattle. The three species contained CP of 284, 399 and 299 g. kg'l DM, respectively; NDF of 471, 574 and 476 g. kg'l DM, respectively; ADF of 215, 203 and 227 g. kg'l DM, respectively. The rumen digestibility of DM of the three species for 24 h were 410, 570 and 731 g. kg'l DM, respectively and of CP were 528, 740 and 778 g. kg'l, DM respectively. The rates of digestion of DM of the three duckweeds were 2.22, 3.63 and 5.73 % h'l, respectively and of CP were 5.14, 4.22 and 6.05 % h'l, respectively. Similarly, the extent of digestion of DM was 853, 723 and 926 g. kg'l DM, respectively and of CP was 801, 874 and 943 g. kg'l DM, respectively. Mixed duckweeds as a component of a concentrate mixture were eaten by the cattle at the rate of 10% of their live weights. It may be concluded that the dry matter and crude protein of the available duckweed were highly degradable in the rumen and may be fed to cattle mixing with concentrates. For the effective utilization of duckweeds as cattle feed their effect on the rumen digestion kinetics of a roughage diet need to be studied carefully.

Islam (2002) found that Duckweed (Lemnaceae), tiny free-floating vascular plants, have four common genera, *Spirodela, Lernna, Wolfia* and *Wolfiella* and about 40 species are worldwide distributed. It attracted considerable attention for utilization as protein supplement in poultry ration to minimize chronic scarcity and high cost of animal protein supplements. Crud protein (CP) content of duckweed (DW) is 7 to 40% on dry matter basis depending on media where it was grown and the species involved. The essential amino acid (EAA) profile of DW is similar to other animal proteins with the exception of methionine. It contains 4 g lysin/100 g protein and it is comparable to other sources of protein. Their production rate of about 80 metric ton/ ha/ year of solid material is higher than other classic crops like alfalfa, soybean etc. Dried duckweed can be used in poultry diet as partial replacement of fish- meal, soybean-meal, alfalfa leaf-meal etc. It may be included as a part of protein concentrate mixture of layer and broiler. Its inclusion level is up to 15% in broiler ration and 40% in layer die simultaneously, it may be useful of the treatment of waste- water and already bier used in many developed countries. After reviewing these aspects it is suggested that DW could be used as an effective protein supplement in poultry diet.

Islam *et al.* (1998). An experiment was conducted to show the effect of duckweed *(Lemna* sp.) as a dietary supplement on Thai silver carb *(Puntius gonionotus)* for a period of 180 days The highest production of 2281.5 kg/ ha was obtained from Tl where only duckweed was supplied as a dietary supplement and lowest 1907.5 kg/ha from T2 where rice bran was used. A Combination of duckweed and rice bran (50:50) yielded 2107.5kg/ha production. There was no significant difference (p> 0.05) in final body weight. Apparent feed conversion ratio varied from 4.5 to 5.2 among the treatments. The result of this experiment clearly indicated that duckweed can be used as an effective supplementary feed for the culture of phytophagus silver carb.

J.B.heppner (1992) An experiment was conducted to observe the biology and immature stages of *Epimorius testaceellus* Ragonot were described, as reared in Florida from pods of the epiphytic bromeliad, *Tillandsia fasciculate* Sw.(Bromeliaceae)

Kabir *et al.* (2009) found that duckweed can effectively be used as feed for polyculture of fish. Effect of duckweed supplementation as fish feed to polyculture system was investigated. Fish were reared for 90 days with or without duckweed supplementation. The ponds were fertilized with cowdung, urea and triple super phosphate. All the important physio-chemical factors including temperature, transparency, dissolved oxygen, total alkalinity, phosphate-phosphorus and nitrate-nitrogen were within productive ranges for fish culture. Ponds were stocked with silver carp, Thai sharputi, tilapia, common carp and mrigel. After 90 days, net fish production was found to be significantly higher in fish fed duckweed at a rate of 20% of body weight compared to fish without duckweed supplement.

Khondker *et al.* (1993a). They observed that cultural experiment of *S. polyrrhiza* . in pond water showed maximum growth under a comparatively low temperature range *(22. 2-22. 5" C).* Under these conditions the rate of growth was 0.97 frond day -1 frond -1 and 2.12 mg day -1 as dry weight respectively in terms of frond number and biomass.

Khondker *et al.* (1993b). They observed that water temperature show a negative effect on the biomass of *S. polyrrhiza* but fall in the biomass vigor related directly with the conductivity, alkalinity, silicate and phosphate levels of water in the studied habitats. Maximum average biomass of the plant was recorded as 63.79 g^2 dry weight. The plant was seen to tolerate a high concentration of nutrients, ions and a low oxygen tension.

Kinser *et al.* (1981) described the immature stages and biology of *Synclita tinealis* (Lepidoptera: Pyralidae: Nymphulinae). Duration of copulation was 15 min; 82 eggs were laid which hatched in five days at 27°C; five larval stages with head capsule width of 0.22, 0.28, 0.40, 0.52 and 0.62 mm, respectively developed from the eggs and lasted 3.9, 2.8, 3.2, 3.1 and 3.2 days respectively; duration of the pupal stage was three days and the adult life span 4-5 days. The larvae made silk cases and fed primarily on *Lemna* and *Spirodela.*

Krishnaswamy and Chacko (1990). They observed that the leaf mining flies *Hydrellia* sp and *Hydrellia pakistanae* Deonier attacking the aquatic weed *Hydrilla verrticillara* (Hydropottaceae) in south India. Their life histories were very similar. The duration of the immature stages of *H. pakistanae* was 25 to 29 days. The number of leaves of *Hydrellia verticillata* mined by a single larva varied from 8 to 12.

Lavery and Costa (1973) studied the geographic distribution of the genus *Parargyractis* Lange (Lepidoptera: Pyralidae) throughout the Lake Erie and lake Ontario watersheds (U.S.A). They reported that *Parargyractis* populations were commonly distributed throughout the watersheds, but the distribution was some-what localized. In 64% of the stream where *Parargyractis* were found larvae and or pupae were relatively abundant. The immature stages were frequently encountered within the same community of insects.

Lavery and Costa (1977) described the life history of *Parargyractis canadensis* Munroe (Lepidoptera: Pyralidae). A yearlong study of the life history of the aquatic Lepidoptera *P. canadensis* was conducted in upstate New York (USA). The population of *P. canadensis* was completed in two unequal generations per year. A long over wintering generation was followed by a shorter summer one. The over wintering generation lasted only 10 months and eggs were laid by the over wintering generation. The summer generation lasted only 1.5 months. Some individuals developed from egg to adult only within 22 days. Moths were present in the streamside vegetation. They also observed that adult females entered the water to deposit eggs.

Mansor and Buckingham (1989) studied on the laboratory host range with a leaf mining duckweed shore fly. A leaf-mining shore fly; *Lemnaphila scotlandae* Cresson (Diptera: Ephydridae) from duckweeds *(Lemna* spp) in Florida was exposed in paired choice oviposition tests to 19 aquatic macrophytes and one alga. Eggs were laid only on six species in the duckweed family, Lemnaceae. Larvae developed to adults only on three of those duckweed species. In no-choice oviposition and fecundity tests, more eggs were laid on common duckweed *(Lemna minor*) than on inflated duckweed *(L. gibba* L) and small duckweed *(L valdiviana).*

Marlier (1978) stated the caterpillars of Pyralidae family included in the microlepidoptera and the subfamily Nymphulinae. He observed that all the aquatic caterpillars, e.g. *Acentropus niveus, Nymphula (Parapoynx) stratiotata, N. nympheata, N. stagnata* and *Cataclysta lemnata* were found in duckweed, pondweed, reeds and *Sparganium.*

Morris *et al.* (1990) conducted experiments on distribution and abundance of larval *Coquillettidia perturbans* in a Florida freshwater marsh. They experimented in a 4.5 ha. marsh near lake Alfred, Florida, all instars of larval *C. perturbans* were found in the same habitats, but early instar larvae were more aggregated than later instars. Larvae were uncommon in open water or in areas dominated by small floating plants such as water fern *(Salvinia rotundifolia),* duckweed *(Lemna minor)* and mosquito fern *(Azolla caroliniana).* There was also a tendency for larvae to concentrate in areas beyond 25 cm from shore.

Muller and Dearing (1994). They states that aquatic larvae of the Pyralid moth *Parapoynx rugosalis* Moschler repeatedly construct protective cases by cutting portions (discs) from leaves of the water lily *Nymphaea ampla* and the underside of the host leaf. In an experiment, larvae with protective cases experience no mortality due to predation by fish. In a series of choice tests, larvae preferentially select young, tender leaves over old, tough leaves for construction of cases and larvae spent significantly less time completing their shelters when cutting discs from young, tender leaves.

Nessimian and Silva (1994) described the immature stages of *Parapoynx restingalis* (Lepidoptera: Pyralidae, Nymphulinae) with notes on its life history. They gave a good description of the authors on the ultimate instar larva and the pupa of *P. restingalis.* They also studied that caterpillars lived in marsh areas of the "restinga" (sand dune vegetation) and fed on the floating leaves of *Nymphoides humboldtianum* (Menyanthaceae) and *Nymphaea ampla* (Nymphaceae).

Nolan *et al.* (1997) reported that egg-mass production was slightly reduced in Hi-Sex hens given diets containing the higher duckweed contents and more markedly in Super Brown hens. The duckweed imparted an attractive color to the egg yolks. A study was made of egg production and egg characteristics in two strains of layers (Tegal Hi-Sex and Tegal Super Brown) when changed from a conventional layer diet to diets in which duckweed was included at 10, 30, 50, 80, 120, 200 g/kg as fed.

O'Nell *et al.* (1996) indicates that duckweed has the potential to replace other plant protein sources such as soybean meal in the diets of laying hens without affecting egg production or egg quality. Egg size, hen-day production, egg mass output, shell characteristics and feed conversion ratio did not differ between diets. Furthermore, a volunteer tasting panel did not detect any significant difference in the eating quality of the eggs from the hens on any of the diets but strongly preferred the yolk color of eggs from hens on diets containing duckweed. Laying hens were given diets in which duckweed replaced soybean meal at concentrations of 0, 65, 95 and 128 g/kg of the diet. The diets were formulated to standard layer die specifications but without artificial pigments.

Oron *et al.* (1987) stated that duckweed is one of the floating plants with a high capability of ammonia uptake and assimilation rate into valuable protein. The results indicate that under adequate operational conditions, depending mainly on the organic loading, the effluent quality meets irrigation reuse criteria and protein yield of the duckweed may reach 12 ton/ha per year, far above other conventional field crops. They conducted an outdoor experiment in mini ponds to evaluate the performance of *Lemna gibba,* a duckweed species, as a domestic wastewater stripper.

Parven *et al.* (2009) experimented bioaccumulation of heavy and essential metals in trophic levels of pond ecosystem. They found that persistence of heavy/essential metals (Pb, Cd, Cu, Co, Mn, Ni, Cr, Fe and Hg) occurred in successive trophic levels of pond ecosystem. They examined duckweed (first trophic level) and a pyralid insect larva (duckweed consumer- second and successive trophic level) in two different ponds (organic and inorganic ponds). In organic pond all of these trace metals were greater in evidence than the inorganic pond. Some heavy and essential metals did not bio-accumulate from duckweed to insect larval body but Lead, Copper, Manganese and Cobalt were evidenced at high concentration in water, duckweed and insect larvae.

Parven *et al.* (2012) The strategic points of a pyralid insect, *Synclita occidentalis* (Pyralidae,Lepidoptera) on duckweed productivity, life cycle and its association with duckweed (host-plant) in pond ecosystem was studied. The insect was found deeply associated with duckweed to complete its life cycle. The pyralid insect attains its pest status at larval stage and continues up to the pupal stage. The larvae build case with duckweed fronds and roots and use duckweed fronds that failed to multiply further. The crop of larva was the largest and widest part of the alimentary canal and varied exceedingly along with larval category. The pest impact in two different experimental miniponds was different but similar in mode of action.

Patil and Thontadarya (1987) described the biology of the teak skeletonizer, *Pyrausta machaeralis* Walker (Lepidoptera: Pyralidae). They observed that the period of egg, larval and pupal development of *P. machaeralis* in laboratory condition varied from
2.5 to 4.5 days, 11.0 to22.0 days and 6.0 to 9.0days respectively and it was 2.0 to5.5 days, 11.0 to 22.0 days and 6.0 to 10.0 days, respectively under field condition. There were five larval instars with a distinct pre pupal period

Reichholf (1970) observed that the species *Nymphula nymphaeta L* was closely associated with *Potamogeton natans* grown with leaves on the surface of stagnant water. Eggs were laid beneath the floating leaves of *Potamogeton.* At 20°C they hatched in 10-

11 days. There were two generations of larvae per year. Both lived in water filled cases that they constructed. The pupation occurred under water on the lower surface of *Potamogeton* leaves. The imago was buoyant and floated to the surface of the water after emergence.

Reichholf (1976) studied the fine structure of the cuticle of hydrophilic and hydrophobic larvae of the aquatic moth *Nymphula nymphaeta* (Lepi: Pyralidae: Nymphulinae). He observed that the hydrophilic instars I and II used dissolved O_2 from the surrounding water and hydrophobic ones took atmospheric air for respiration. The cuticle of the hydrophilic was smooth and covered only with simple, rounded elevations while the hydrophobia had complex volcano- like protuberances.

Rejmankova *et al.* (1990) experimented on maximizing duckweed Lemnacea production by sustainable harvest strategy. They found that the external factors (Nutrient contents) affecting vegetative growth of duckweed. They reported that growth of duckweed is independent of concentration of Nitrogen and Potassium above 10 and 2-3 mg/1 respectively.

Resh and Ronald (1986) described the life history of the caddisfly *Dibusa angata* and its association with the red alga, *Lemna australis.* They studied that adult emergence occurred during April and May. First larval instars appeared in mid November. Instars 1-4 occurred at the base of thalli of *L. australis* Atkinson (Rhodophyta: Lemnaceae) guts of fourth instars contained diatoms. The fifth instar was unique among insects in being entirely depended on *L australis for* food and case making material. Case making began soon after the moult to the fifth instars; stripe of *L. australis and* silk were intermeshed to form a case of two parallel, flattened oval valves. Larvae sometimes ate the living algae that form the case. Pupation occurred in either terminal or basal areas of the *L. australis* thallus.

Rusoff *et al.* (1980) described a method for extracting protein from four species of duckweed. The crude protein of solar-dried duckweed ranged from 25.2 to 36.5% and that of the protein concentrate from 37.5 to 44.7%. The essential amino acid profile of the protein concentrate compared favorably with the FAO reference pattern with the exception of methionine. Average values (g/100 g of protein) were as follows: lysine, 4.0; methionine, 0.9; isoleucine, 3.6; leucine, 6.7; phenylalanine, 4.2; threonine, 3.1; and valine, 0.9. They suggested that duckweed protein concentrate could be used as an effective protein supplement in diets low in lysine such as those based on corn or rice.

Sarder and Islam (1983) have given some information on the life history of *Argina syringa* Cr. (Lepidoptera: Hypsidae), a pest of sunnhemp. The life history of *A. syringa* was studied in three generations. The life cycle was completed in 23 to 30 days. In its third generation (July-August) the duration of each stage was shorter and the adult moth laid fewer eggs compared to the first and second generations (April-June). It might be attributed to the high humidity and mature sunnhemp leaf available to the later generation.

Steinly *et al.* (1987) studied the distribution of shore flies (Diptera: Ephydridae) in Illinois. They reported new state or habitat records for *Ephydra cinerea, Ditrichophora exigua, Lemnaphila scotlandae, Lytogaster excavata, Lfurva, Nostima scutellaris, Paralimna punctipennis, Polytrichophora orbitalis, Pseudohecamede abdominalis, Psilopa dupla, Scatella obsolete, Scatella quadrinotata, S. stagnalis* and *Scatophila unicornois* (Diptera: Ephydridae) Notably, *Lemnaphila scotlandae* was collected from duck-weed and *E. cinerea* associated with salt habitats. *Scatella obsoleta* and *Scatella stagnalis* were collected in a hydroponics greenhouse.

Truax *et al.* (1972) suggested that duckweed might be a suitable ingredient for poultry diets if it can be harvested economically. It is also known that this plant serves as a food for wild duck, again suggesting that it could be useful as a poultry feedstuff. It grows rapidly and is resistant to most pest and diseases. Tests also indicate duckweed removes substantial amounts of chemicals from wastewater, which could reduce the contamination resulting when lagoon water flows into lakes and streams. Evidence collected so far shows that when duckweed grows on water high in nutrients, such as that in an animal waste lagoon, the food value is much higher than when it grows in natural waters.

Tuskes (1977) described the biology of *Parargyractis confusalis* which is an aquatic pyralid (Lepidoptera: Pyralidae). He observed that in northern California (USA) *P. confusalis* (Walker) had 2-3 generations per year depending on climatic condition. Adults lead a terrestrial life, though the female re-entered the water to oviposit. The adults, larvae and pupae existed underwater.

Viswam *et al.* (1989) conducted laboratory studies on the host plant preference of *Mansonia annulifera.* They selected host plant for oviposition, developmental duration and survival rate for immature of *M. annulifera* in the laboratory in association with the following aquatic weeds; *Azolla* sp, *Spirodela polyrrhiza, Lemna minor.* They reported that most (61.5%) of egg clusters were laid on *Pistia stratiotes* 6.4% on *Spirodela polyrrhiza,* 2.6% on *Azolla* sp and 1.3% on *Lemna major*

Wang and Messing (2012) Advocated that aquatic plants differ in their development from terrestrial plants in their morphology and physiology, but little is known about the molecular basis of the major phases of their life cycle. Interestingly, in place of seeds of terrestrial plants their dormant phase is represented by turions, which circumvents sexual reproduction. However, like seeds turions provide energy storage for starting the next growing season.

Zaher *et al.* (1995) experimented suitability of duckweed, *Lemna minor* as an ingredient in the feed of Tilapia, *Oreochromis niloticus.* Three isoprotenious (28%) feeds were prepared from locally available ingredients having duckweed, water hyacinth leaf and no plant meal. During 70-day growth trial period in glass aquaria, the effect of the 3 dietary treatments was found to be statistically significant. It was noted that feed containing the duckweed was more effective than the feed containing water hyacinth or rice bran in the diet of *Oreochromis niloticus.*

CHAPTER-3

DUCKWEED BIOMASS GROWTH DEVELOPMENT IN INORGANIC AND ORGANIC POND

Chapter-3

Duckweed biomass growth development in Inorganic and Organic pond.

3.1 Introduction

Duckweeds are free floating aquatic plants commonly growing in stagnant or slowly flowing water bodies. The plant body of duckweed looks like a flat to a globular green leafy structure having few delicate or no roots. Under optimum presence of nutrient (nitrogen, phosphorus. calcium and others) in water duckweed grows rapidly and can double its biomass in 2 days. Besides their rapidly growing nature, the duckweed plant also contains a considerable amount of protein (6-45%). Protein content depends very much on the conditions of growth. Fish like Grass carp, Silver carp and Tilapia directly consume duckweed.

Duckweed contains a lot of minerals. The carbohydrate and protein amounts are noticeable, which has made it as a valuable food source (Landolt and Khandoker 1987). Duckweed acts as an agent for water pollution control and waste water management (Alaereats *et al.* 1996, Chakaravorty *et al.* 1984). Duckweed is the aquatic vascular plant and proved to be a good accumulator of some toxic metals (Zayed 1998 and Parven *et al.* 2008). In recent year a commonly occurring aquatic plant 'duckweed' consider as a prominent; environmentally sound bid-resource of Bangladesh. Duckweeds are grow in normal and wastewater of pond, ditches and drains etc. Few farms in Bangladesh are trying to increase and establish the culture of duckweed to raise the important protein sources of our country.

It can provide fertilizer, food for human and feed for livestock and in addition decrease water pollution and increase the potential for water re-use (Skillicorn *et al.* 1993). Duckweed facilitates income generation in rural areas. It has vital role in the socio-economic development of rural people. Considering the above point duckweeds are treated as functional bioresource.

Taxonomy of studied, Duckweed (*spirodela*)

Kingdom-plant

Sub-Kingdom-Phanerogamia

Divisioin-Embryophyta

Sub-Division-Angiospermae

Class-Monocotyledoneae

Order-Spathiflorae

Faily-Lemnaceae

Genus-*Spirodela*

Species-*S. polyrrhiza*

3.2 Objectives

- To observe phonological stages of *Spirodela* species.
- To observe duckweed biomass growth pattern and variation with the seasonality round the year.

3.3 Materials and Methods

Different physical materials were used to conducting the experiment these are as follows-

1. Sample collecting container (polypet)
2. Skt microscope
3. Digital weight measurement machine
4. Duckweed productivity counting net.
5. Duckweed weight measurement balance machine
6. Iron net quadrant (12 cm ×12 cm)
7. Insect sweeping net
8. Hygro-thermometer clock.

Materials and tools used in experiment

Plate 1.Sample collecting container (polypet)

Plate 2. Skt microscope

Plate 3 .Digital weight measurement machine

Plate 4.Productivity counting net

Materials used in research work

Plate5. Digital weight measurement balance machine.

Plate 6. Duckweed productivity counting net.

Plate 7. Iron net quadrant (12cmx12cm)

Plate 8. Insect sweeping net

3.3.1 Study Area

Mirzapur Kumudini Hospital Complex in Tangail (MKHC) was selected as the experimental stations for the research investigation. In the Kumudini Hospital Complex area duckweed culture were continued in two different types of ponds. In one set of ponds inorganic materials were used as food ingredients consider as **station-1**, and in the other set of ponds organic matters are used and considered as **station-2**. In inorganic pond inorganic fertilizers such as-

Triple super phosphate (TSP)-150gm.

Murate of potash (MP)-150gm

Urea (700) gm were used in composition

In organic pond hospital wastages were used as nutrition. These organic wastes were randomly used in station-2.

There were 15 Inorganic ponds and 3 fish pond and only one large zig zag shaped Organic pond were situated in our experimental stations. Samples were collected from three different Inorganic ponds and three different places (concave, covex and stright area) of Organic pond. The total areas of inorganic ponds measured were 7512 sq. meter and Organic pond was 5175 sq. meters.

Another research site was Zoological Garden of the University of Dhaka. Two minipond were prepared for conducting research work. Some earthen charies were also used for experiment.

Some experiments were conducted in the Enviornmental Biology and Biodiversity Laboratory (EBBL), Department of Zoology, University of Dhaka.

3.3.2 Study Period

The findings that have been earried out based on field investigations. This experiment was conducted at nine days continuous data from 9-16 September 2007.

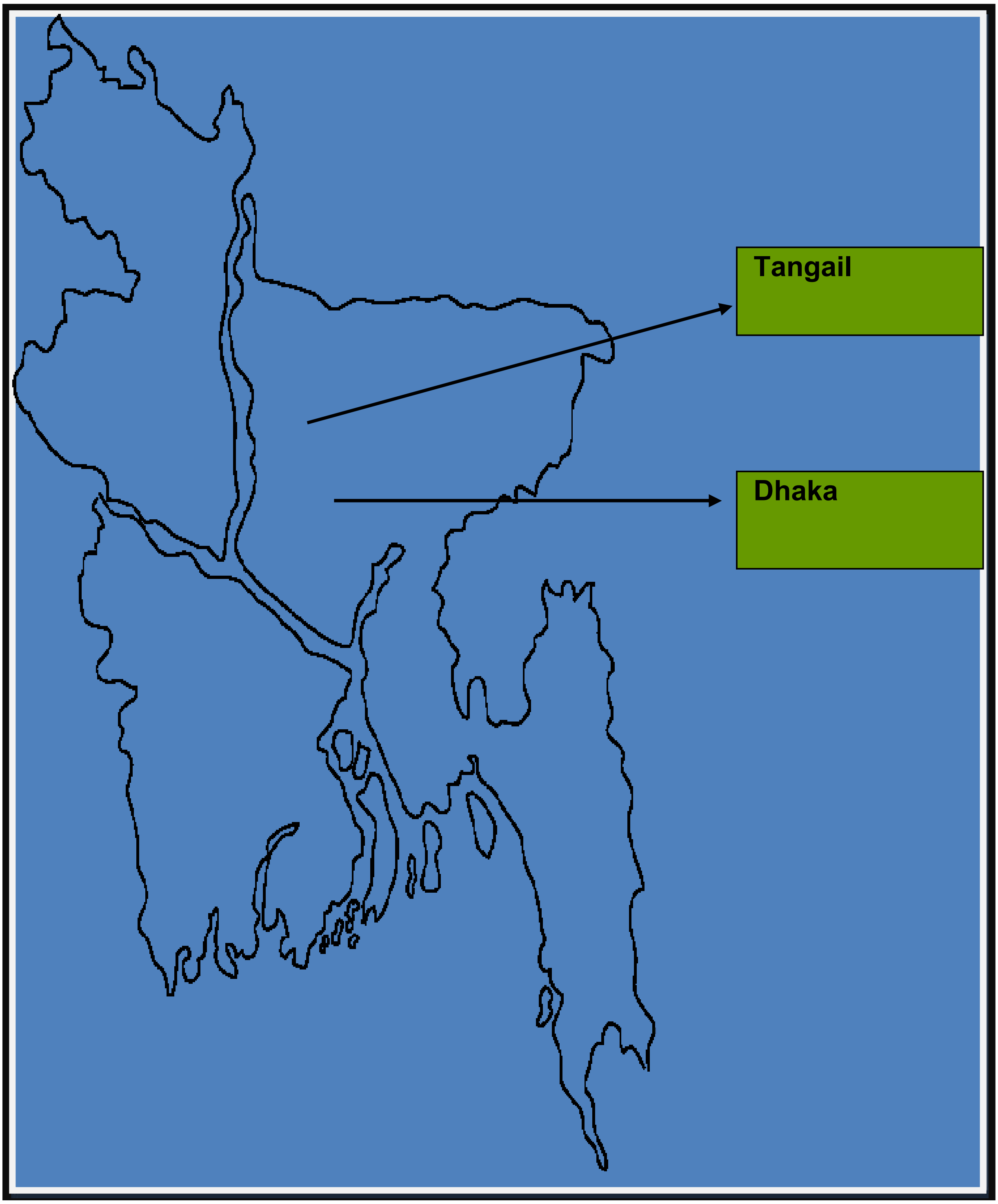

Fig.1. Study area

Fig.2. Research site in Mirzapur of Tangail district

Kumudini Hospital complex, Mirzapur

Plate 9. Main building of Kumudini Hospital Plate10. Doctors quarter adjacent to main hospital

Plate11. Ananda asram

Plate12.Devendra Ward

Association of flora with Duckweed

Plate13. Krisnachura (*Delonix regia*)

Plate14. Shukdarshan (*Crinum latifolium*)

Plate15. Kesaraj(*Wedelia calendulacea*)

Association of fauna with Duckweed

Plate 16. Toad *(Bufo melanostictus*)

Plate 17.Duck *(Anas platyrhynchos*)

Plate18. Dragon fly(*Macromia magnifica*)

Plate19. King fisher(*Alcedo atthis*)

Experimental Station-1(Inorganic pond)

Plate 20 . Culture of Duckweed in Inorganic pond

Plate 21. Culture of duckweed in inorganic pond showing divided by bamboo particle

Experimental Station-2 (organic pond)

Plate 22. Culture of Duckweed in hospital waste water.

Plate 23. Hospital waste water was released in the pond to purify,

Sketch of inorganic pond

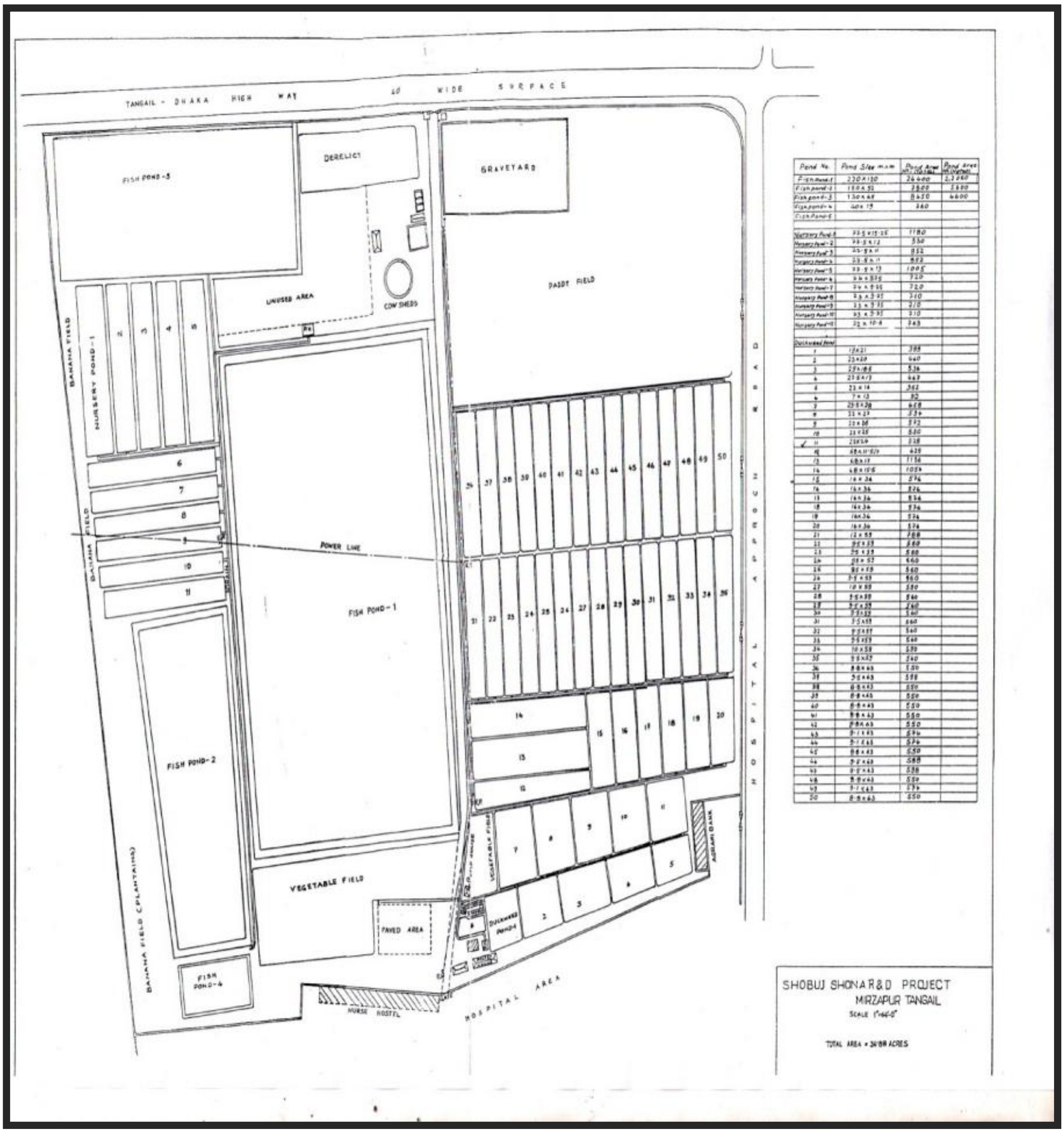

Fig. 3. Sketch of Inorganic pond

Sketch of organic pond

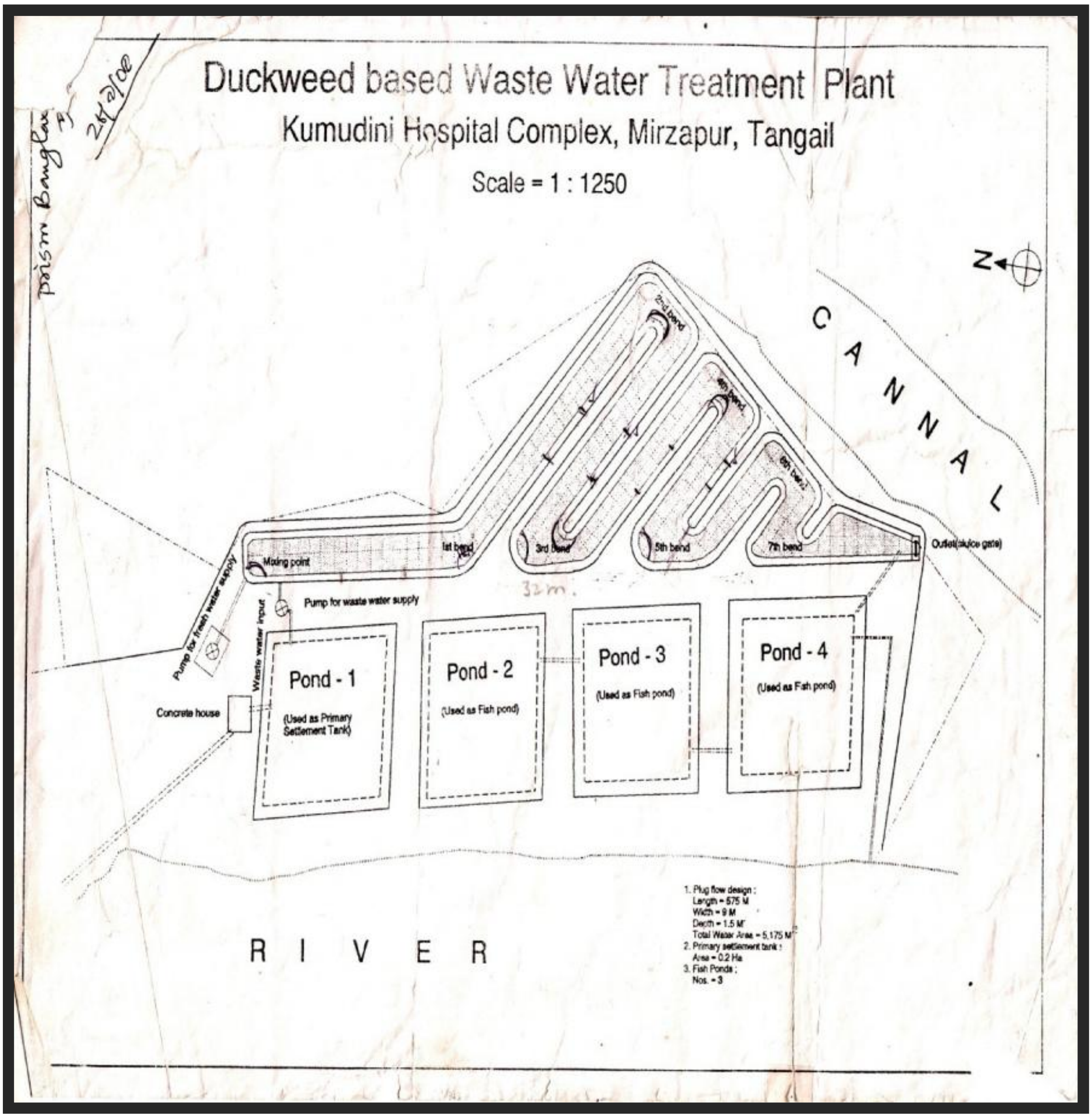

Fig. 4. Sketch of Organic pond

3.3.3 Methodology

Duckweed Biomass growth observing trap preparation.

For conducting the experiment, Duckweed Biomass growth observing trap were very special type of arrangement. It was (50×50×50cm3) square size thin iron rod structure, covered with mosquito net. Four bamboo sticks were attached tightly with the four corner of the square iron rod structure for anchor the soil under the pond.

In the Duckweed Biomass growth observing examination 24 trap were arranged in Inorganic pond and 24 traps were in organic pond. Each of the traps were provided with 20 gm of duckweeds.

3.3.4 Sample Collection

On the first day of experiment, 20gm of the duckweeds were weighed with the help of a measuring balance machine and release duckweed very gently in each biomass counting traps, before releasing duckweeds were kept for 30 minutes in the sunlight to remove the excess water. Much care were taken to avoid destruction of roots and fronds, as they were very sensitive and tender. The biomasses of duckweeds releasded in the productivity counting net of both organic and inorganic ponds were measured after 24 hours of their release.

After 24 hours, duckweeds were collected from trap (1-3) of inorganic pond and trap (25-27) from organic ponds. The duckweeds were dried under sunlight for 35 minutes. Then the weight of the collected duckweed were taken carefully with the help of a weight balance machine, then the data was recorded in self prepared printed sheet.

After 48 hours data were recorded from trap (4-6) in inorganic pond and three samples trap (28-30) from organic pond. In this way sampling had been taken till the ninth day for both inorganic and organic ponds. Within nine days, the weights of 48 samples in all were taken on the biomass growth development experiment. The temperature of Inorganic pond were average 29^0c and in 32^0c in organic pond and humidity was 90% in IP and 36% in Op during experimental time.

Plate24. Experimental inorganic pond (16x11x3ft)

Plate 25. Experimental organic pond (13x9x3ft)

Plate 26. Duckweed culture in earthen container

Research site at Dhaka University

Plate 27.

Plate 28.

Plate 29. plate 27, 28and29 Research environment in EBBL lab in DU

Culture of Duckweeds in Experimental stations

Plate 30. Duckweed Collection process

Plate 31. Releasing of Duckweed in exp.pond

Plate 32. Duckweeds are released from the Net to another pond.

Plate 33. Field men are harvesting Duckweeds from organic pond

Observation on Biomass increase of Duckweed

Plate 34. Drying of Duckweed in sunlight

Plate 35. Releasing of duckweed

Plate 36. Productivity counting net in Ip

Plate 37. productivity counting net in Op

3.4 Result

Duckweeds, or water lens, are flowering aquatic plants which float on or just beneath the surface of still or slow-moving bodies of fresh water and wetlands. Also known as "bayroot", they arose from within the arum or aroid family (Araceae), and therefore, often are classified as the subfamily **Lemnoideae** within the Araceae. Classifications created prior to the end of the twentieth century classify them as a separate family, **Lemnaceae**.

3.4.1Taxonomy of Duckweed

The duckweed found in Bangladesh has been considered under the family, Lemnaceae. They primarily reproduce asexually. Flowers, if present at all, are small. Roots are either very much reduced, or absent entirely. They were suspected of being related to the Araceae as long ago as 1876, but until the advent of molecular phylogeny it was difficult to test this hypothesis.

Starting in 1995 studies began to confirm their placement the Araceae and since then, most systematists consider them to be part of that family lemnacea.Their position within their family has been slightly less clear, but several twenty-first century studies place them in the position shown below.They are not closely related to *Pistia*, however, which also is an aquatic plant in the family Araceae.

The genera of duckweeds are: *Spirodela*, *Landoltia*, *Lemna*, *Wolffiella*, and *Wolffia*.

Our experimental genera was *Spirodela*.and it has three species, *Spirodela punctata, Spirodela polyrrhiza, Spirodela intermedia.*

These plants are very simple, lacking an obvious stem or leaves. The greater part of each plant is a small organized "thallus" or "frond" structure only a few cells thick, often with air pockets (aerenchyma) that allow it to float on or just under the water surface. Depending on the species each plant may have no root or may have one or more simple rootlets.

Key character of duckweed Genera

According to root they would be

Subgroup A, with root

SubgroupB, without root

1a. Plant body with 1 - several roots.

2a. Root one..**Lemna**

2b. Roots 2 - 12.

3a. Roots 7 - 12 (or more); plant 10 mm long.........**Spirodela**

3b. Roots 2 - 3 (up to 5); plant 3 - 6 mm long..........**Landoltia**

1b. Plant body without roots.

4a. Plant body flattened; 3 - 10 mm long.......................**Wolffiella**

4b. Plant body globose-ovoid; 0.6 - 1.2 mm long.........**Wolffia**

3.4.2 Habitat of Duckweed

One of the more important factors influencing the distribution of wetland plants, and aquatic plants in particular, is nutrient availability.] Duckweeds tend to be associated with fertile, even eutrophic conditions. Duckweed can be spread by waterfowl and small mammals, transported inadvertently on their feet and bodies, as well as by moving water. In water bodies with constant currents or overflow, the plants are carried down the water channels and do not proliferate greatly. In some locations a cyclical pattern driven by weather patterns exists in which the plants proliferate greatly during low water flow periods, then are carried away as rainy periods ensue.

Description of experimental duckweed

Gaint Duckweed is the common name for plants in the genus *Spirodela.* Gaint Duckweed fronds are usually larger than those of common Duckweed. The size of the fronds of Gaint duckweed generally ranges from 2.0 to 7.0mm in length and 1.0-6.0mm in width. The Fronds of the Gaint Duckweed occur solitarily, or in groups of two or more. Its fronds colour is green to dark green on the upper surface and reddish purple on the lower surface. Gaint Duckweed usually has two or more roots extending from the lower frond surface, occasionally a frond will be seen which only has single root.

3.4.3 ***Economic Importance of Duckweed***

Duckweed is an important high-protein food source for waterfowl and also is eaten by humans in some parts of Southeast Asia. As it contains more protein than soybeans, it is roupssometimes cited as a significant potential food source.The tiny plants provide cover for fry of many aquatic species. The plants are used as shelter by pond water species such as bullfrogs and bluegills. They also provide shade and, although frequently confused with them, can reduce certain light-generated growths of photoautotrophic algae.

The plants can provide nitrate removal, if cropped, and the duckweeds are important in the process of bioremediation because they grow rapidly, absorbing excess mineral nutrients, particularly nitrogen and phosphates. For these reasons they are touted as water purifiers of untapped value.

The Swiss *Department of Water and Sanitation in Developing Countries*, SANDEC, associated with the Swiss Federal Institute for Environmental Science and Technology, asserts that as well as the food and agricultural values, duckweed also may be used for waste water treatment to capture toxins and for odor control, and, that if a mat of duckweed is maintained during harvesting for removal of the toxins captured thereby, it prevents the development of algae and controls the breeding of mosquitoes.

These plants also may play a role in conservation of water because a cover of duckweed will reduce evaporation of water when compared to the rate of a similar size water body with a clear surface.

Duckweed also functions as a bioremediator by effectively filtering contaminants such as bacteria, nitrogen, phosphates, and other nutrients from naturally occurring bodies of water, constructed wetlands and waste water.

Different Duckweeds

Plate 38. *Lemna* species

Plate 39. *Spirodela* species

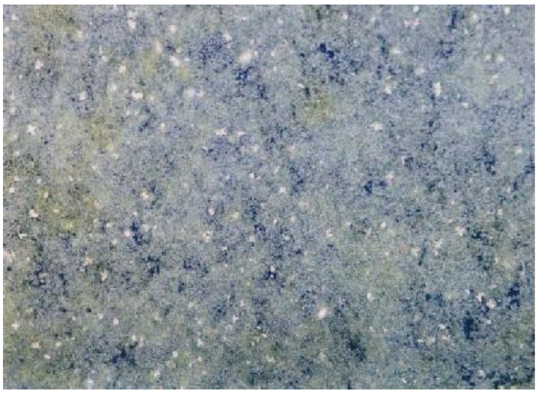

Plate 40. *Wolffia* Species

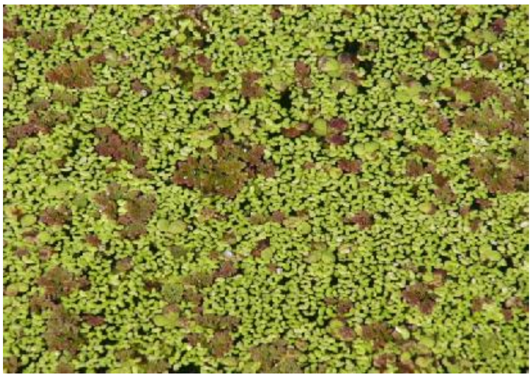

Plate 41. *Azolla* and *Lemna* mixed

Plate 42. Duckweed fronds

Plate 43. Duckweed roots

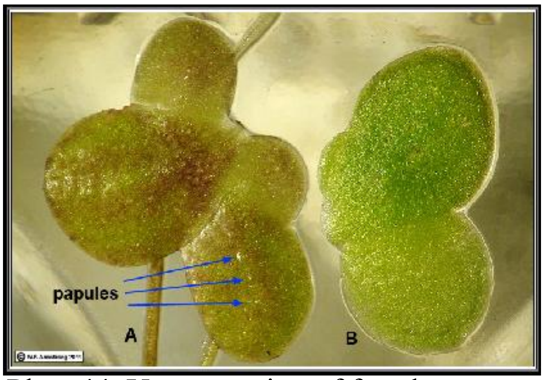

Plate 44. Upper portion of fronds

Plate 45. Lower portion of fronds

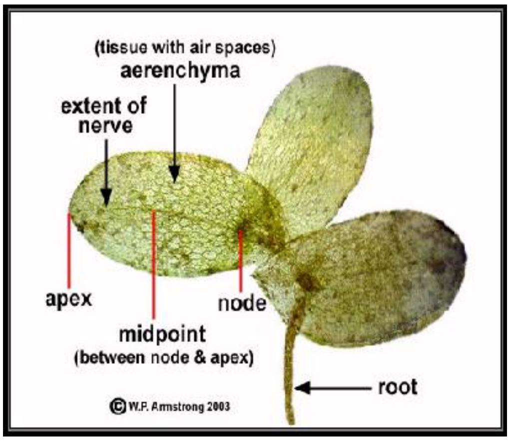

Plate 46. Groups of frond

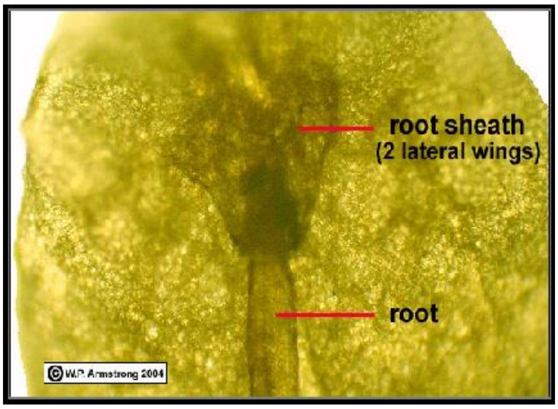

Plate 47. Single root of duckweed

3.4.4 Reproduction and multiplication

All plants in the duckweed family reproduce both vegetatively through budding, and by seed. All four of the genera, *Lemna, Spirodela,Wolffia,*and *Wollfiella* are known to flower and produce seed, though flowering is not frequently observed.

The primary means of reproduction of these plants appears to be the vegetative production of daughter plants by budding. The process of forming new plants occurs rapidly under good growth condition, leading to the occurrence of very dense infestation of weed growth. *Spirodela* or Gaint Duckweed has one other means of reproduction that helps the plant survive periods of poor growth conditions, such as dresought or low temperature. Gaint Duckweed can produce specialized fronds that have no roots and are called turions. These turions are denser than a typical vegetative frond, thus once formed, they sink to the bottom of the body of water. Later, during more favorable growth conditions, the turion begins growth and floats to the surface, forming a
new plant.

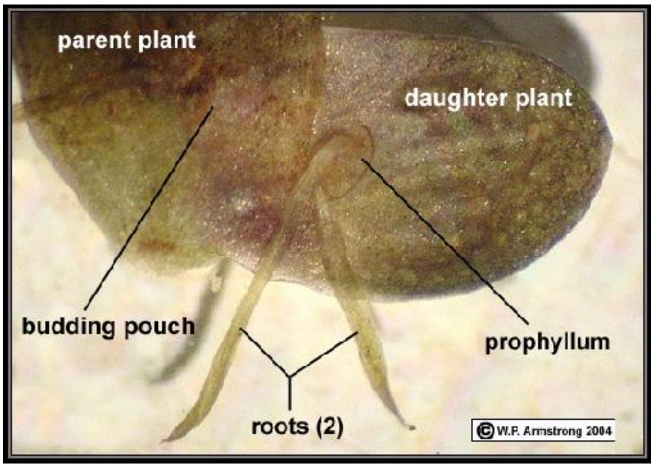

Plate 48. Reproduction of Duckweed. (parent and daughter plant)

3.4.5 *Duckweed Biomass growth observation in Inorganic and organic pond*

The data of duckweed Biomass growth development were presented in Table-1 and Table-2, and results were shown in the fig 5 and fig 6

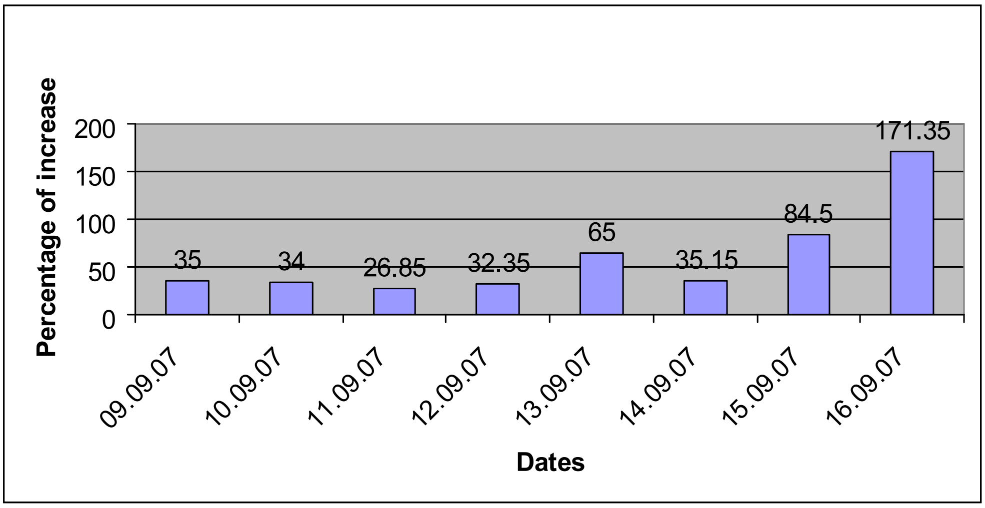

Fig.5. Duckweed Biomass growth pattern in Inorganic pond(8 days)

In Inorganic pond after 24 hours biomass growth were 35% after 48 hours it was found 34%. In this way 26.85%, 32.35%, 65%, 35.15%, 84.5% and 171.35%
Biomass growth rate of the duckweeds in IP was reached at double position in 8^{th} day.

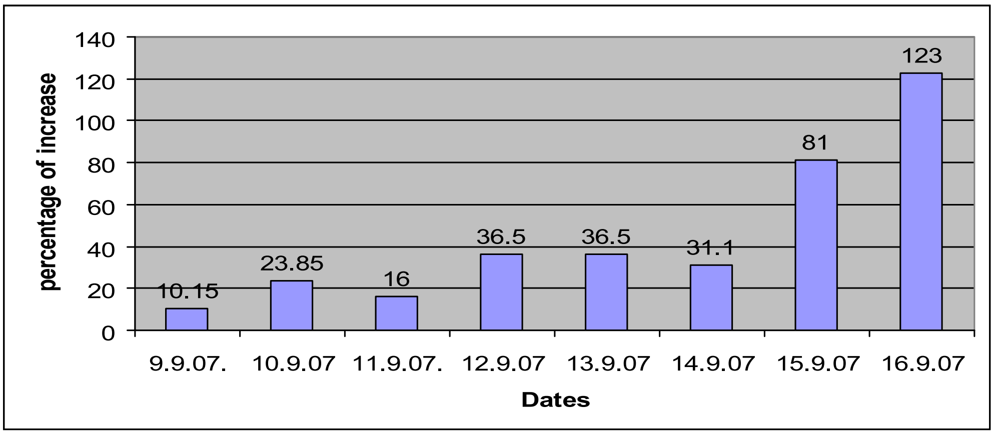

Fig.6. Duckweed Biomass growth pattern in Organic pond (8 days)

In Organic pond after 24 hours duckweed Biomass growth were 10.15% increasing rate was found 23.85% in 48 hours, in this way 16%, 36.5%, 36.5%, 31.1%, 81% and 123%. In organic pond biomass growth development were also reached at double position in 8^{th} day. The growth rate was found significantly varied from the station in the last date of the examination.

General information						Experimentation			Remarks
Pond		Tenure of culture	Tenure of insecticide	Date of release	Duckweed mass(gm)	Date of examination	Duckweed mass(gm)	Percentage of increase	
Position	No								
Ip	1 2 3	Two months	One months	8.9.07	20 gm	9.9.07 1st day	Min-25.100 gm Max-27.100gm Ave-27.00gm	35%	
	4 5 6	Two months	One months	8.9.07	20 gm	10.9.07 2nd day	Min-26.300 gm Max-27.500 gm Ave-26.8 gm	34%	
	7 8 9	Two months	One months	8.9.07	20 gm	11.9.07 3rd day	Min-23.500gm Max-26.500 gm Ave-25.37 gm	26.85%	
	10 11 12	Two months	One months	8.9.07	20 gm	12.9.07 4th day	Min-25.600 gm Max-27.30gm Ave-26.47 gm	32.35%	
	13 14 15	Two months	One months	8.9.07	20 gm	13.9.07 5th day	Min-30.9 gm Max-36.7 gm Ave-33.1 gm	65%	
	16 17 18	Two months	One months	8.9.07	20 gm	14.9,07 6th day	Min-24.6 gm Max-29 gm Ave-27.03 gm	35.15%	
	19 20 21	Two months	One months	8.9.07	20 gm	15.9.07 7th day	Min-34.3 gm Max-43.2 gm Ave-38.9 gm	94.5%	
	22 23 24	Two months	One month	8.9.07	20 gm	16.9.07 8th day	Min-44.55 gm Max-65.9 gm Ave-54.27 gm	171.35%	

Table 1. Experiment on Trend of Biomass Increase in Inorganic pond

General information						Experimentation			Remarks
Pond		Tenure of culture	Tenure of insecticide	Date of release	Duckweed mass(gm)	Date of examination	Duckweed mass(gm)	Percentage of increase	
Position	No								
op	1 2 3	Two months	One months	8.9.07	20 gm	9.9.07 1st day	Min-20.90 gm Max-22.70gm Ave-22.03gm	10.15%	
	4 5 6	Two months	One months	8.9.07	20 gm	10.9.07 2nd day	Min-23.800 gm Max-25.400 gm Ave-24.77 gm	23.85%	
	7 8 9	Two months	One months	8.9.07	20 gm	11.9.07 3rd day	Min-21.900gm Max-25.400 gm Ave-23.200 gm	16%	
	10 11 12	Two months	One months	8.9.07	20 gm	12.9.07 4th day	Min-24.700 gm Max-29.700gm Ave-27.3 gm	36.5%	
	13 14 15	Two months	One months	8.9.07	20 gm	13.9.07 5th day	Min-24.00gm Max-30.300 gm Ave-27.300 gm	36.5%	
	16 17 18	Two months	One months	8.9.07	20 gm	14.9,07 6th day	Min-23.800 gm Max-28.85gm Ave-26.22 gm	31.1%	
	19 20 21	Two months	One months	8.9.07	20 gm	15.9.07 7th day	Min-33.500 gm Max-39.300 gm Ave-36.200 gm	81%	
	22 23 24	Two months	One month	8.9.07	20 gm	16.9.07 8th day	Min-31.600gm Max-56.00 gm Ave-44.600gm	123%	

Table 2 Experiment on Trend of Biomass Increase in Organic pond

3.4.6 Statistical Analysis

All statistical analysis has been performed using SPSS software for windows (version 16) and Microsoft office Excel 2007.

In biomass growth development, average growth of Inorganic pond was always higher than Organic pond in each case, except in the 4th days. By testing two samples we can say that, in 1st day there were significant differences in biomass growth in Ip and Op. (P value was=.007) but this was not happen in next seven another days. (See Appendix 28,29)

3.5 Discussion

In both inorganic and organic ponds Duckweed biomass growth pattern were found zig zag shaped, that means in inorganic pond in 24 hours it growth in 35% and after 48 hours it declines 34% and next 72hours it again declines at 26.85% and after 96 hours it grows suddenly 32.35% and next 120 hours again grow 65% and then after next 144 hours it become lower in 35.15% and last days after 192 hours it grows rapid growth 171.35%

This rapid growth phase may be called exponential growth phase according to Harper (1977)

In op duckweed biomass growth pattern were more or less same .after24 hours it was 10.17%, in this way 23.85%,16%,36.5%,36.5%,34.5%,81%,and 123%.

The Biomass growth of duckweeds in inorganic pond was apparently higher than the Organic pond. In the inorganic pond different fertilizer were used regularly. These fertilizers contain elements like Nitrogen (N) and phosphorus (P) which effect the vegetative growth of duckweeds. (Rejmankova *et al.*1990). The duckweeds growth might be increased by temperature and by other factors like p^h of water, incident light and nutrient concentrations (Leng 1999)

CHAPTER-4
LIFE CYCLE AND BEHAVIOURAL OBSERVATION OF THE PYRALID INSECT

Chapter- 4

Life cycle and Behavioral observation of the pyralid insect

4.1. Introduction

Generally host plant choice has been shaped by the selection of insects to maximize fitness, i.e. the opportunities of survival and growth of a female's offspring (Strausz 2010). One key factor in the ecology of phytophagous insects is the interaction with their natural host plants, thus maternal host choice is a particularly important step in the life-cycle of all herbivorous insect species (Rabasa *et al.* 2005, Janz *et al.* 2005, Batary *et al.* 2008). Recognition and selection of the best quality foods available by ovipositing females is crucial for optimal and successful larval performance (Liu *et al.* 2006, Ngu *et al.* 2008, Talsma *et al.* 2008b). Due to the low dispersal ability of the juvenile stages compared to adults; especially during the young instars; the selection of optimal quality host plants and suitable habitats is a critical step in the life-cycle of all Lepidoptera (Fartmann and Timmermann 2006, Eichel and Fartmann 2008)1) Oviposition patterns are a result of female choosiness at different spatial scales, i.e. the host plant scale and the site scale (Anthes *et al.* 2003, Wiklund and Fridberg 2008). Therefore several studies have focused on the selectivity of egg depositing female butterflies at different spatial scales (Rabasa *et al.* 2005, Fartmann 2006, Loritz and Settele 2006, Batary *et al.* 2008, Eichel and Fartmann 2008).

All herbivorous insects show some degree of host selectivity (Bernays and Chapman % 1994). Under natural conditions, insects are confronted with many external stimuli, their own internel physiological conditions and responses, and a series of environmental constraints (Visser 1986, Bernays and Chapman 1994, Badenes *et al.* 2004). This makes it very difficult to discern the relative importance to the insect of chemical, visual, and mechanical stimuli from host and non-host plants (Schoonhoven *et al.* 1998, Hooks and Johnson 2001). However, it is generally assumed that the process of host selection in specialist insects is governed primarily by volatile chemical signals, later by visual stimuli, and finally by non-volatile chemical signals (Hem *et al.* 1996, Hooks and Johnson 2001)

The adult stage of *Synclita Occidentalis* is terrestrial. But this stage of the insect is not pest itself. This insect attains its pest status at larval and pupal stage. The eggs of the insect pest are habitually deposited on healthy leaves immediately after the eggs hatches to larva, the larva begins to feed and cause to the host plant. (Quayum *et al.* 1983). The larva occupy 75% of its lifetime and consumes large amount of food for its growth and development. (Rensburg *et al.* 1990). The host plant preference and infestation intensity of insects are increased by the availability of suitable leaf sheath for adult egg laying and larval development. (Bashar *et al.* 1999). Impact of pyralid insect on the duckweed productivity, the larval and pupal duration in the life cycle of the pest stand necessary. The pyralid larval cannot be controlled by pesticides use due to the fact that it is well protected in the larval and pupal stages (Ashaf SMA *et al.* 1998) Different parasites are found to active at the developmental stages of the insect though out the year (Copple HC *et al.* 1977). The present experiment has been emphasized to identify the life stages of pyralid and its association with duckweed (host plant). This experiment was undertaken with a view to analyze the association that could be utilized as a tool for pest population suppression in the aquatic ecosystem.

4.2 Objectives

1. To study the developmental stages *of S.occidentalis*
2. To observe various adult behaviours of the *S.occidentalis*
3. To examine the coincidence between the life cycle of Pyralid and its host plant phenology.

4.3 Materials and Methods

The physical materials were used in the study were

1. Sampling iron net quadrant (12cmx12cm)
2. Duckweed sampling spoon ($3cm^{2)}$
3. Emergent trap.
4. Light trap
5. Adult collecting net.
6. Petridis (11cmx11cm)
7. SKT Stereo microscope
8. Brushes
9. Needle
10. Forceps

11. Plastic polypets (12cmx8cm)
12. Thick thread
13. Glass beakers.
14. Slides
15. Boxes
16. Vials
17. Scale
18. Pencil and sign pen etc. for the experiment of life cycle and observation of Pyralid insect.

4.3.1 Study area

Experiment on the life cycle of *S.occidentalis* was also conducted in the Inorganic and Organic pond in Mirzapur Kumudini Hospital complex and EBBL lab in Department of Zoology, University of Dhaka.

4.3.2 Study period

The Experiment on the life cycle and behavioral activities of *S.occidentalis* was conducted from December 2006 to November 2007. Samples were collected minimum three to maximum five times in a month.

4.3.3 Sample collection

Adult collecting net was made with small mosquito net on a badminton frame. The net/sieve was (42x20cm), mosquito net was attached with the badminton in conical shape.

At first adult moth was swiped by the sieve and turned the net in special manner for preventing the captured adult to go out. After that narrow conical portion of the net had to drag to the top. Naturally insects were flying to the top. Combatable manner had to create for the aggregation of the insects on the top of the cone. When all insects gathered in the upper portion of the net, they were inserted the killing jar. Some chloroform mixed with cotton put in the killing jar was closed with the cap. A record was maintained far conting adult for observing the morphology of adult insect (male and female). Pyralid adult insects were collected by hand directly through the chain of the prolongation of emergent trap and collected in vials preserved in an insect box.

Pyralid larval/ pupal cages were collected from four different inorganic ponds in random basis by sampling iron net quadrant . Five random samples were collected from each pond. The numbers of larval /pupal cages from the samples were recorded.

4.3.4 Sample preservation

The collected samples were taken to the laboratory (E.B.B.L) Department of Zoology , university of Dhaka. Pyralid moth is so tiny and soft, so it was mounted on points for preservation. Points are elongated triangular pieces of heavy paper, about 10 millimeter long and 4 millimeter wide at the base and the insect was glued to the tip of the point. Points can be cut with the scissor. The point was put on the pin, the pin was grasped by the pointed end and the upper side of the tip was touched to the glue and then touched to the insect. It is special type of procedure followed by the lab, but the fundamental idea was borrowed from Borrer *et al.* (1989).Following the procedure the adult moths were preserved and made suitable for using them in the further study. Larva and pupa were collected with the metallic sieve and hand picking and put in to the polypet. After reaching lab, larva and pupa were preserved in 70% alcohol in vials.

Plate 49. Preserved Adult of *Synclita occidentalis*

Plate50**.** Adult in the laboratory**.**

Plate 51. Adult in the Field.

4.5 Result

Plate 52. Cork sheet was placed in the pond covered with net to observe the life cycle

Plate 53. Egg laying activity of pyralid insect

Plate54. Egg placed in the glass container with duckweed fronds

Plate 55. Different types of glass container for rearing the adult insect in the lab

Life cycle

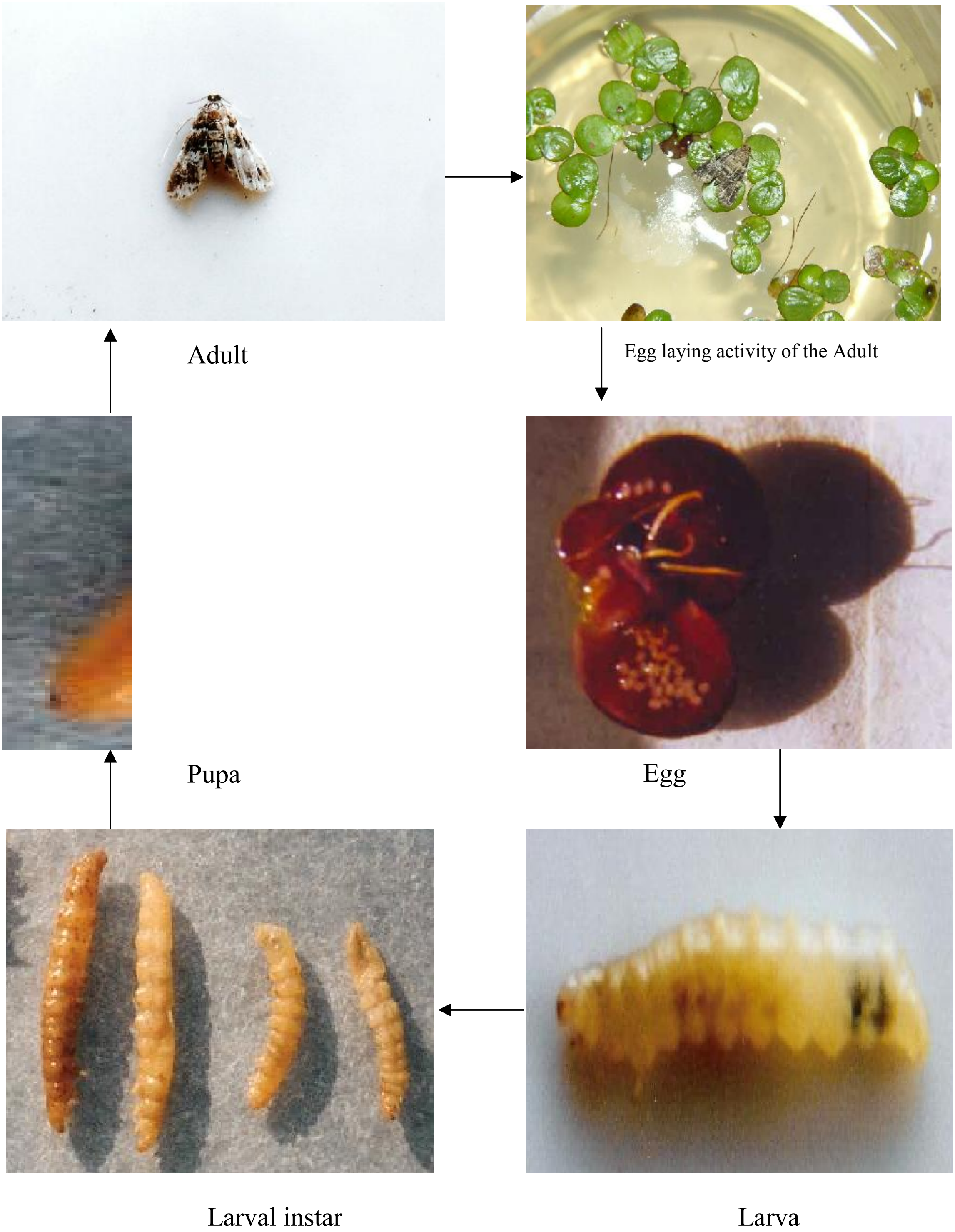

Plate 56. Life cycle of the pyralid insect (*S.occidentalis)*

The Cases constructed by the larvae and pupae of the pyralid insects in the duckweeds of the Inorganic and Organic pond

Month	Larval Cases						Pupal Cases					
	Larval Cases (IP)			Larval Cases (OP)			Pupal Cases (IP)			Pupal Cases (OP)		
	Length (mm) Mean	Width (mm) Mean	No. of Fronds Mean	Length (mm) Mean	Width (mm) Mean	No. of Fronds Mean	Length (mm) Mean	Width (mm) Mean	No. of Fronds Mean	Length (mm) Mean	Width (mm) Mean	No. of Fronds Mean
May	15.5	6.5	11.75	15.5	8	10.75	14.5	7.5	10	14.75	10	11.5
June	13.75	6	9.25	16	9.5	12	11	5.5	10	10.75	6.25	8.25
July	11.5	6.5	7.25	13.75	7.5	10	8.5	5.75	6	10.75	5.5	7
August	12.6	6.2	7.4	15.8	8	13	13.6	8	7.4	13.75	6.25	7.8
September	13.75	6.25	7.75	14.75	8.25	10.75	11.25	4.5	9.75	17.5	9.25	12
October	15.25	5.75	10.5	15.75	13.5	13.25	12.75	6.25	7.75	14.5	9.75	8
November	19.75	8.5	11.25	15.5	12.25	14.5	17	8.75	6.2	14.25	9.25	7.5
December	16.8	7	9.2	13.2	11.4	11.8	12	6	5.4	11.5	6.25	9.75
January	14.75	7.5	9.25	12.25	7.75	9	13.25	5.5	7	12	9	8.5
February	12	6	9	16.25	10.75	11.25	9.25	5	7.25	10.25	7	7
March	10.25	6	6.25	15.5	10.75	10	9.75	4.5	6.25	8	5.7	7
April	15.25	5.5	8.5	16	12.75	11.5	9.75	4.75	8	12	9.75	9.75

Table 3. Larval/pupal case construction made by pyralid insect (IP= Inorganic pond, OP = Organic pond)

4.5.1 Life Cycle and Biology

Life cycle of pyralid insect included four stages, Adult, egg, larva, and pupa. After hatching, the larvae enclose themselves inside cut leaf pieces. Cases made by young larvae are water-filled and oxygen uptake occurs cutaneously (presumably via the epidermal papillae). Cases of older larvae are air filled chamber. Larvae abandon smaller cases as they mature and construct larger cases by new leaves. The case may consist of two entire leaves, parts of leaves, or of parts of many plants tied together with silk. Prior to pupation, the larvae attach their cases to petioles or leaf blades of their host plants above or below the water surface, and spin their cocoons inside their cases.

4.5.1.1 Adult

Adult Pyralid moths exhibit marked sexual dimorphism. Females are distinctly larger than males with females having wingspans of 15-19 mm and males with wingspans of 11-13mm.Females wings are light brown with orange brown and dusky markings. The wings of males are dusky overall, and marked with brown and white.

4.5.1.2 Mating and Egg laying behavior

Mating behavior was observed in inorganic duckweed pond. Their total mating time was 45 minutes. In last few minutes female move its antenna up and down. They were mating at their point of lower abdomen. They were moderately calm in their total copulating period. After their separation the copulated couples were captured in the net and it was carried by a plastic container which has easy excess of air. The adult were replaced in a glass container with duckweed and male found dead in the next day and female were survived for 3 to 4 days. After mating the female started to oviposite eggs on the under surface of the duckweed fronds by curving the tip of the abdomen.(Bashar *et al.*2008) The female laid eggs continuously for two days after emergence and characteristically stopped on the third day. After laying eggs the female become exhausted and finally died. Viswam *et al.* observed that *Mansonia annulifera* (Lepidoptera;Pyralidae) laid eggs in cluster on duckweed fronds of *spirodella* sp.

4.5.1.3 Behavioral Observation of Insect

Four different types of behavior observed during the study period. Among the behavioral aspects the flying behavior were observed in maximum and egg laying and mating in minimum. The resting behavior of pyralid insect was found more abundantly.

4.5.1.4 Materials and Methods

Physical materials were used in the experiment such as:

1. Light trap.
2. Torch.
3. Some electric wire.
4. Multiplug.
5. Insect sweeping net.
6. Recording sheet, etc.

Construction of light trap

A thin square size iron rod frame was for the light trap.10 cm iron rods were welded at the four corners of the structure for setting the trap on the earth. Two iron rings (9x3 cm diameters) were also made for strengthening the extension of the light trap. The structure was covered with a piece of mosquito net.

A bulb (25 watt) was placed in the bulb holder inside the trap and it was covered with a shade above. The bulb was connected with the wire and plug for getting electric supply. The net was put on the main iron frame and bind with the metal string at the lower portion (at 10cm above from the ground) of the frame. Two rings were also attached with the two opening of the extension with the metal string. Then one polythene sheet (55x55x55cm3) was attached with the lower portion of the main iron frame. Four iron rods of the light trap perforated into the polythene sheet. The polythene sheet was sown at the lower portion of the net with iron rod by the metal string. Last of all, the bulb with shed put into the trap through the chain of the upper surface of the light trap and tied with the bamboo (60 cm) stick by thread for staying at fixed position.

Installation of light trap

The light trap was installed near or within the pond where the flying insects was expected to be abundant. The light trap was fixed firmly on the ground. Polythene sheet was used for covering the light traps to protect rain water after taking every sample.

Procedure of data collection

The light trap set at on early evening and lasted for half an hour. The insects trapped were collected daily and recorded. The adult pyralid were counted three ways, number of adult present (in the case), number of adult outside the case, and number of adult present on the polythene sheet placed below the light trap.

Plate 59. Light trap was used to observe the behavioral activity

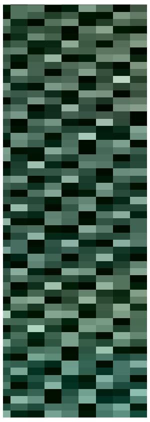

Plate 60**.** Mating behavior of pyralid insect

Behavioral observation of the pest

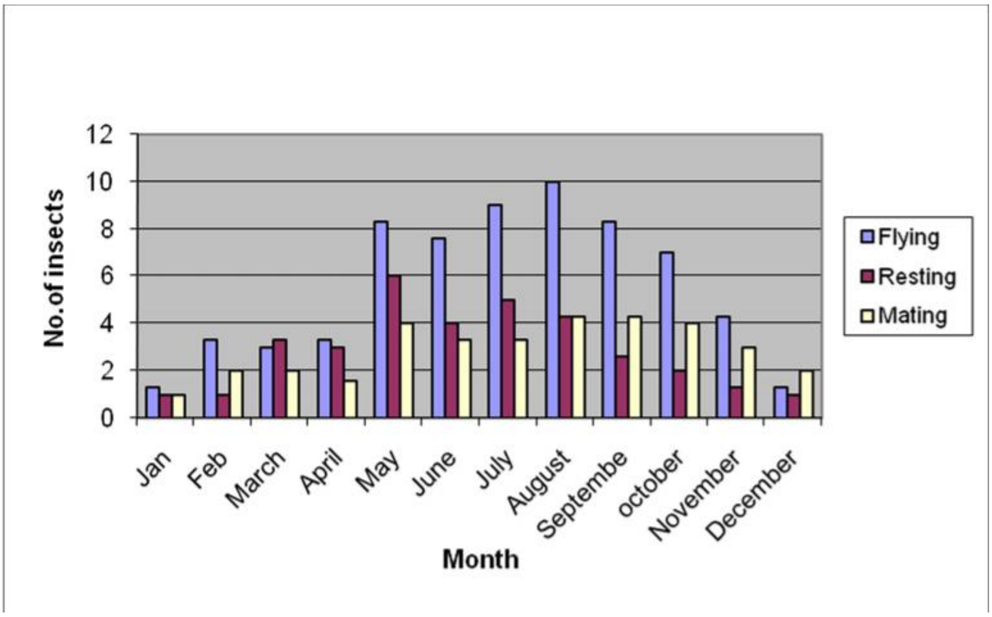

Fig. 7. Behavioral observation of the pest (n=412)

Among the behavioral aspects the flying behavior were observed in maximum and egg laying and mating in minimum. The resting behavior of pyralid insect was found more abundant.(fig 7)

4.5.2 Eggs

The female moth lays whitish, oval, flattened eggs near the edges of submersed leaves. The eggs are deposited either singly or slightly overlapping, forming ribbon like masses near the edges of submersed leaf surfaces.

4.5.2.1 Incubation period

Incubation period was found to vary from three to four to seven days. The colour of the eggs becomes brownish white before hatching. The first hatched larva was very small, lived as duckweed fronds minor and observed only under microscope. Merrit and Cummins found that incubation period of Pyralid insect was about 6-11 days.

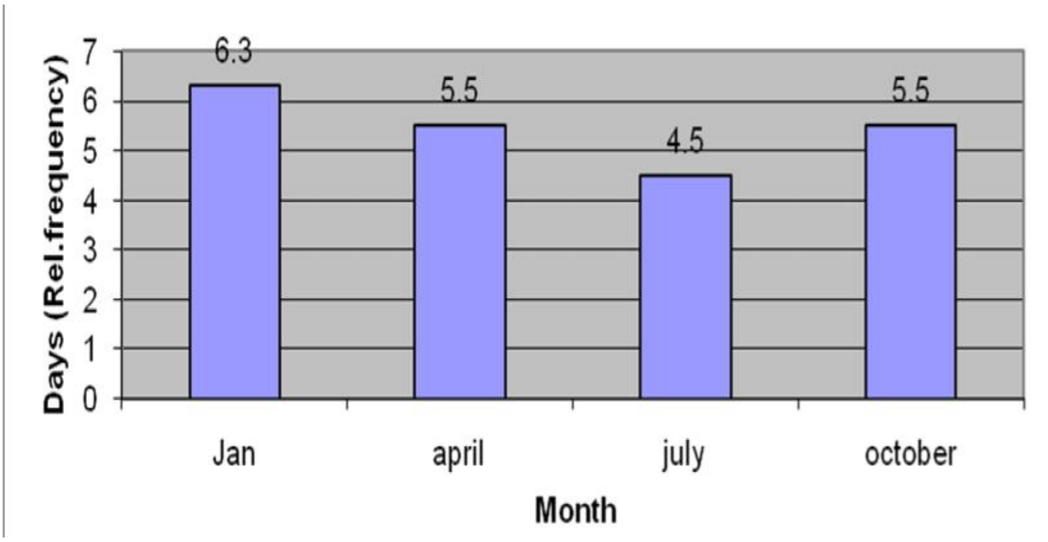

Fig.8. Larval hatching time of pyralid insect *(S.occidentalis)*

On an average the incubation period for hatching varies from 4.5 days to 6.3 days, being more during (winter) season and less during summer.(fig.8)

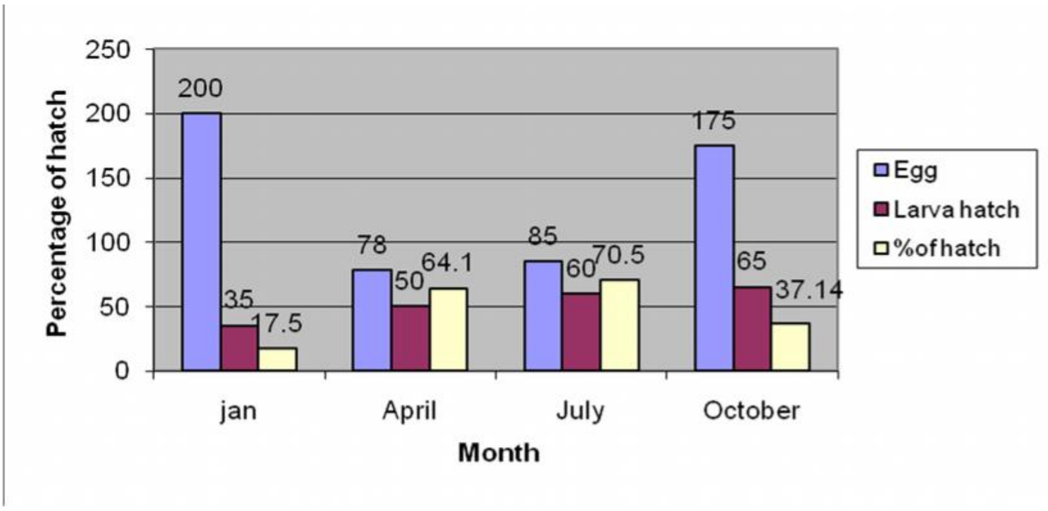

Fig.9. Relative assessment of egg hatch to larva.

Not all eggs that were laid are hatched. Only certain percentage of eggs was hatched, and it varies widely. It was higher in July and lower in January. (fig.9)

4.5.3 Larva

The larvae of the Pyralid insect live in air-filled cases, constructed from the leaf materials they cut from the plants upon which they feed. Depending upon the size of the plant, the case may be constructed from two entire leaves, or more commonly, fragments of leaves. The body of the larvae is creamy white, but darker anteriorly. The head is yellow brown with an inconspicuous, brown, genal stripe. The surface of the epidermis is thrown up in to small papillae, which give the body of the caterpillar a satiny appearance. The head is yellow to brown with random darker patches. The openings of the respiratory system are lacking. Crochets are typically arrange in two transverse bands with the anterior-most band distinctly larger.

4.5.3.1 Larval period

Duration of larval period was found to vary from 16-20 days. The case making longevity and functioning stands as the key factors both for pest status and adaptability of the insect in aquatic condition. The used duckweed fronds for case making are not to capable to further multiply. Except in size and colour variation very little morphological differences were observed among larval categories. According to Bashar and Aslam(1999) the Pyralid larval stages passed by four larval categories (1,2,3.4) Hyung Keun Oh (2010) *et al.* observed that *P.panopealis* Leaf Pyralid moth appears to favor somewhat higher temperature. In addition to larval period, the duration of egg, pre pupal and pupal period also were shortened sharply as temperature goes up. Whereas the duration of adult stage shortened a maximum of only two days as temperature goes up.

4.8.5 Pupa

Pupation occurs within the case surrounding the larva, which has previously attached the case to either leaf blades or the petioles of the plant, either above or below the water surface. The larva spines a coccon within the case it has constructed from plant material.

4.5.4.1 Pupal period

Case making adaptability in the pupal stage was found highly significant. Some new fresh duckweed were attached with case of larva. Pupal case was characteristically triactinal in appearance and made an angle with the upper part of the case. The pupal stage was found to spend 20-24% time of the entire pupal stage. Kinsher and Neunzig reported that the duration of pupal stage of *synclita* sp was 3days.

4.5.5 Hosts

Synclita occidentalis has a wide host range and is known to feed on nearly 60 plant species. The following plants arranged by families and genera are known to be hosts. The number of species, if more than one within each genus, is in parenthesis. Acanthaceae: *Hygrophila, Nomophila, Synema;* Alismataceae: *Enchinodorus* (3), *Sagittaria;* Amaranthaceae: *Amaranthus;* Apiaceae: *Hydrocotyle* (3); Aponogetonaceae

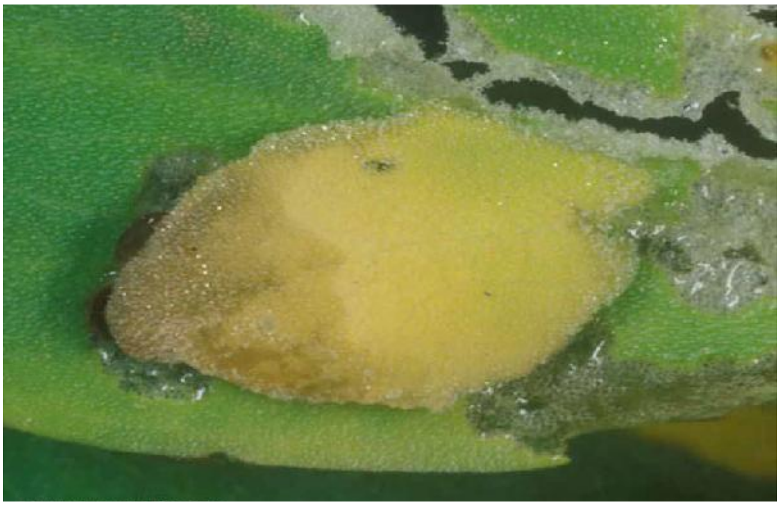

Plate 57. Larval case of *S.occidentalis*

Plate 58. Larva comes out from larval case.

Three other species of *Synclita* occur in the United States with one, *S. tinealis* Munroe, in Florida. The adult of *S. tinealis* is much smaller than that of the waterlily leafcutter and has longer, narrower and darker wings. The larvae of *S. tinealis* are not well known, but seem to feed on and most often make their cases of duckweed, *Lemna* sp. The larvae of *Munroessa gyralis* (Hulst) and *M. icciusalis* (Walker) are similar to those of the waterlily leafcutter, but the anterior and posterior transverse bands of crochets are the same size. *Munroessa* adults are more brightly colored than *Synclita* and are yellowish-orange and white or brownish in color. Although *Munroessa* larvae may make portable cases, they usually cut only one leaf piece and attach it to a whole leaf and live between.

4.5.6 Construction of Case by Pyralid Larvae

Pyralid larvae make new cases again and again if the old or previous cases are destroyed or somehow the larvae are removed from the cases. Under the experimental condition, it was found that matured larvae out of previous ages made new cases again and again. In the first experiment larvae took 2.45 hours time to construct new cases after coming outside of the previous cases. In another experiment, two matured larvae made new cases after two hours coming out from previous cases but one last instar larva (which was just in pre-pupal stage) moved very slowly and failed to make new case. After collection of these two larvae outside from those new cases, they again dived under the water and went to the lower surface of the duckweeds and were trying to make new cases. They took one and half hour to make new cages again. These new cases were not so compact, small back portion of the larvae were open to the outside. Again these matured larvae put into the beaker for observing their case making behavior, within two hours they again made cases. After one day they also took chance to make cases again, but one larva failed to make case and found as dead on the duckweeds whereas another larva can make case successfully. It indicated that, out of cases the pyralid larvae try to make new cases again and again up to be a pupa or death.

4.5.7 Construction of pupal case by pyralid pupae

Structure of the pupal case was quite different in shape and size. In the pupal stage larva do not take any food it remains in starvation. In Pupal case the fronds were fresh as the larva does not eat the fronds.

4.6 Discussion

In the present study egg laying behavior was properly evaluated in the lab condition [$23^0 \pm 2^0 c$ temperature and 85% RH). The arrangement was made in the lab to have a record on the eggs at their continuous observation under SKT microscope. The eggs were laid in scattered or in cluster like a chain under the frond of duckweeds, on an average a female moth laid 250-350 eggs. The incubation period lasted for seven day (Knopf and Habeck 1976)

Report that, *Samea multiplicalis* (Lepidoptera: pyralidae). Female each lay about 150 eggs during their brief life span. (Four to seven days.) Eggs most often are laid singly among the epidermal host plant hairs on the lower surfaces of waterlettuce leaves or the upper surface of salvinia leaves, or lodged between the scale loke leaves of *Azolla*. Eggs hatch in about four days in (28^0C).

Kinser and Neunzig(1981) observed in *S tinealis*, Female lays 82 eggs and total number of eggs produced in the ovary is on an average 300 eggs. Lavery and costa (1977) reported that pyralid moths resent in the stream side vegetation and that adult females entered the water to deposit eggs.

In our Experiment, On an average the incubation period for hatching varies from 4 to 7 days. The incubation period was higher in winter and less in summer. as the temperature had the great effect on egg hatch and larval development and pupal period. (Hyung *et al* 2010) .

Only certain percentages of eggs were hatched, but not all eggs. It varies widely, it was higher in July that means in summer when temperature and humidity was higher and it becomes lower in January when the temperature and humidity were low.

The pyralid female selected the duckweed frond for egg lying due to the high protein content of duckweed and convenient to use duckweed as host plant. Insects are preferred particular host plant for oviposition, development and survival of young. Development stage of pyralid insect was directly dependent on the host plant (duckweed) association for food and shelter (Bashar *et al.* 2008). The present findings also supported by the observations of (Jermy and Bzentesi 1978) *Ostrinia furnacalis* (Lepidoptera, Pyralidac) insect preferred to lay eggs on the lower leaf surface of the mug bean leaves and most of the larval feeding was confined inside the steam. (Telekar *et al.* 1991)

Larva

The incubation period of experimental pyralid insect *S occidentalis* was 4-7 days, after seven days of incubation period the eggs of *S occidentalis* hatched to larvae. The newly hatched larvae started to feed on the duckweed fronds and to make a case made of duckweed fronds in which they reside. The larvae make a new cage again if the older cage was destroyed. The larva completes undergoes with few instars to goes before pupation.

Kinser and Neunzig (1981) observed five larval instar of *S.tinealis* and the larvae make silk cases and feed primary on *lemna* and *spirodela.* According to Habeck (1991) Larvae *of S.obliteralis* reside between the two roundish pieces of leaves that form a sandwich like portable case. When feeding on small plants, these cases can consist of whole leaves or even whole plants.

Fannah (1987) reported that the females of *Elophila* on *Azolla* in sierra leone laid eggs in batches of 16-165 on the adaxial side of the floating *Azolla* frond, and larvae hatched four days later.

Pupa

The pupa of *S.occidentalis* was obtect type. They were enclosed in a cocoon which was made by the 4^{th} of final instars larvae. The cocoon remained within the larval cage. The pupal period was short taking four days to become adults.

Kassulke (1984) makes an experiment, he reported that, in *Samea Muiltiplicalis* pupation occurs within a silken cocoon. This cocoon usually is formed withing the spongy portion of a leaf, but on *S. molesta* it was constructed among old leaves pupal development requires four to seven days at 28^0C on waterleltuce and eight to nine days at 26^0C on *S. molesta*. The temperature range in the pupal stage was same to that of the author.

Kinser and Neunzig (1981) reported that the pupation of *S tinealis* occurs under water on the host plants, *Lemna* or *Spirodela*. They also observed that the duration of pupal stage of the pyralid moth is three days. The pupation of *Dibusa angata* occur either in terminal or basal areas of the *lemna australis* thallus (Resh and Ronald 1986) Buckinghamand

Binnett (1996) reported that the pre pupa and pupae of the pyralid *Parapoynx diminutalis* remains for 1-2 and 6-7 days respectively.

Adult

The pupal of *S. Occidentalis* emerged into adults. The pupal period lasted for four days. According to Buckingham and Binnelt (1996) The adult pyralid *Parapoynx diminutalis* live three to five days in lab condition at 24.4^{0}C.

Aslam (1987) reported that the adults of *Nymphula africalis* emerge from cocoons within a week.

Duration of life Cycle

The life cycle of pyralid moth *Synclita Occidentalis* ranged from 26 to 47 days depending upon the environmental conditon. The duration of life cycle included incubation period 4-7 days, larval period 16-20 days, pupal period 4 days and adult life span 2-4 days. The females lay eggs three days after emergence.

According to Deloach *et al.* (1979) reported that *Samea Multiplicalis* (Lepidoptera: Pyralidae), The total developmental times (egg to adult) are 25 and 42 days under the two respective temperature.

Tuskes (1977) observed that in northern california (U.S.A) the pyralid *Parargyractic confusalis* (walkes) had 2-3 generation per year depending on climate condition. Adults lead a terrestrial life, though the female re-entered the water to oviposite. The adults, larvae and pupae existed underwater.

CHAPTER-5

ABUNDANCE OF THE PEST IN DIFFERENT STAGES OF THE LIFE AND THE DUCKWEEDS

Chapter-5

Abundance of the pest in different stages of the life and the duckweeds.

5.1 Introduction

Insects are common almost everywhere and easy to observe. Many species, both common and rare can be reliably identified in the field without killing the individuals. (Padhey *et al.* 2006). As many species are strictly seasonal and prefer only particular set of habitats, (Kunte 1997), they are good indicators of habitat quality (kocher and williams 2000). The most natural way to define abundance is population density that is the number of individuals per unit of area (Komonen *et al.* 2001). Many species are strictly seasonal and their population dynamics are generally considered to be governed by environmental factors (Hussain *et al.* 2011) keep this thought in front the present investigation has been undertaken with several objectives as stated below.

5.2 Objectives

1. To examine the seasonal abundance of pyralid insect (Adult and larval, pupal stage together.)
2. To observe the adult emergence pattern in lab.

5.3 Materials and Methods

Depending on objectives, the current investigation has been adopted procedures and materializes to find out the results.

5.3.1 Study species

Our experimental species was *Synclita occidentalis.* Adult moth exhibit marked sexual dimorphism. Females are distinctly larger than males, with females having wingspans of 15-19mm and males with wingspans of 11-13mm. Female are brightly coloured than males. The total life span of pyralid adult *S. occidentalis* was two-four days. It makes association with duckweed on laying eggs on duckweed fronds.

Classifications the insect pest

Phylum- Arthropoda

Class- Insecta

Order- Lepidoptera

Family- pyralidae

Genus- *Synclita*

Species-*S.occidentalis*

5.3.2 Study Sites

Mirzapur Kumudini Hospital Complex were chosen for the abundance study of adult and larva/pupa of pyralid insect. In Mirzapur Hospital Complex two types of pond were nstation-1 and station-2 were given in **chapter-3**. This area were semi-natural and natural and planted vegetation.

5.3.3. Study period

The findings were based on filed investigations in Mirzapur Kumudini Hospital Complex carried out from May '06 to April' 07.

5.3.4 Methodology

Different physical materials were used in study period that were

1. Sampling iron net quadrant (12cmx12cm)
2. Duckweed sampling spoon (32cmxhandle 17cm)
3. Adult collecting net
4. SKT microscope
5. Brushes
6. Needles
7. Forceps
8. Plastic ploypet container
9. Thick nylon rope
10. Glass beaker
11. Slide
12. Vials
13. Scale
14. Pencil and Sign pen

15. Differnet digital Cameras used to photographs

Plate 61. The Duckweed pest pyralid adult *(Synclita.occidentalis)*

Plate 62. Preserved specimens of *S.occidentalis*

Adult sampling

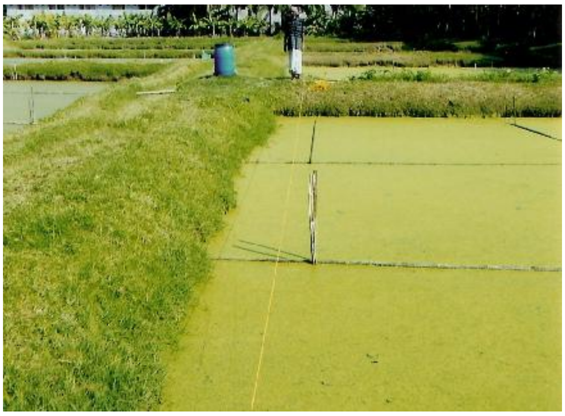

Plate 63. One miter periphery of the pond Plate 64.Sampling from convex area

Plate 65. Sampling from concave area Plate 66. Sampling from straight area (organic)

5.3.5 Sample Collection

Samples were collected from one mitre periphery of the experimental pond and one mitre was measured by the thick nylon rope which was tightly placed from one end to another end of the selected three pond of the experimental stations. In organic pond three place were selected in concare-1 cenvex-1 and straight-1 and adult samples were also collected from one miter pherephery of the organic pond with the help of the metalic sieve, which was made mosquito net on a badminton frame. Adult was swiped by the sieve and turned in to special manner for the preventing the captured adult to go out. When all insects gathered in the upper portion of the net, they were inserted the killing jar. To making them senseless, some chloroform were mixed to cotton put in the killing jar. In data sheet record was maintained for counting adult for observing the morphology of adult insect and abundance of the pyralid adult.

Pyralid larval and pupal cases were collected from three different ponds in Inorganic ponds and Organic ponds in random basis by sampling iron net quadrant. Five samples were collected from each pond. The numbers of larval pupal cases from the samples were recorded. Seasonal abundance of pyralid pest and its availability were observed throughout the year.

5.3.6 Sample preservation

The collected samples were taken to the Environmental Biology and Biodiversity Laboratory (EBBL), Department of Zoology, University of Dhaka for further study. Pyralid moth was very delicate and fragile so it was preserved in the insect box which was special type of arrangement. These special type preservation ideas were borrowed from Borrer *et al.* (1989).

Larval and pupal cage were collected with the iron rod quadrant and then put in to the polypet and the larval and pupal cases were preserved in 70%, alcohol in vial after reaching the laboratory.

5.3.7 Study Procedure

Collected alive adult were put in to the large beaker with fresh duckweed and covered the beaker with mosquito net for passing oxygen and light. Eggs were observed with the SKT microscope, larva pupa and adult stages were examined by visual observation using scale.

5.3.8. Statistical analysis

All these statistical analysis was performed by SPSS for windows (Version 16) M.S.excel(2007) was used to draw graph, table and figure.

5.4 Result

Density dependant mechanisms are supposed to maintain insect population more or less stable, but some theories support the view that climatic factors can also regulate populations if they can act in a density dependent way. (KIMMINSI 1987)

5.4.1 The abundance of pyralid insect in inorganic pond

Adult:

- Wings are covered with scales
- Fore wings less than 15mm. long sometimes reduced.
- Hind wings finely patterned
- Mouth siphon well developed and coiled

Adult moths exhibit marked sexual dimorphism. Females are distinctly larger than males, with females having wingspans of 15-19mm and males with 11-13mm. Females wings were light gray brown and dusky markings. The wings of males were dusky overall, and marked with brown white.

In Inorganic pond from the graph, abundance of pyralid insect were found three peak month in one year, that were August, October and April. and less in number from November to February. These insects were found round the year. Total numbers of insects collected from inorganic pond were 3675. The populations were abundant in the summer and rainy season but during the winter the insect were thinly populated.(Fig.10)

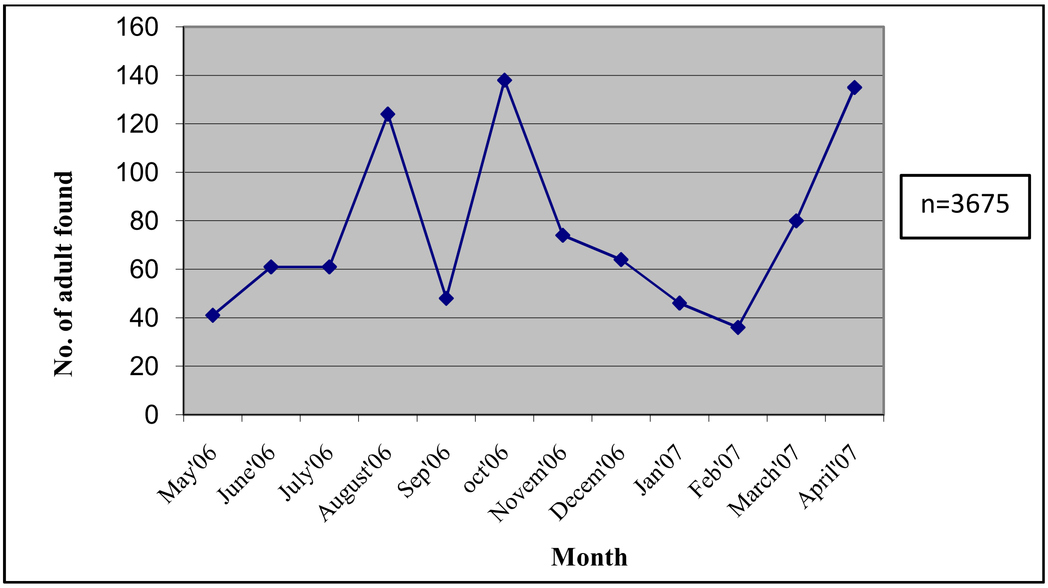

Fig.10. Adult abundance of pyralid insect in Inorganic pond.(n=3675)

In Organic pond peak of abundance were found in the month of April. It was the starting of summer. These insects were also available round the year. The numbers of the insect were less in the month of January. Total numbers of insects collected from organic pond were 350.(fig.11)

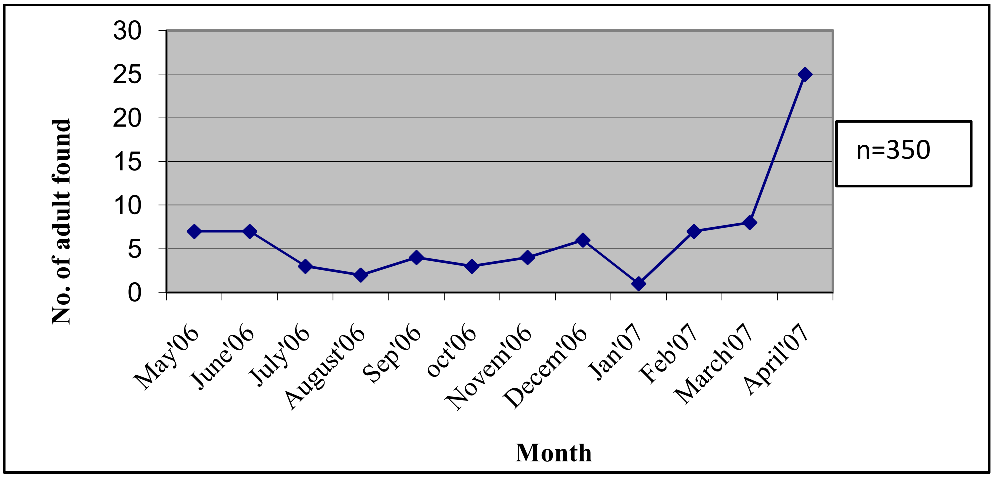

Fig.11. Abundance of pyralid in Organic pond in different month during study period. (n=350)

In the comparison of the two ponds results were not similar. Abundance of insets were more in Inorganic pond (station-1). The peaks of the abundance of the insects were different, but in the both ponds it was present round the year. (fig.12)

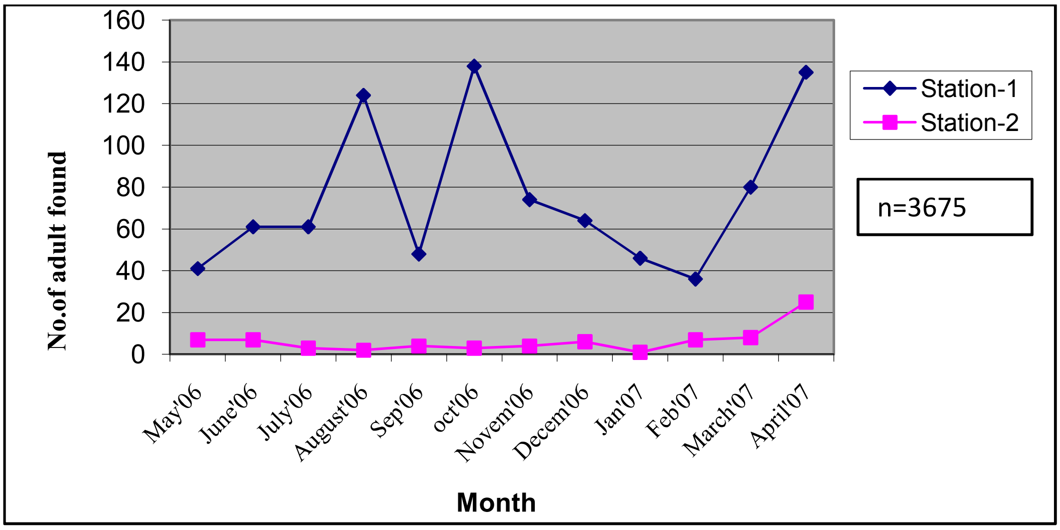

Fig.12. Comparison of Adult Abundance in Ip and Op of different months during the study period.(n=3675)

5.4.2 larval /pupal abundance in the Inorganic and Organic pond

Larval/ pupal abundance were higher in inorganic ponds. Only month of August and October larval/ pupal abundance were slightly higher in organic pond. Larval and pupal abundance were lower in January.(fig.13)

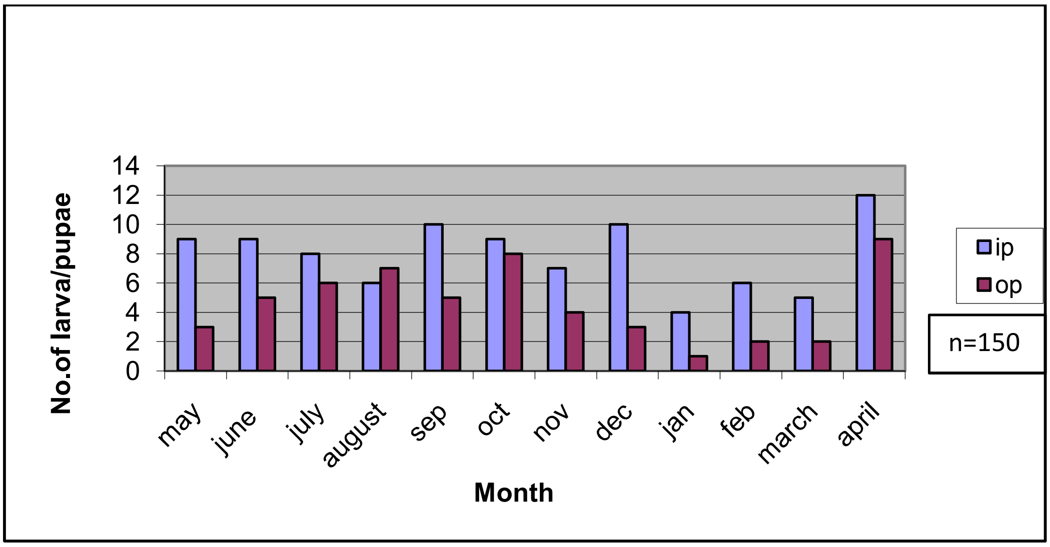

Fig.13. Seasonal abundance of Larva and Pupa in Ip and Op in different month in study period. (n=150)

Larva:

The larva of the pyralid insects had a pair of non-joined fleshy prolegs tipped with tiny hooks (crochests) on abdominal segments. Antennae are shorter than body.

Plate 67. Larval case of *S. occidentalis*

Plate 68. Larva of *S.occidentalis*

The larva of this insect make cases with duckweed roots and fronds. The larva of this insect constructs two different types of cases during these stages of development. One for the larva another for the pupa.

The larval cases were flat having two sides the dorsal and ventral side. Both the sides were made of duckweed frond.

Pre Pupal stage:

Case making adaptability in the pre pupal stage was found highly significant. Some new fresh duckweeds fronds were attached with the case. Pre pupal case was characteristically triactinal in appearance and made an angle with the upper part of the case. The pupal stage was found to vary from 4-6 days. In the pupal stage they were found to spend 20-24% time of the entire stage.

Pupa:

-Legs and antenna are fused to body

- Antennas are shorter than body.
- Pupa develops under water in cocoon.

The ultimate instars of the larval cage construct a characteristic case and goes for pupation during this stage, (The stage before starting pupation) the insect consumes voraciously. The pupa was obtect type.

Plate 69. Pupal case of *S. occidentalis*

Plate 70. Pupa of *S. occidentalis*

Kinser and Neunzig reported (1981) that pupation of *s tinealis* occurs under on the host plants, *Spirodela*. They also observed that the duration of pupal stage of the pyralid moth was three days.

5.4.3 Adult emergence pattern of pyalid insect in lab.

To observe the adult abundance of pyralid insect experiment on adult emergence patter on lab was essential, for this experiment we prepared self innovated plastic rearing bucket.

Rearing bucket.

It was a plastic bucket (in 20 litre). It was covered with mosquito net and attached to the bamboo stick. In one side in mosquito net it had the opening to collect the adult insect. The plastic bucket was full of nutrient water with larval\/ pupal cage with duckweed. Water surface in experimental container was divided with four cork sheet.

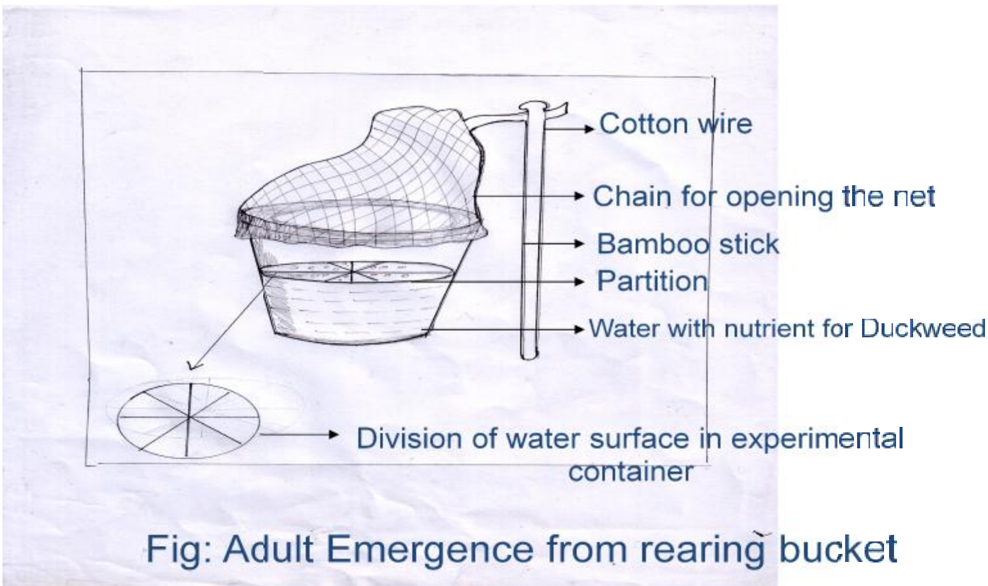

Fig.14. Rearing bucket for adult emergence.

5.4.4 Adult emergence pattern in inorganic pond and organic pond.

From this experiment it was observed three peak of adult abundance. One was the month of September and another two months were the July and August.(Raining season).It becomes very low in the month of November and March. From December to February and April to June abundance was almost similar.(fig.15)

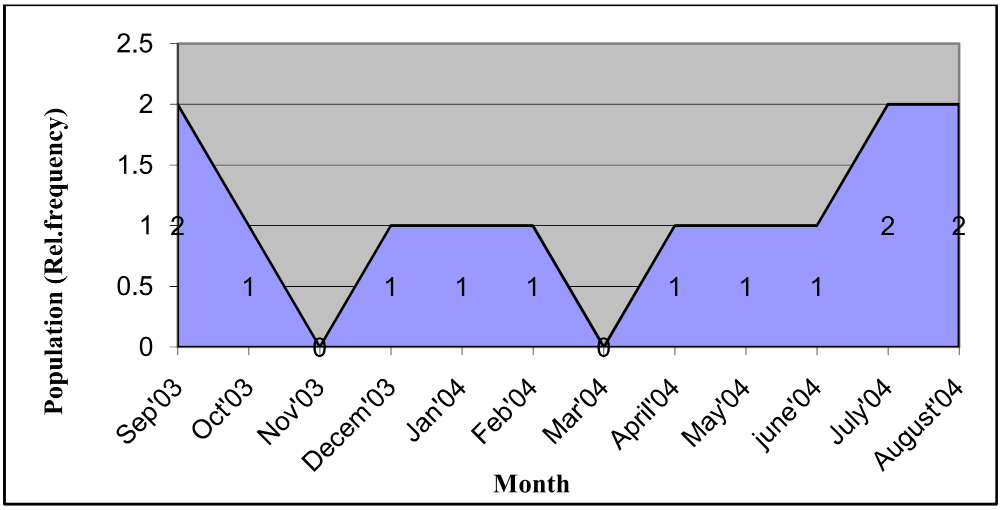

Fig.15. Adult emergence pattern in Inorganic pond.

Adult emergence pattern were higher in the month of September and August in Organic pond.. It becomes very low in the month of December and March. It remains constant from April to June.(fig.16)

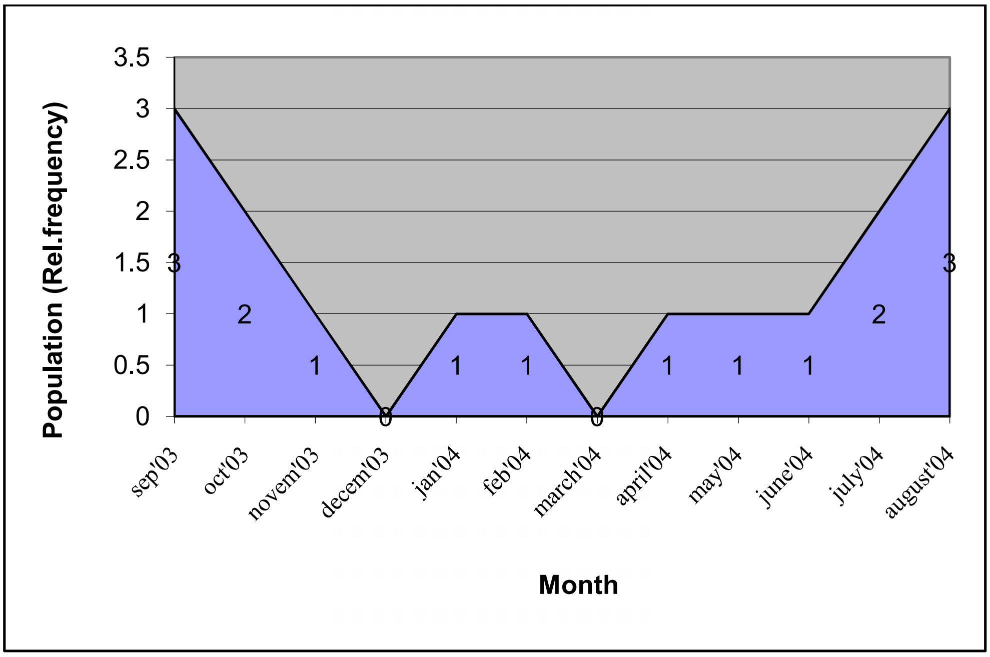

Fig.16. Adult emergence pattern in Organic pond in different month of study period.

From the comparison graph of the two experimental stations we can observe adult emergence pattern were higher in organic pond than the Inorganic pond only in December adult emergence pattern were higher in Inorganic pond. (fig.17)

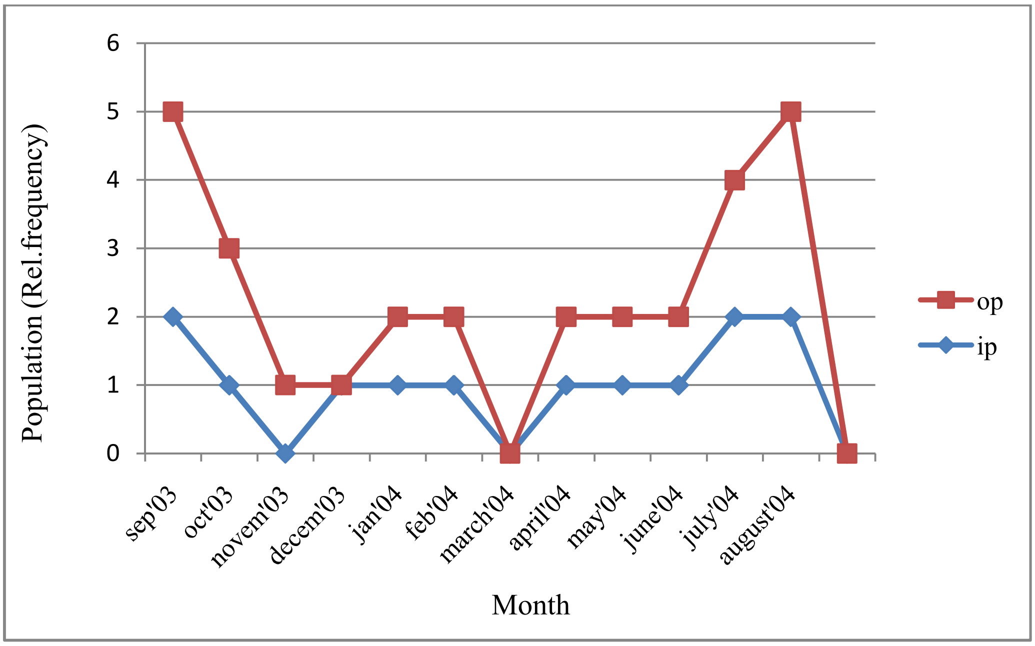

Fig.17. Comparison of Adult emergence pattern in Ip and Op in different month of study period.

5.5 Discussion

Abundance of insects were more in Inorganic pond than the organic due to amount of the nutrition that used of the duckweed culture, whereas in the organic all the medical water were used in the duckweed pond through the drains. Chang and stomp (2009) reported that nitrogenous fertilizers or compounds are helpful in the growth of duckweed. So it may be accepted that the abundance of the pyralid moth *S. occidentalis* was related to the duckweed production. The more of the duckweed production, higher will be the pyralid insect production. According to (Timothy *et al.* 2000) An increase of plant matter in a subsurface ecosystems would in fact indicate an increase in both the number and diversity of aquatic populations. The specific ecology of each respective region of the pond has an impact on the quality and quantity of the insect life present there.

On the other hand abundance of the adult insects were more in summer and rainy season then the winter. Bhadriraju (1993) reported that temperature had the greatest influence on egg to adult development time, followed by relative humidity and diet.
Density dependant mechanisms are supposed to maintain insect populations more or less stable, but some thoeries support the view that climatic factors can also regulate population if they can act in a density dependent way (Kimmins 1947). Lavery and Costa (1973) reported that *Parargyractis* populations were commonly distributed throughout the watersheds, but the distribution was somewhat localized due the availability of resources helpful for their population growth.

Abundance of larval and pupal availability was observed in Inorganic and Organic pond. larval availability was higher in inorganic pond (station-1) than the organic (station-2). As from the above result we can observe adult were more available in station-1. So larval/pupal abundance were also co-related with their adult availability.

Abundance of larval and pupal was also higher in summer and rainy season than the winter. Bashar *et al*. (2007) recorded severe infestation caused by a pyralid insect pest on duckweeds. Larval abundance were peak in September and October. Larval abundance were diminished to zero state in January, maximum number of pupa were recorded in September. The pest population were virtually low in December and January.
(Hyung 2010) observed that the *perilla* leaf pyralid moth *pyrausta panopealis* appears to favor somewhat higher temperature. In addition to larval period, the duration or egg, Prepupal and pupal period also were decreased with temperature , whereas the duration of adult stage shortened a maximum of only two days as temperature goes up.

Tuskes (1977) observed that in North Carolina (U.S.A) the pyralid *parargyractis confusalis* (Walker) had 2-3 generations per year depending on climatic condition. Adults lead a terrestrial life, though the female re-entered the water to oviposit.
Forno (1983) described the pyralid moth *Argyractis subornata* reared on the roots of water hyacinth *Eichhornia crassipes.* Developmental time at 25^0c was 61 days for moths with five instars and 71 days for those with six instars. At 20^0c the life cycle was half again as long as at 25^0c. No development occurred at 15^0c. The more common host plant in the field was water hyacinth.

CHAPTER-06

NATURE OF INJURY OF DUCKEWEED FRONDS AND ROOTS

Chapter- 06

Nature of injury of Duckweed fronds and roots.

6.1 Introduction

Harbivores must find the right place at the right stage of development, Aide and Londono, 1989; Devokata and Schmidt, 1990.

In insect, life cycle persist in a year may be more than one is called the monovoltine insect. The phytophagus insects they have got the reproductive diapauses stage (In the adult). They require fresh elimination from their host plant to have the development of sexual maturity. This initiates the introduction of the plant insect relationship.

One important component of plant herbivore (insect) interactions over both ecological and evolutionary time scale is plant defense. Defense influences the population dynamics and distribution of plants and herbivores (Price *et al.* 1991). Herbivore insects are adapted to tolerate plant defense, which feed a wide range of plant species. Both plant defense and insect adaptations are involving a metabolic cost. Lepidopteron larvae that lead an aquatic life exhibit some interesting morphological and behavioral adaptations. (Bashar *et al.* 2006).

The experimental insect *S. occidentalis* was selected the duckweed as principal host plant for food and shelter. Although some authors have attempted to find out the key pest of duckweed but very few studies are carried out on the infestation intensity, association and interaction with the host plant (duckweed) and pyralid insect. This study confined to find out the pest status, nature of injury of host plant by the pyralid insect and its association with the host plant in aquatic ecosystem. Considering the great importance of duckweed the insect pest association and interaction that attain the insects pest status, was under taken in the study.

6.2 Objectives:

- To observe and examine how it becomes pest and its status.
- To observe nature of injury caused by the pyralid pest (*S. occidentalis*) on duckweed fronds and roots.

6.3 Materials and Methods

Different physical materials were used to perform the experiment. There are as follows-

1. Duckweed collecting metallic iron rod quadrant (12cmx ×12am)
2. Plastic polypet
3. Petridis
4. Glass Beaker
5. Sample Collecting Spoon
6. SKT microscope
7. Needle, brush
8. Thermo hygrometer for recording temperature and relative humidity
9. Paper and sign pen for data collection
10. Different digital camera of photographs

6.3.1 Study area

In Mirzapur Demo farm two types of ponds were selected for sample collection. They were categorized as Inorganic and Organic pond. In the Inorganic pond they used inorganic fertilizers, Cow dung, decomposed materials and in Organic pond supplied with organic matters (drainage, domestic and hospitalize waste materials) used as duckweed nutrients.

6.3.2 Study Period

The findings were based on field investigations in Mirzapur Kumudini Hospital Complex from August 2006 to July 2007 as well as Environmental Biology and Biodiversity lab (EBBL), Department of Zoology, University of Dhaka.

6.3.3 Study Species of duckweed

Only *Spirodela* species were used as our experimental biological materials. Pyralid larvae used duckweed as food and shelter. Duckweed fronds and roots were injured by the feeding habit of larvae. The infested fronds were not able to multiply or further grow. The duckweed mass (infested and non infested units) pyralid larvas, pupal and adult were collected as biological materials.

6.3.4 Sample Collection

Samples were collected by sweeping duckweed with a metallic sieve (12cm× 12cm). These samples were carried with a plastic polypets from experimental stations to the EBBL lab department of Zoology, University of Dhaka samples were placed in a 500ml glass beaker with water, and covered with mosquito net. Duckweed masses were supplied as larval food whenever necessary.

6.3.5 Study procedure

The total number of insect larvae, pupae and adult which associated with duckweed samples was recorded by visual observations to find out the infestation intensity of pyralid insect on duckweed productivity.

The infested units and the larval abundance were recorded data wise to estimate the infestation intensity according to the methods of Baustista *et al*. (1984). Mode of infestation and infestation intensity was measured by the methods of Israfil and Abraham (1967). Randomly selected different kinds of infested and non-infested duckweed units with various number of duckweed fronds were observed under SKT microscope. The number, colour, external appearance and the presence of roots cap were observed to compare the infestation intensity and mode of infestation according to the methods of (Bashar *et al.* 1999).

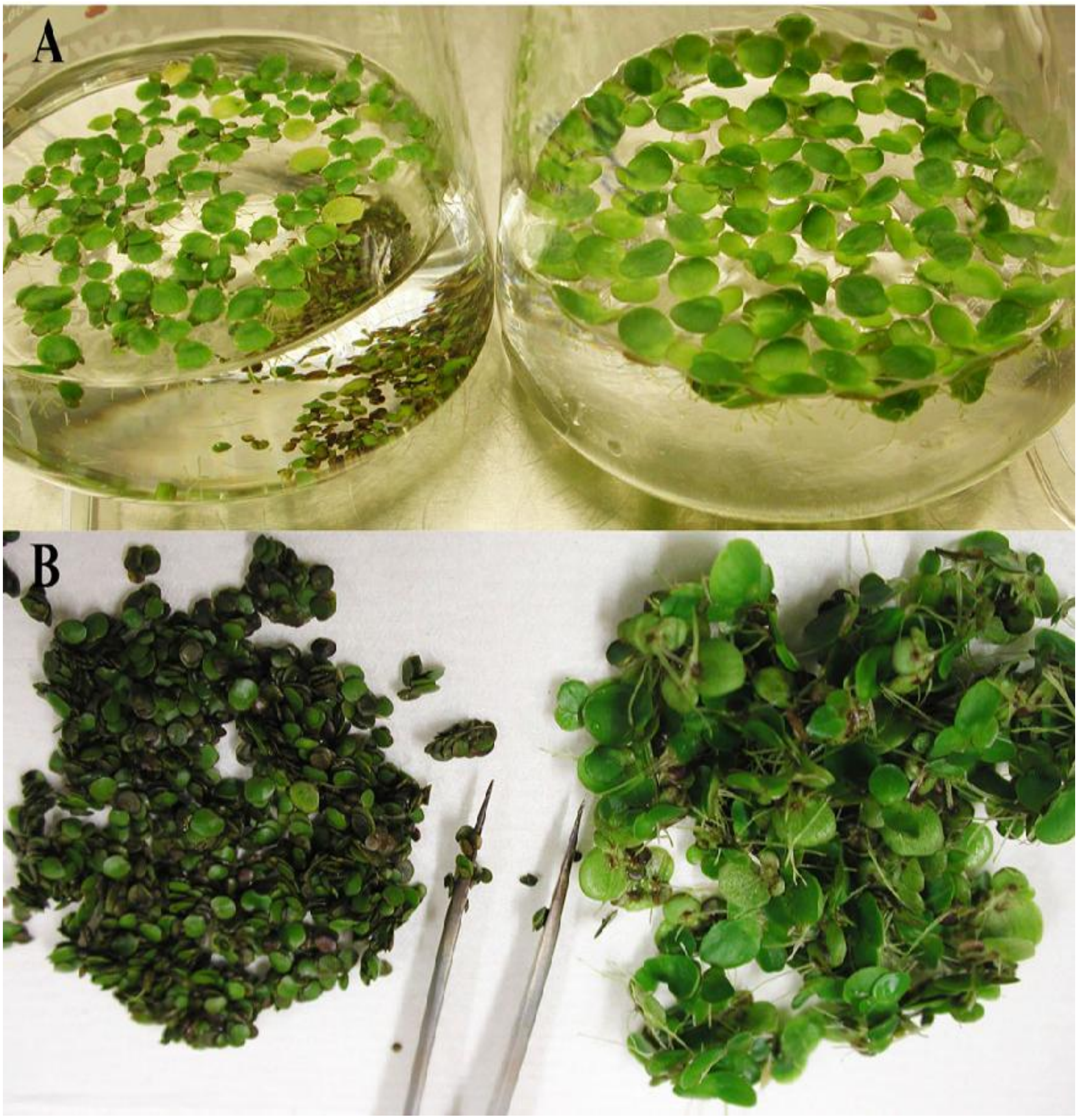

Plate 71. A Fresh Duckweed fronds B Fresh Duckweed roots

Plate 72. Duckweed fronds were unable to multiply due to damage caused by Pyralid larva.

Plate 73. Maximum areas of the fronds were eaten by the Pyralid.

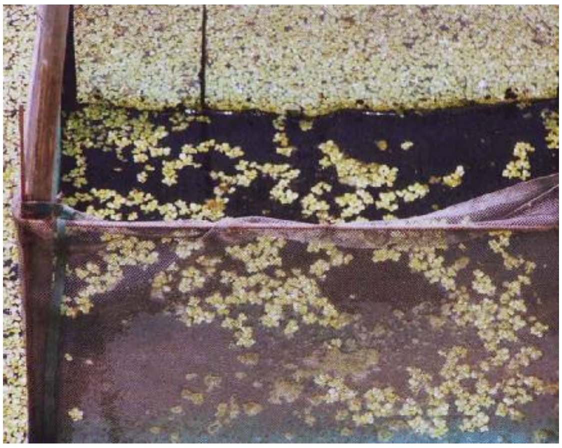

Plate 74. Duckweed productivity was satisfactory.

Plate 75. Duckweed productivity was not satisfactory.

6.4 Result

Our experimental insect *S. occidentalis* was totally aquatic insect and they pass their life cycle in water. The larvae of this insect make cases with duckweed leaves in combination with the duckweed's roots and fronds on the ventral surface. This special type of characteristics case making was that of the Trichopteran case making. Merit and Cummins(1996).

The case making longevity and functioning stand act as the key factors for pest status and adaptability of the insect in aquatic condition.

The larvae of the insect constructed cases in two different stages of insect development. One for the larva and another for the pupal stage. The numbers of the duckweed fronds in larval pupal cases were varied according to the length and width of cases also along with the larval categories.

The voracious feeding habit of pyralid larva caused maximum damage on duckweed productivity. The used fronds were failed to budding or further growth , lose its roots and cannot get nutrition and ultimately stopped their further multiplication. It was the main obstacles in the duckweed production. The nature of damage caused during pupal case was similar to that of the larval case. According to Bashar and Aslam (1998) the pyralid larval case making adaptability is special for the aquatic mode of life. It is difficult to control this insect at the larval stage due to the presence of protective larval case (Akiko *et al.* 2002).

Pre pupal stage found highly significant in infesting the duckweeds. Some new fresh duckweed was attached with the larval case. The internal white color gelatinous sheath of larval cases becomes rigid and strong at this stage. The pupal case was characteristically triactinal in appearance.

Plate 76. Larval caseof *S.occidentalis*

Plate 77 pupal case of *S.occidentalis*

Comparison of the size of the larval case in IP and OP

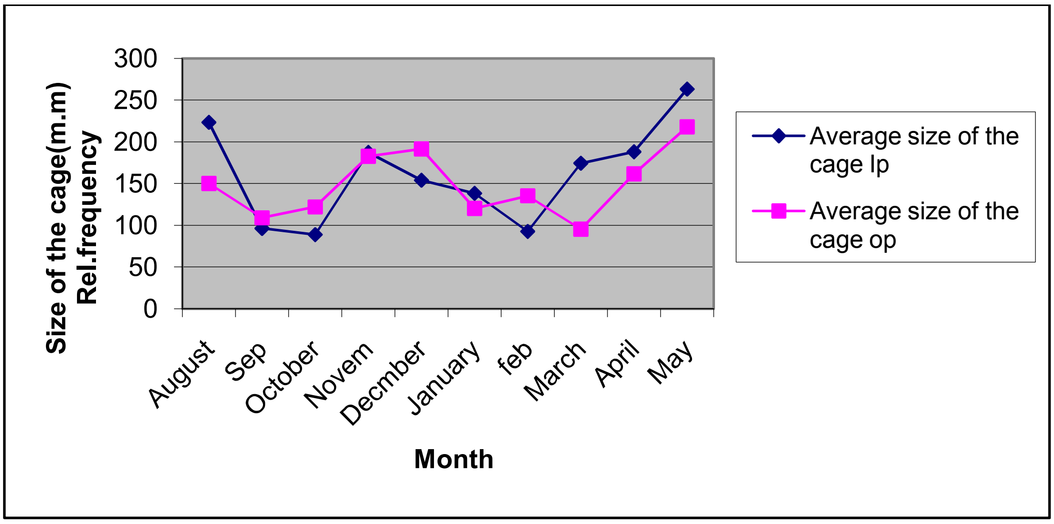

Fig.18. Comparison of the size of the case in Ip and Op

Average sizes of the larval case in IP were larger in the month of August. It becomes also higher in the month of March to May. On the other hand, from September to February size of the larval case in Op were bigger than IP. (It was the beginning of winter). (fig .18)

Comparison of larval size between IP and OP

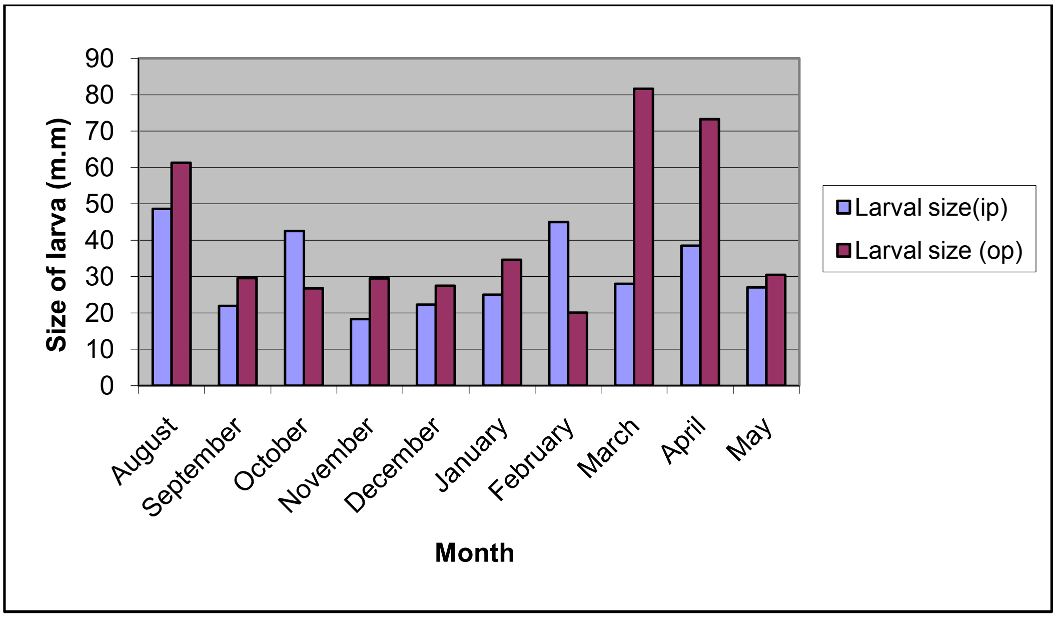

Fig.19. Comparison of larval size between Ip and Op

Larval size of OP was almost bigger in size around the year, only in the month of October and February larval size of op was small than IP.(fig 19)

6.4.1 Infestation of Fronds

Infestation of fronds in case (IP)

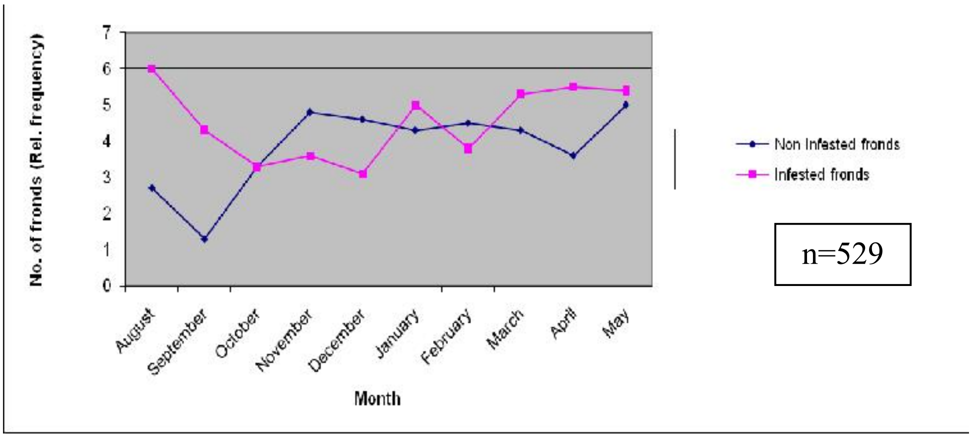

Fig.20. Infestation of fronds in case (Ip) (n=529)

Infested fronds were found higher in the month of August and September in Ip, and lower in the month of November and December and February. Infestation gradually increases in the month of March to May during the study period. (fig.20)

Infestation of fronds in case (OP)

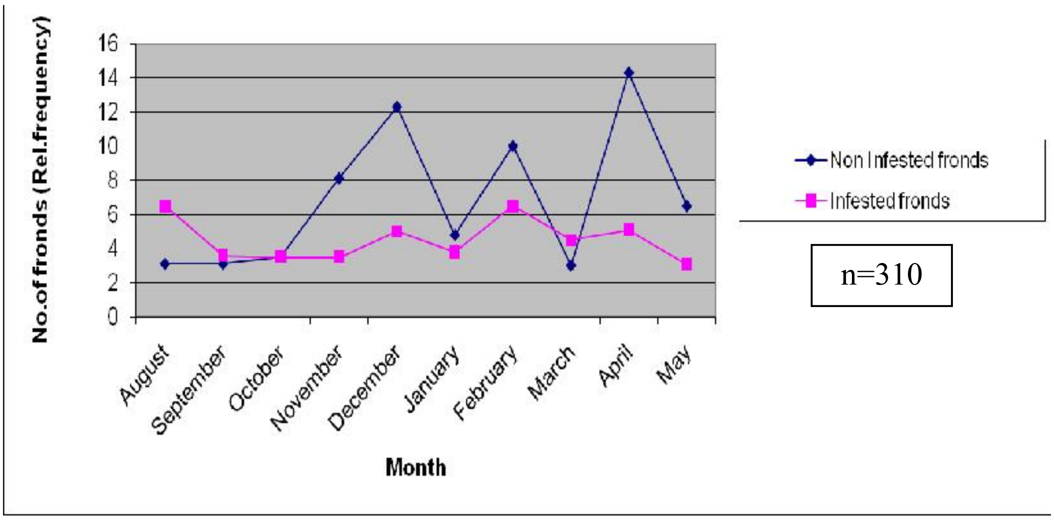

Fig.21. Infestation of fronds in case (op) (n=310)

Numbers of fresh duckweed fronds were higher in op, round the year that means infestation were lower in rate in Organic pond.(fig.21)

Comparison between the no of fronds in IP and OP

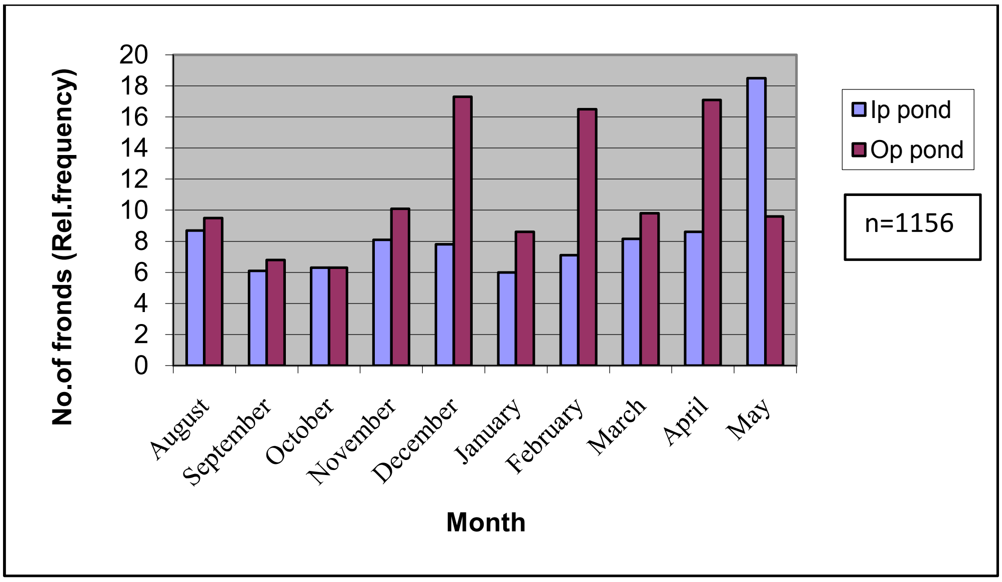

Fig.22. Comparison between the no. of fronds in Ip and Op (n=1156)

Numbers of fronds in Organic pond were always higher than the Inorganic pond. We can observe the infested fronds were less, but fresh duckweed fronds were more in Op.

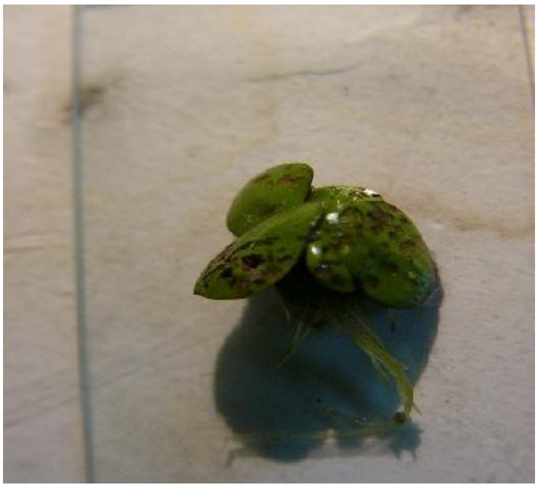

Plate 78. Fronds were severely infested by the attack of the pyralid insect.

Plate 79. Fronds and roots were severely Infested due to case making strategy.

Case making Strategy

Plate 80. Larval cases made by fronds.

Plate 81. Larval activity to making case with fronds.

Plate 82. Movement of larva Within the case.

Plate 83. Different types of larva out of case.

Relation between the larval size and fronds attacked in (Ip)

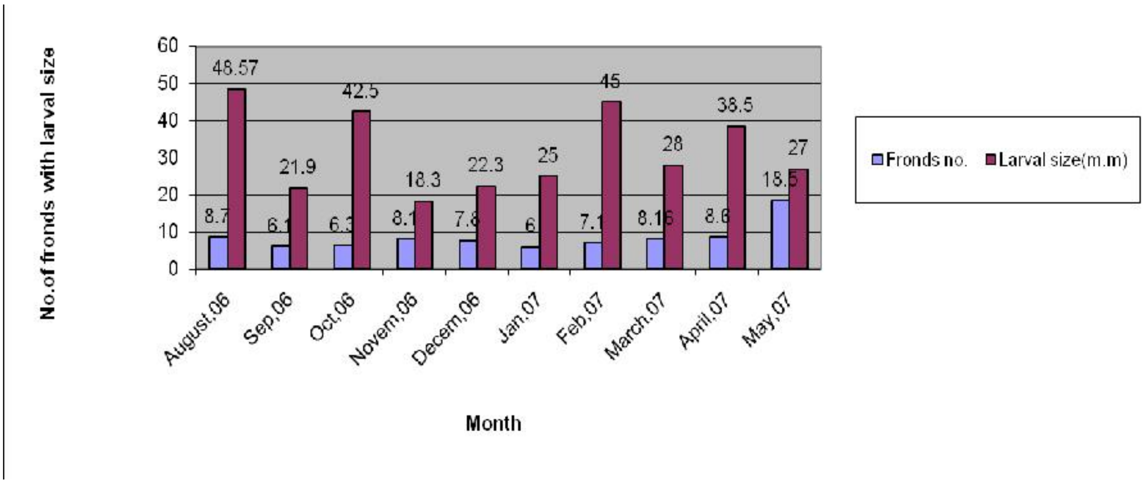

Fig 23. Relation between the larval size and fronds attacked in (Ip)

Larval development varies from summer to winter, but the larval development higher in August and lower in November, but the developments of fronds remain more or less stagnant round the year. Fronds development, multiplication was stopped due to larval attack, but the larva don't destroyed all of the fronds they use in the case.

Relation between the larval size and fronds attacked in (Op)

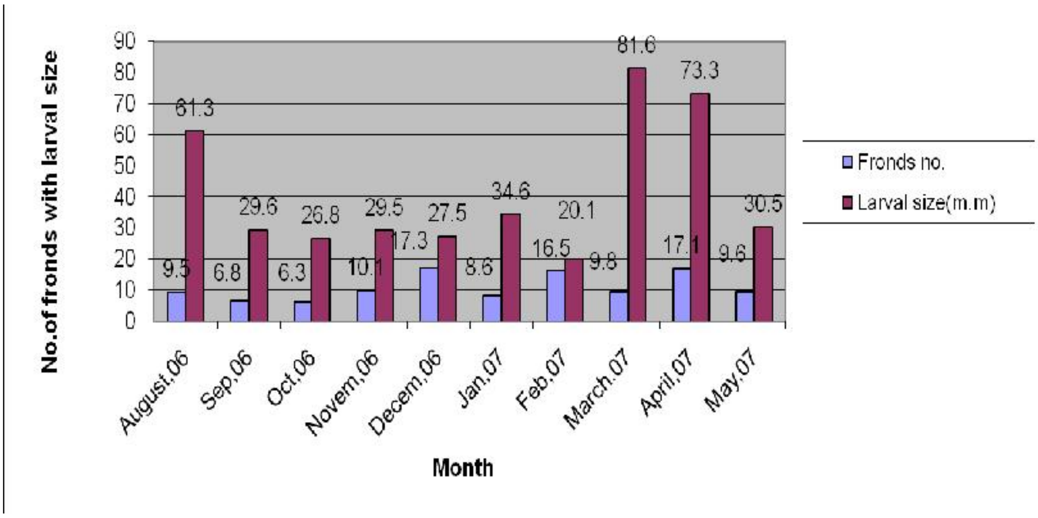

Fig. 24. Relation between the larval size and fronds attacked in (Op)

In the same way larval development was varies in different season but the infested fronds development was stopped, but the larvae always maintain the balance of their food and shelter, so they don't destroy or damage all of the fronds ,they use in case.(fig.24)

6.4.2 Infestation causing mechanism

No. of non infested fresh duckweed fronds in (Ip and Op)

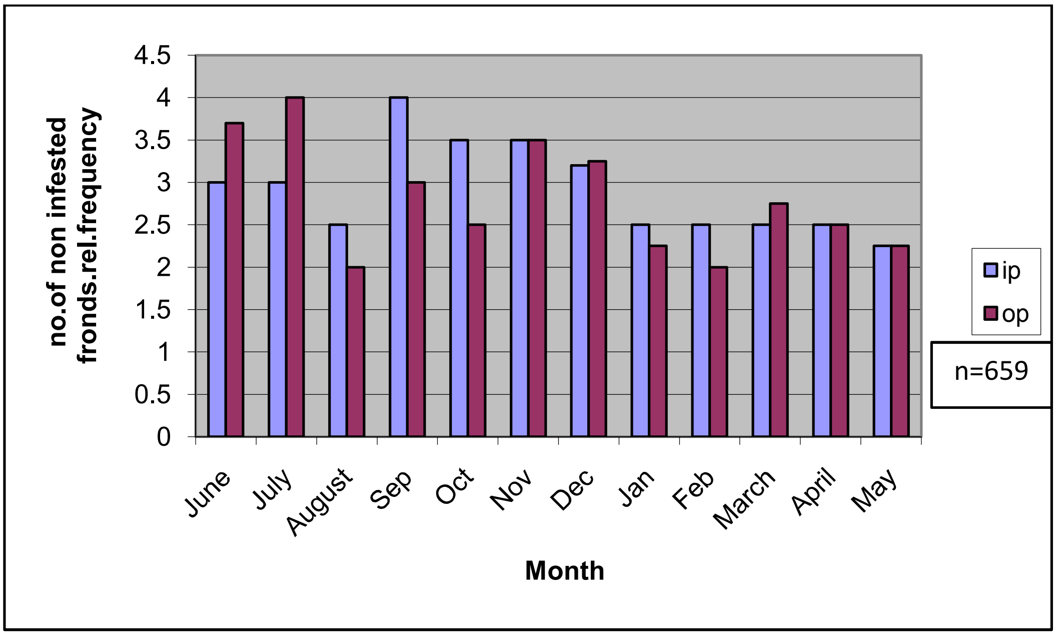

Fig.25. No of non infested fresh duckweed fronds in (Ip and Op) (n=659)

In the month of September and October no. of fresh duckweed fronds were higher in IP. In June and July No. of fresh fronds were higher in OP.(fig 25)

No. of infested duckweed fronds in (Ip and Op)

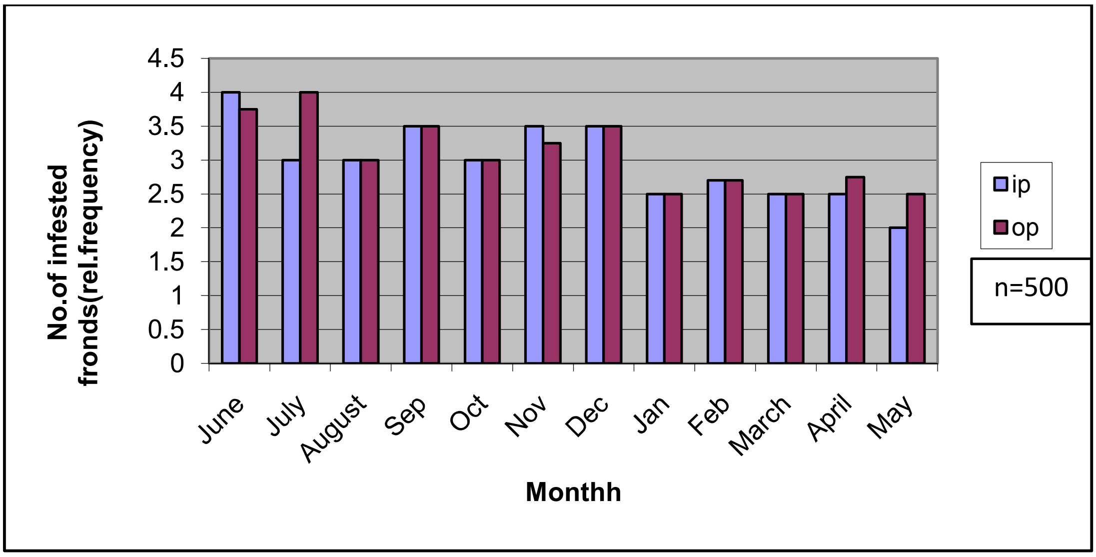

Fig.26. No of infested duckweed fronds in (Ip and Op) (n=500)

Average No. of infested fronds were found more or less similar in number in both ponds round the year, that means infestation was persists in both the pond . (fig 26).Infested fronds were found higher in July, April, and May in Op and in Ip infestation were higher in June and November.

No. of infested duckweed root in (ip and op)

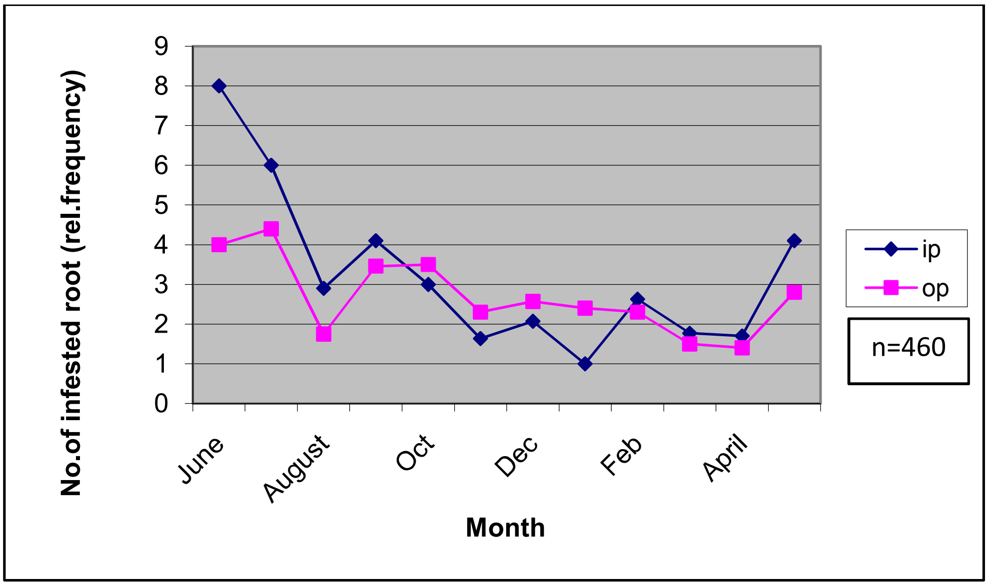

Fig.27. No of infested duckweed root in (ip and op) (n=460)

Average Number of infested roots was higher in June- September, and lower in November-January in Ip. In op, infested roots were higher in October- January and lower in June –September. (fig .27)

No. of non infested duckweed root in (ip and op)

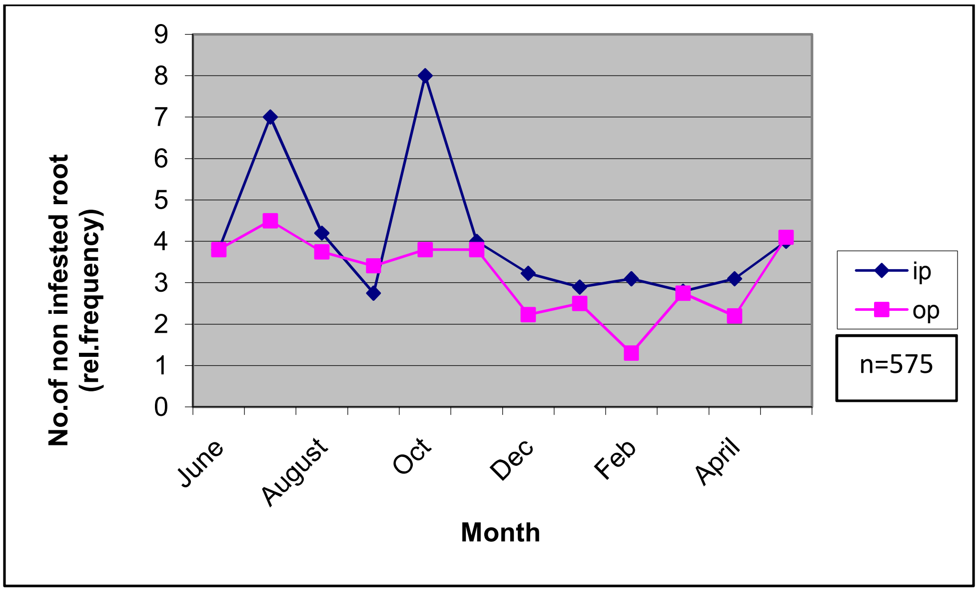

Fig .28.No.of non infested root in (Ip and Op).(n=575)

Average no. of fresh duckweed root was higher in Ip than Op.(fig.28)

6.4.3 Infestation rate

Level of infestation (in fresh duckweed fronds)

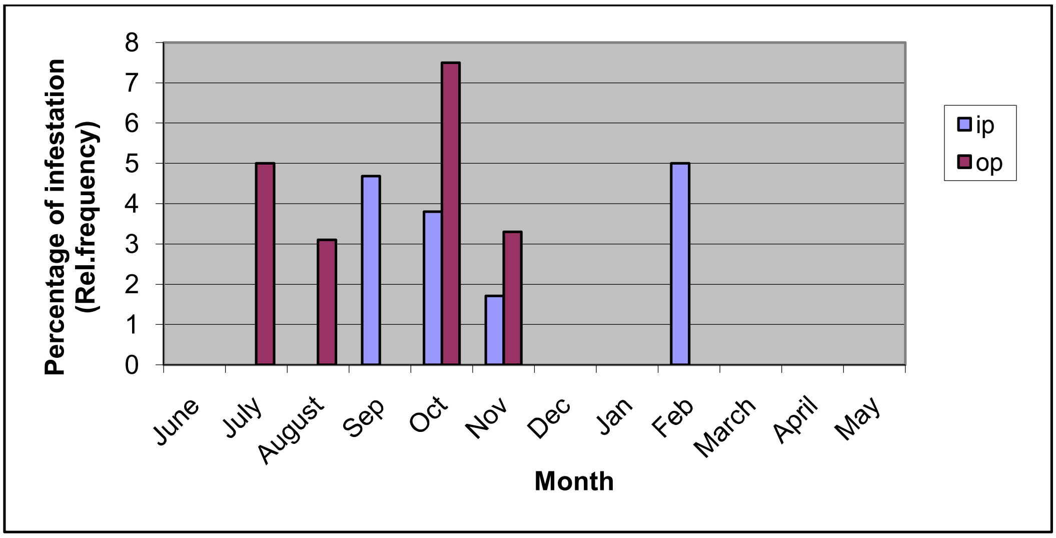

Fig.29. Percentage of infestation in the case of fresh duckweed fronds in Ip and Op

In the case of fresh duckweed fronds percentage of infestation were low in IP than the OP.

Level of infestation (infested duckweed fronds)

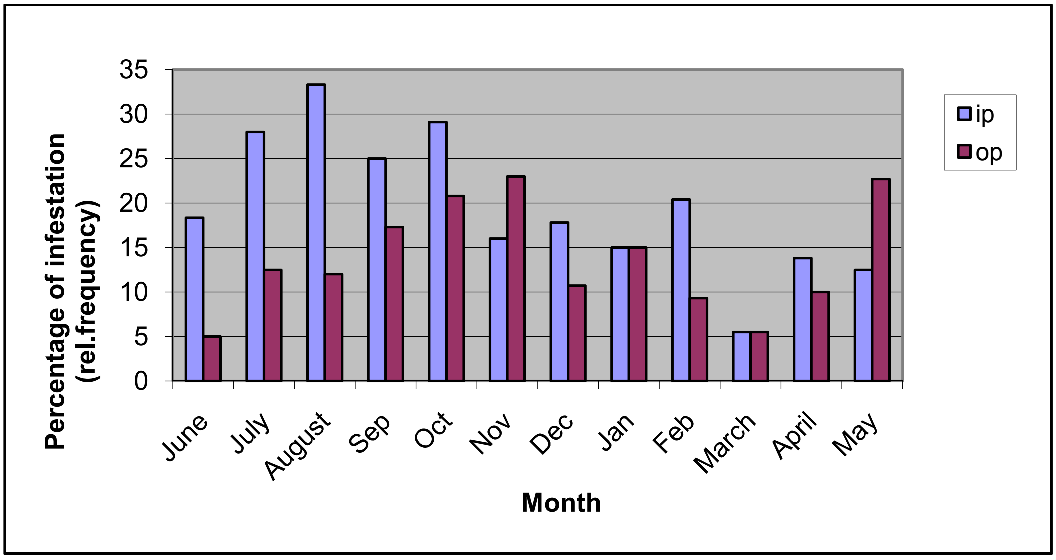

Fig. 30. Percentage of infestation in (infested fronds) in ip and op.

Percentages of infestation (in infested fronds) were higher in IP than the OP. The other reason of the higher infestation may be the use of insecticide for pest control, and the uses of inorganic fertilizer for duckweed nutrition.

Level of infestation (in non infested duckweed root)

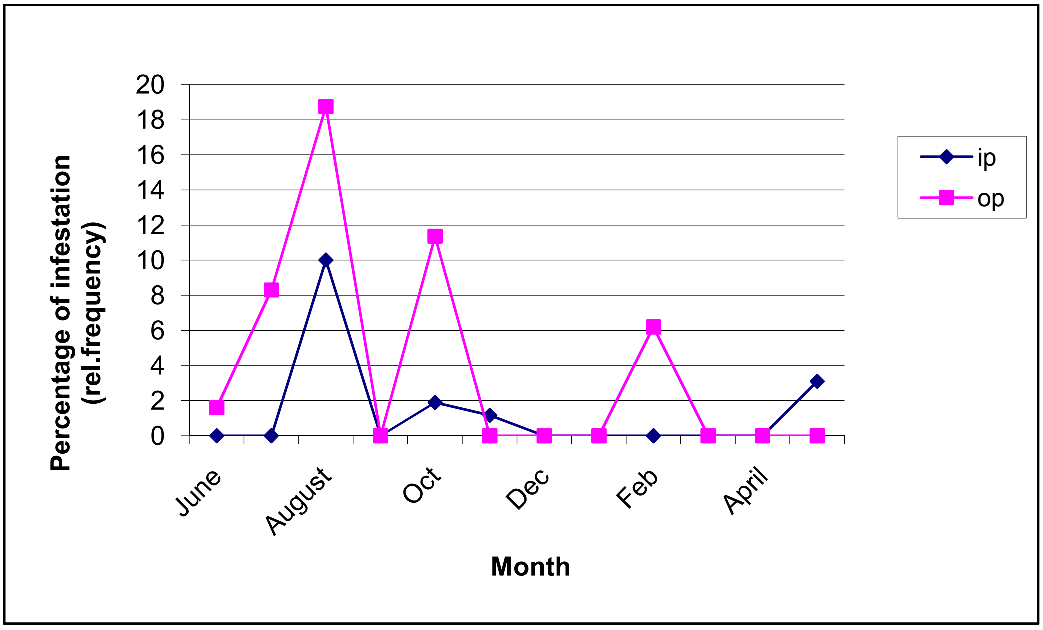

Fig.31. Level of infestation in fresh duckweed root in Ip and Op

In the case of fresh root percentages of infestation were higher in Organic pond than the Inorganic pond.(fig.31)

Level of infestation (in duckweed infested root)

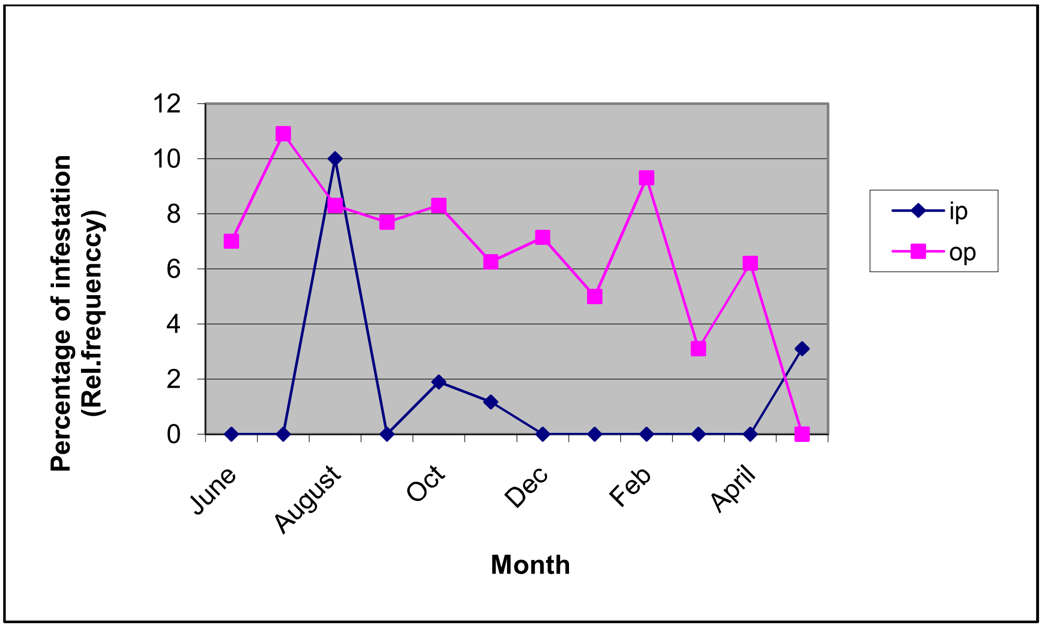

Fig.32. Level of infestation in Duckweed infested root in Ip and Op.

Percentages of infestation (in the case of infested root) were also higher in OP than the IP. Another reason of higher root infestation of organic pond was presence of heavy metal in hospital waste materials that they absorb. (fig 32)

Relation between infested fronds and infested roots in Inorganic pond

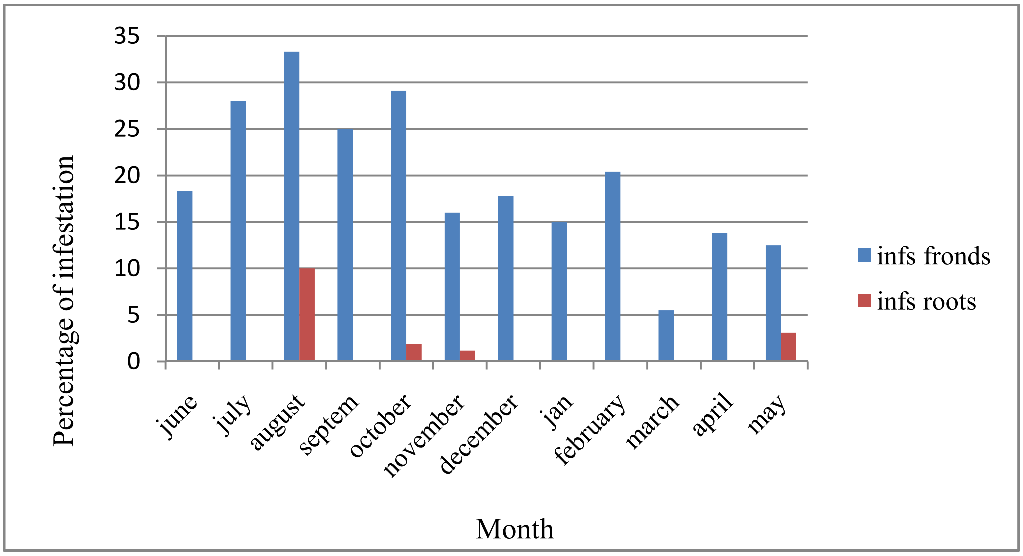

Fig.33..Relation between infested fronds and infested roots in Ip.

The comparison between infested fronds with infested roots in IP, it was established that fronds infestation were more vulnerable than the root infestation As the pyralid insects mostly attacked the fronds, and stopped the multiplication of the fronds development, for this reason pyralid attain its key pest status in duckweed growth.(fig33).

Relation between infested fronds and infested roots in organic pond

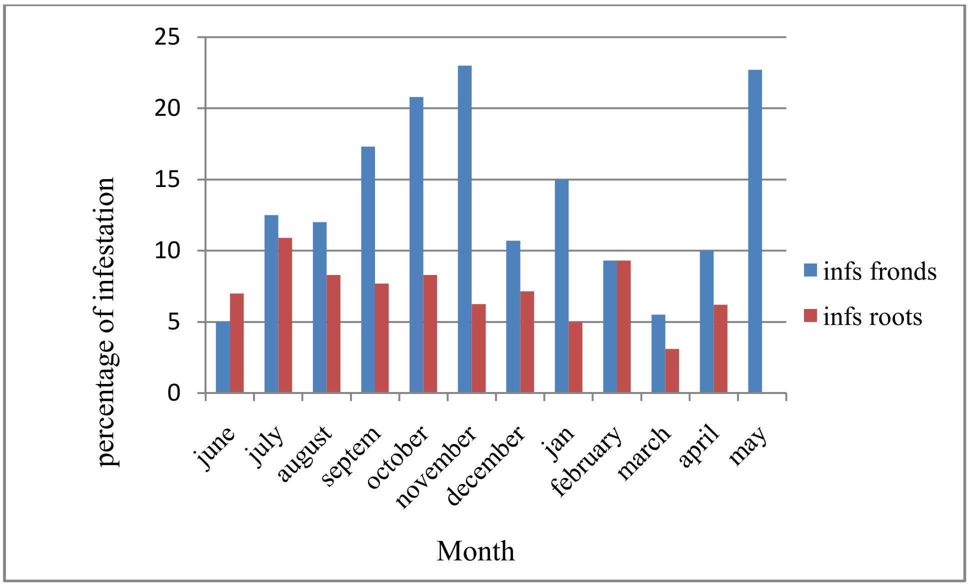

Fig.34.Relation between infested fronds and infested roots in Op.

The comparison between infested fronds with infested roots in op ,it was observed that fronds infestation were high round the year, it may have the various reason due to pyralid/aphid infestation, bacterial/fungal infestation etc, but in the case of root infestation it was significantly higher than Ip, as it absorb the organic hospital waste materials by their root.(fig 34)

6.4.4 Statistical analysis

In Statistical analysis, correlation result between infested fronds and infested root In Inorganic pond was 0.507904 (Moderately positive Correlations exist between them).

On the other hand, correlation result between infested fronds and infested root in Organic pond was -0.22145 (Weak negative correlation exist between them)

All these statistical analysis was performed by SPSS for windows (version 16)

6.5 Discussion:

From our experimental result we observe, Number of fronds and fresh duckweed were higher in OP, as the duckweed use hospital waste for their nutrition and growth and as they were less infected by pyralid insect.

Larval development varies in different reason but the infested fronds developments were stopped but the larvae always maintain the balance of their food and shelter. So they don’t destroy or damage all of the fronds.

In the case of infested fronds percentage of infestation were higher in IP, as in IP, they use insecticide for pest control and use of inorganic fertilizer for duckweed nutrition.

The comparison between infested fronds with infested roots in IP, it was clear that fronds infestation were more serious and vast than the root infestation as the pyralid mostly attacked the fronds and stopped their multiplication.

In Op fronds infestation were present more or less round the year, but the roots infestation were significantly higher as it absorb hospital waste materials by their roots (Bashar *et al.* 2007)

According to (Michal *et al*. 1989) they show that herbivorous insects affect plant performance. It is an entirely different matter to demonstrate that insect herbivory affects plant population dynamics.

Sophora pyralid moth, the larvae are voracious feeders and prefer tender young leaves. However they will eat tougher old leaves and stems if necessary. Damage can initially be observed as small tracks and pin-sized holes made by the newly hatched caterpillars with increased damage to the edges of the leaves due to the feeding of the larger larvae.

In angiosperms, flower loss attributable to insect attack ranges from less than 10% to almost 100%. For example, 80% of the bushes of the composite shrub *Guteirrezia microcephala* that were heavily attacked by the grasshopper *Hesperotettix viridis* failed to produce any flowers at all. (Parker, 1985).

Angiosperms also lose many of their undispersed seeds to insect herbivores. Sucking insects such as aphids can greatly reduce the rate of fruit filling and can sometimes curtail fruit production altogether. (Sheppard, 1987) sprayed the umbel rays of *Heracleum sphondylium* to exclude hogweed aphid, Carvariella Pastinacae and found that seed production and seed size both increased substantially. On the most heavily infested umbels there was no seed production at all.

Some insects cause such inconspicuous damage that assessment and attribution of seeds lossess is remarkably difficult. Heteroptera such as *Lygas*. can cause seed losses of more than 50% in umbelliferous vegetable crops such as carrot, celery, dill, parsley by killing the embryo without disturbing other parts of the seed (Flemion, 1958).

Plant growth rate, plant shapes and the allocation of resources do seed productions are all influenced to a greater or lesser extent by insect herbivory. Even relatively low levels of insect herbivory can, if sustained have a significant effect on the growth of young trees (Warrington, 1985).

CHAPTER-7
LOSS ASSESSMENT OF DUCKWEED GROWTH DUE TO PYRALID INSECT

Chapter-7

Loss Assessment of Duckweed growth due to Pyralid insect.

7.1 Introduction

In the widest sense a pest is an insect that causes harm to humans, their livestock, crops or possessions. The key word is 'harm' and it interpreted as 'damage' which of course, can often be measured. Moreover, damage can usually be equated to economic loss in term of actual money. Harm at its lowest level of interpretation includes nuisance and disturbance (Dennis S. Hill, 1997).

Pest status is given when the insect causes a particular level of damage, but the designation really only applies to that particular insect population on that host at that time. On other host or at a lower population level, the insect might well not be on pest status.

The basic economic importance of pest insects, there are two main ways in which insects become pests, these are as a result of ecological and also economic changes.

There are three main aspects on importance, and these are as follows-

1. The size and state of the pest population.
2. The nature of damage done by the pest.
3. The value of the damage done as assessed by human society.

Loss Assessment

Insect pest infestation can be assessed with some level of accuracy. With a crop in the field it is difficult to estimate the expected yield loss, but a damage assessment can be made and the size of the insect population causing the damage can be determined. The assessment sequence would be:

- Insect pest population
- Damage assessment

Many insect populations however, do cause damage of some significance, but the correlation between pest population size, damage levels, and expected reduction of crop yields is not straight forward. The total number of factors interacting to determine crop yield is large and the effect of single factor (Such as pest population size) is clearly difficult to determine. Many agricultural research stations in different parts of the world have specialized in those crops particularly suited to local environmental conditions, the result is an accumulation of empirical data which helps up to generalize about pest populations and their probable effect on crop yield.

The two main aspects of infestation to be assessed are the incidence and the severity. Pest incidence is the proportion of pest in infected to pest-free plants in a sample (or diseased to healthy). The severity of the infestation is a measure of the size of the pest population on the plants, or the extent of the damage, it is usually measured as so many insects per plants, or so many egg masses per fruit. The severity of a disease is usually measured as the proportion of a plant or plant organ which shows disease symptoms.

The U. K. 'Biological Sites Recording Scheme' advocates the use of four abundance categories for population size assessment, without using lengthy and detailed sampling procedures and is appropriate for use in assessing field populations of insect pests on crops. The categories of abundance are:

Abundant (a) = Very common (VC)

Frequent (f) = Common (C)

Occasional (O)= Uncommon (U)

Rare (r)= Rare (R)

The extent of crop damage is usually proportional to the numbers of insect pests, and would accordingly be rated thus:

6 } Very severe (VS)
5 }

4 Severe (S)

3 Mild (M)

2 } Very mild (VM)
1 }

Presumably 'very mild' damage would be in the injury category of Bardner and Fletcher (1974) and would be detectable but not of any economic importance, where as 'mild' damage would probably be just above the 'Economic Injury level'. Because of the tremendous range of types of pest damage and also the number of factors involved in crop production.

7.2 Objectives

- To examine pest and pest status.
- Impact of larval/pupal cases on the duckweed productivity.
- Loss assessment of duckweed growth in fronds and roots.

7.3 Materials and Methods

Different types of equipment were used to conduct the experiment. These are as follows:

1. Twelve earthen containers (18×18×10cm)
2. Sampling iron net quadrant (12cm×12cm)
3. Duckweed sampling spoon (9×9cm^2)
4. 36 cork sheets (32×32cm^2) one inch central hole
5. Knife/Anticutter
6. 4 large plastic bottle (2.5 litre)
7. Stereo-SKT microscope
8. Medium Petridis (11cm×11cm)
9. Brushes
10. Needle
11. Mosquito nylon net
12. Thick Thread
13. Pencil and Sign pen
14. Gallon (5 liter) were used for conducting the experiment of loss assessment of Duckweed growth

7.3.1 Study area

In Mirzapur Kumudini Hospital Complex in Mirzapur Demo farm, two types of ponds were selected for sample collection. The sample collections were made for examination of infestation intensity of Duckweed. The examination were carried out in two different ponds as

a) In inorganic pond where inorganic chemical fertilizer where used for duckweed nutrition.

b) Organic pond where hospital waste materials were used as nutrition for duckweed.

7.3.2 Study Period

Loss estimation of duckweed productivity was conducting from 12-15th march 2007 at the ponds of Mirzapur Kumudini Hospital Complex as well as Environmental Biology and Biodiversity lab (EBBL). Department of Zoology, University of Dhaka.

7.3.3 Sample Collection

Samples of duckweed were collected from both the ponds separately by a duckweed colleting metallic sieve (12cm×12cm)

7.3.4 Sample Preservation

The collected samples were taken to the Environmental Biology and Biodiversity Laboratory (EBBL), Department of Zoology, University of Dhaka for further study. The samples were preserved in the suitable environment in earthen container placing them in front of the window.

7.3.5 Duckweed culture in earthen pot

Twelve earthen pots were used for conducting the experiment (18×18×10cm). Cork Sheet ($5\times5cm^3$) were placed in mud container to hold three replicates in a pot separately. Six earthen pots with mud of inorganic pond and another six earthen pots with organic pond were taken for conducting experiment. Previously pond water with mud was collected in plastic container and gallon from the selected two ponds. The duckweed infestation rate by the pyralid larvae were categorized as O%, 25% 50% and 75%. To assess the infestation rate, infested fronds were divided into four sections; when one section was infested termed as 25% infestation. When two sections were infested termed as 50% infestation and lastly when three sections were infested termed as 75% infestation.(fig 35)

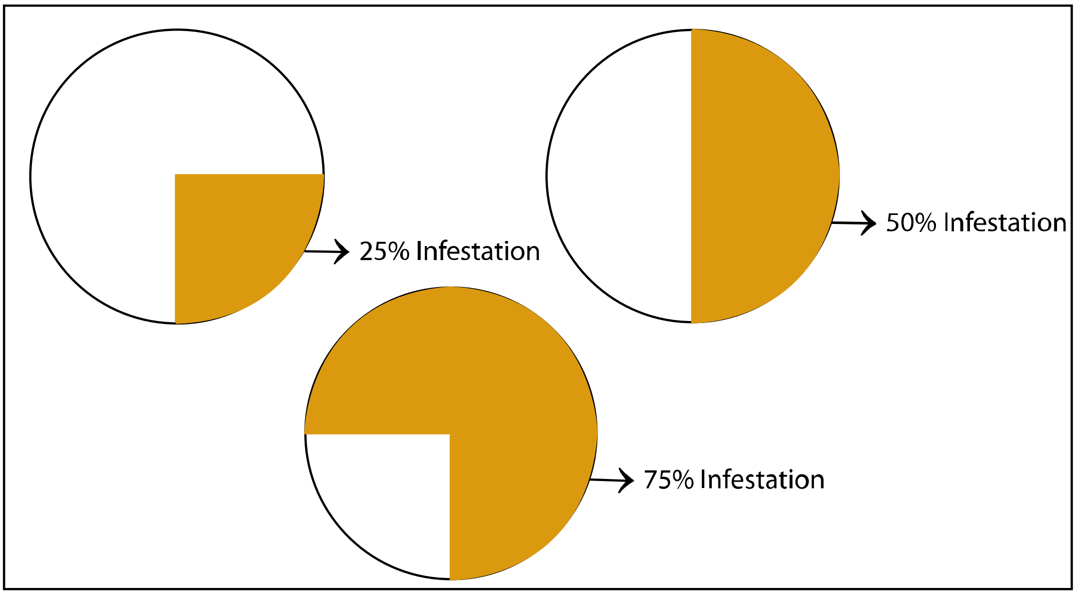

Fig. 35. Fronds Infestation in Percentage

Three replicates in three separate cork sheets were used for each category. Impact of the larval and pupal case making process was also observed in this experiment.

Plate 84. Duckweed growth in a earthen pot with a separate cork sheet.

Plate 85.The rate of infestation observed in earthen pot in the laboratory.

Plate 86. Twelve earthen pots were used for conducting this experiment.

7.4 Result

7.4.1 Loss estimation of duckweed productivity by pyralid insect pest

Pyralid insect (*S occidentals)* it causes the great damage on duckweed productivity. It attacks and destroys the duckweed completely; as a result the duckweed fronds cannot multiply and finally impede the duckweed production.

Infestation rate	Replicant No.	Fronds development (lengthx width) mm of Inorganic pond				Growth%	Remarks
		1st day	2nd day	3rd day	4th day		
0%	1	103	134	120	124	22.2%	
	2	89	119	124	124		
	3	95	106	106	103		
	Total	287	359	350	351		
	Average	95.67	119.67	116.67	117		
25%	1	163	190	167	203	33.15%	
	2	110	142	147	154		
	3	95	109	131	133		
	Total	368	441	445	490		
	Average	122.6	147	148.3	163.3		
50%	1	116	131	129	116	15.17%	
	2	153	225	216	232		
	3	133	131	115	115		
	Total	402	487	460	463		
	Average	134	162.3	153.3	154.3		
75%	1	114	149	150	151	25.79%	
	2	92	96	96	96		
	3	77	114	110	109		
	Total	283	359	356	356		
	Average	94.3	119.6	118.6	118.6		

Table 4. Loss assessment of Duckweed productivity by *S.occidentalis* in Inorganic pond

7.4.2. In Inorganic pond

Duckweed growth in the Inorganic ponds were 22.2%, 33.15%, 15.17%, 25.79% against in 0, 25, 50 and 75 percent infestations respectively by the *S occidentalis* on four consecutive days.(see table 4) At 0% infestation, the average of duckweed frond development on four consecutive days were 95.67, 119.67, 116.67, 117 mm2 and the percentage of growth were 22.2% at 25% infestation, the average were 122.6, 147, 148.3, 163.3 mm^2 on the respective four days and the percentage of growth were 33.15%, 50% infestation the average were134,162.3,153.3,154.3 mm2 on the respective four days and the percentage of growth were 15.17%,at 75% infestation, the average value were, 94.3, 119.6, 118.6, 118.6 mm^2 and the percentage of growth were 25.79%. The growth rates increased from the 0% infestation, and 25% infestation, but in the 50% and 75% infestation the growth percentage were decreased. (Table 4)

Infestation rate	Replicant No.	Fronds development (length x width) mm of organic pond				Growth %	Remarks
		1st day	2nd day	3rd day	4th day		
0%	1	134	125	114	146	24.12%	
	2	85	108	128	141		
	3	125	153	150	140		
	Total	344	386	392	427		
	Average	114.6	128.6	130.6	142.3		
25%	1	76	88	88	88	24.73%	
	2	54	76	77	77		
	3	60	62	68	72		
	Total	190	226	233	237		
	Average	63.3	75.3	77.6	79		
50%	1	112	120	123	116	17.2%	
	2	125	133	152	151		
	3	94	124	125	121		
	Total	331	377	400	388		
	Average	110.3	125.6	133.3	129.3		
75%	1	57	59	78	78	2.19%	
	2	74	74	74	74		
	3	51	51	52	34		
	Total	182	184	204	186		
	Average	60.6	61.3	68	62		

Table 5. Loss assessment of Duckweed productivity by *S.occidentalis* in Organic pond

7.4.3. In Organic pond

The percentage of growth of the duckweed in organic pond were 24.12% 24.73%, 17.2% and 2.19% against 0, 25, 50 and 70 percent infestations respectively by the pyralid moth *S occidentals* on four consecutive days. (see table 5)

At 0% infestation the average of duckweed frond development on four consecutive days were 114.6, 128.6, 130.6, 142.3mm^2 and the percentage of growth were 24.12%. at 25 percent infestation, the average were 63.3, 75.3, 77.6, 79.mm^2 on the respective four days and the percentage of growth were 24.73%; at 50 percent infestation, the average were 110.3, 125.6, 133.3, 129.3mm^2 on the respective four days and the percentage of growth were 17.2%, at 75 percent infestation, the average value were 60.6, 61.3 68 and 62 mm^2 and the percentage of growth was 2.19%. The growth rates increased in 0% and 25% infestation, but in the 50% and 75% infestation the growth percentage were decrease.(See table 5)

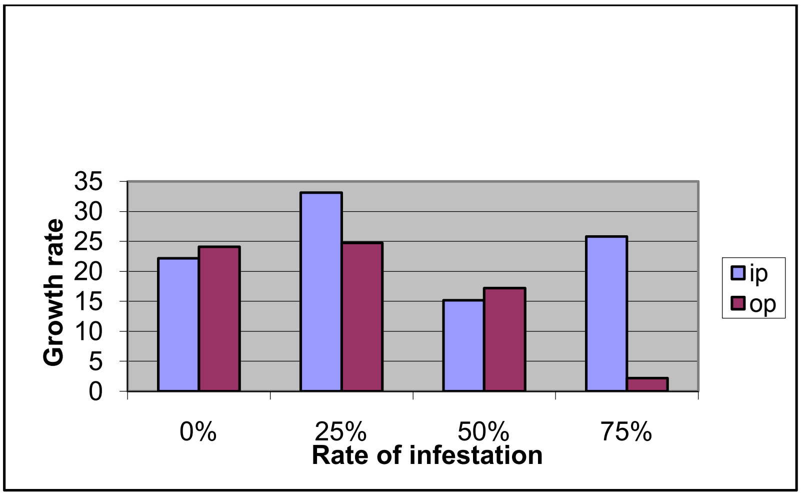

Fig. 36. Comparison of loss assessment of duckweed productivity by pyralid insect in Ip and Op

In both inorganic and organic ponds growth rates of duckweed were hampered due to infestation of pyralid insects.50%,and 75% infestation rates reduced the production rate of duckweed.(fig 36)

7.4.4 Impact of larval and pupal cages on the duckweed productivity

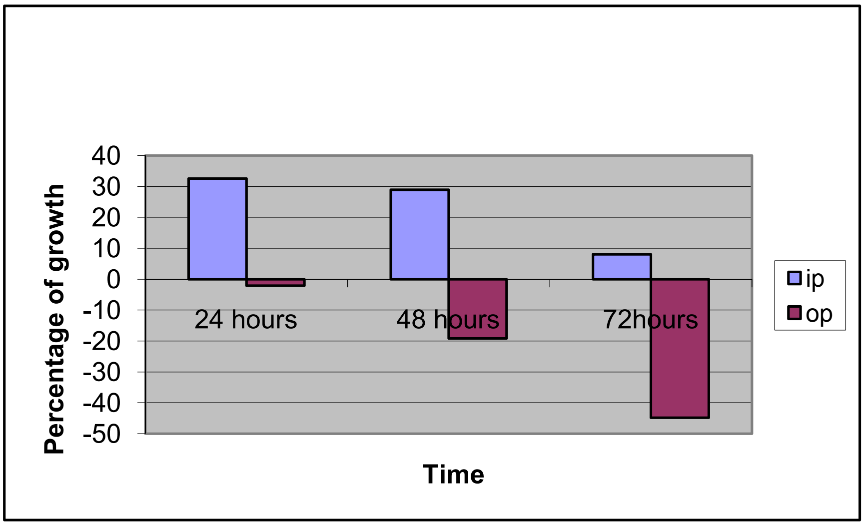

Fig. 37. Comparison of infestation by pyralid larval cages on duckweed productivity in Ip and Op.

Larval cage making process had the great effect on duckweed productivity in Ip and op. After 24 hours it was 32.54%, after 48 hours it was 28.93% and after 72 hours it decreased the growth that was 8.05% in ip. In op it was in negative growth -2.07%,-19.14%, and -44.28% growths respectively.(fig 37)

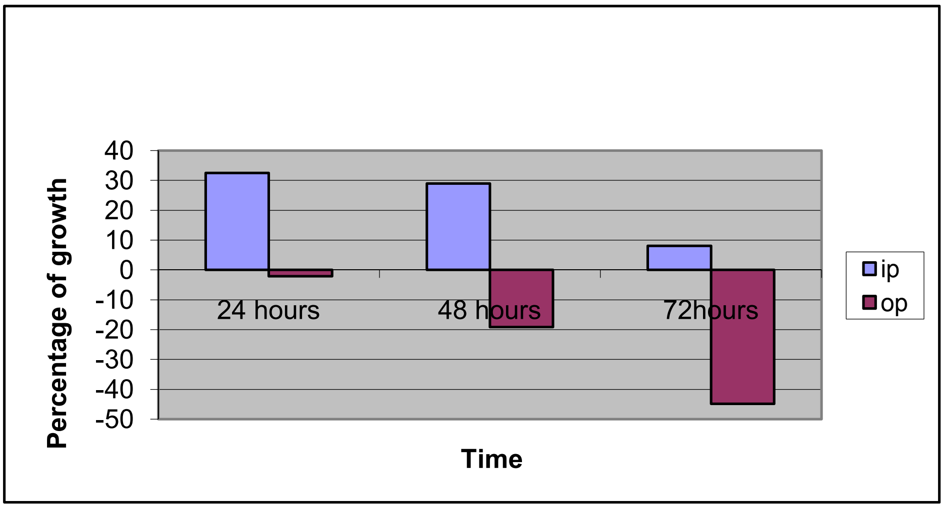

Fig.38. Comparison of infestation by pyralid pupal cages on duckweed productivity in Ip and Op.

Pupal cage making process had also great effect on duckweed productivity in Ip and op. After 24 hours it was negative growth -7.81%,after 48 hours it was -11.78% and after 72 hours it decreased the growth that was -19.95% in ip. In op it was also negative growth - 1.41%,- 1.14%,and -5.63% growths respectively.(fig 38)

7.4.5 Statistical analysis

In T-test result in earthen container there was enough difference in mean value of Ip and Op in each case. (see Appendix 30,31) but this difference was not significant.

In 0% infestation p value was=.0777

25% infestation P value was=.383

50% infestation P value was=.826

75% infestation P value was=.342

All this statistical analysis was performed by spss (version 16)

7.5 Discussion

The loss suffered by a crop is a function of the pest population, behavior of the pest and the crop plants. Damage to the plant occurs because of the effect of injury by the insect. A simple damage to the plants by an insect may or may not lead to crop loss. The reduction in quantity quality of the produce is the crop loss. The loss in quality may affect the appearance of the crop produce, its nutritive value or it may result in the produce being rendered unfit for use.

Insect pests damage crop plants either by feeding or during the process of oviposition. Some of the insect pest species are host specific and they feed on plants of a single species and are termed *monophagous.* Others attack plant species belonging to the same family and are known as *oligophagous.* Others are capable of infesting plant species belonging to several diverse families and are called *polyphagous*. .(Atwal *et al.* 1999)

The amount of damage caused by insect pests of crop plants is a function of the pest population its characteristics of feeding or oviposition behavior and the biological characteristics of the host plants. Each of these factors is affected differently by the environmental factors, both biotic and abiotic. It is, sometimes, rather difficult to establish correlations between the levels of pest population and plant damage. The estimation of damage is, however, critical to pest management.

The growth of duckweed was highly affected by pyralid pest attack and it causes a great damage on its productivity both in the inorganic and organic pond, except in 25% infestation, where an increase tendency of duckweed growth was observed, but in 50% and 75%, infestation the growth was decreased. Larval and pupal case making process had an impact on duckweed productivity. In both cases with the infestation of pyralid insects the number of duckweed fronds was reduced in case making process.

In this present study it was found that infestation of pyralid insects' lossess the duckweed production in both inorganic and organic ponds. According to Bashar and Aslam (1998), *S occidentalis* caused a continuous economic injury in the duckweed production farms of Bangladesh. The insect was treated as a key pest for the duckweed (*Spirodela* sp.) population in minipond ecosystem. This insect attained its pest status at a larval stage. The larvae of different instars make case with duckweed fronds and roots and the larva of final instars constructs case for the pupa. Both the larval and pupal cases making are the key technical stages for bringing the insect to its pest status. Both larval and pupal cased fronds failed to multiply and ultimately die. It causes a great loss on duckweed productivity as it was high it may double within twenty four hours.

CHAPTER-08
SOCIO-ECONOMIC IMPORTANCE OF THE RESEARCH WORK

CHAPTER-08
SOCIO-ECONOMIC IMPORTANCE OF THE RESEARCH WORK

8.1 Introduction

The global developmental activities are adversely affecting the ecological balance of nature that touches every living being in the planet. To maintain the ecological balance we have to look into this intricate problem from a holistic point of view. Bio-resources are considered as 'economic goods and services that nature provides.'

From this holistic perspective all living organisms (Plants, animals and microbes get the status of 'Bio-resources').

Duckweed is a tiny aquatic plant with enormous potential both for animals and environment. In recent years a commonly occurring aquatic plant 'duckweed' has become prominent, because of its ability to concentrate minerals from polluted water that arising from sewage treatment facilities. However, it is high potential as a food resource for live stock (Skillicorn *et al.,* 1993 and Lang *et al.* 1994). Duckweed grows on water with relatively high levels of N,.P,K and concentrates the minerals. Its lucrative role is recognized in the synthesis of protein.

In Bangladesh, pond ecosystems, duckweed productivity has been studied in view to have its sustainable production and supply for fish, poultry feed and for water treatment (Journey *et al.* 2001). Pond ecosystem of Bangladesh occupied about 4.46% of the total fresh water habirar (Ameen *et al.* 1986 and Zaman *et al*. 1993). Various types of pollutants recently have threatened the environment of Bangladesh. Pollutants originating from sewage industrial effluents, artificial fertilizer and pesticides use (Tahmida *et al*. 1996). Duckweed is used as an agent for water pollution control and wastewater management (Harvey and Fox 1973). This has been an increasing realization of the importance of the role of trace metals in human food. When duckweed in cultured, the nutrients and trace minerals are removed from it. In recent year this has been a growing concern over the increase in heavy metals contamination affecting the terrestrial and aquatic environments and ultimately their biological affect on man (Hares 2000). The long term accumulation of chemicals introduced into surface water after results in toxic concentration of chemicals in sediments.

Spirodella polyrhiza (Lemnaceac: duckweeds) is common duckweed sp. in Bangladesh and grow in pond. ditches, drain etc where organic wastes are abundant. PRISM (Project of Rural. Agriculture Industries, Science and Medicine) at Mirzapur, under the district of Tangail in Bangladeshi maintains the cultures of the duckweed (*Spirodella sp)* since 1990.

The productions of duckweeds are highly hampered due to infestation of insect pests (Bashar 1997), Bashar and Aslam 1998; Talekar *et al*. 1991; Pats and Ekbom 1992 and Labatte and Gol 1993. Bashar (1997) has found that both aphids and Pyralid larvae are the key posts for causing stagnancy in the duckweed productivity. According to him without managing the pest population so colossal ness in the production of duckweed is not possible. Giving importance of our previous findings the present work programme has been undertaken.

We are now to examine the constraint factors for duckweed productivity on some point to evaluate the pest productivity relations and cost affectivity, the pest management approaches and their applications for duckweed stable production, the key pest identification and the nature of injury, the life cycle of the key pest and the association with duckweed, factors responsible for duckweed productivity depletion, use of duckweed as fish and poultry feed and toxic metals absorption and bio-accumulation propose of duckweed productivity for sound environment.

The adoption procedure has been taken in the state to be practiced under following objectives.

- To bring the duckweeds from the status of 'weeds' to the status of bio-resources.
- To make duckweed as wealth for rural area.
- To encourage duckweed productivity in pond ecosystem
- To find out the constraint-factor of duckweed productivity.
- To bring the productivity and management system within the capability and captivity of the rural people.
- To popularize the duckweed production both for the economic and environmental benefit.
- To provide employment opportunity to the literate and illiterate manpower.

- To make small industries based on duckweed.
- Innovation of different tools for the Dckweed farming in minipond ecosystems.

8.2 Economic Importance of Duckweed

Plate 87. Duckweed used as fish feed within the frame of bamboo stick.

Plate 88. Harvested duckweed in the bamboo basket.

Plate 89. Harvested duckweed was supplying in the bamboo frame as fish feed.

UTILIZATION IN FISH CULTURE

Plate 90. Different types of fishes in the fishing net

Plate 91. Fishermen were catching fishes

Plate 92. Fishermen were collecting fishes

Plate 93. Collected fishes for sale

UTILIZATION AS POULTRY FEED

Plate 94. Collecting eggs from Nursery room of poultry

DUCKWEED PROCESSING SYSTEM

Plate 95. Series of duckweed drying tray of drying machine.

plate 96 .Front side of duckweed drying machine.

Plate 97. Back side of duckweed drying machine

Plate 98. Drying duckweed kept in the polythene large bags.

Plate 99. Duckweed bags were stored on the bamboo platform.

POULTRY FEED PROCESSING SYSTEM

Plate 100. Corn dust is the essential element of the poultry feed

Plate 101. Powder of different ingredients of poultry feed

Plate 102. Grinding machine of different ingredient

Plate 103. Mixing machine of poultry feed.

8.3 Popularization of duckweed productivity in rural areas and sustainability in economy

Bio-resources are more important in present time, emphasis has been given on the less or harmful things to make them as useful and beneficial for humankind. The research to bring the duckweeds from the states of 'weeds' to 'wealth'. Now a day, duckweed is the most promising bio-resource for twenty first century. So, it is very important to inform everybody about the importance and usages of duckweeds for various proposes. Utilization of bio-resources is largely depending on the popularization. In Bangladesh, popularization of duckweeds can be made by spreading information effectively through the neighbors, relatives; local leaders, duckweed dealers, NGO workers. Upazila Agriculture Officers, members of district /Upazila administration, radio, television, newspapers, agricultural organization etc.

8.4 Processing, preservation and food production of duckweed for different animals

The use of duckweed as the economically potential biomass requires drying pelleting or powdering. This potentiality could take into practice by following the two methods as Solar drying method and Air blowing method.

8.4.1 Solar drying method

Harvested duckweeds are spread on the brick- built ground under the sunlight of the open sky. Scorching heat of sun makes the duckweed crisp and very light. Passive solar drying, spreading the fresh material on the bare ground, or on a grassy pasture, is the simplest form of post harvest processing. Dried duckweed is light,

8.4.2 Air blowing method

Two types of boxes are used for drying duckweed by air blowing method. Large box holds 5-6 shelves for spreading duckweed. There are three opening in the front lower portion of the large box for receiving air from the small box and most of the area of upper portion (under the roof) is open for pass the air from inside the large box. There are three openings also present in the front side of the small box. Three long black polythene rolls are connected with the opening of the boxes. Two fans are used in the small box for continuous air supply. Air passes from the small box to lower portion of the large box through black polythene and through the duckweed net shelves and come out into the opening of the upper portion of large box. Air absorbs the water from the duckweed in this way. After drying. Duckweeds are preserved in the airtight ploythene bag and put on the bamboo platform for long time preservation. This dried duckweed has been used to prepare for the animal feed. Duckweeds in the form of pellets or dried meal can be stored without difficulty for five or more years. Evidence suggested that weevils, mice. rats, does not attack it preferentially. Percentage of duckweeds and other ingredients have been varied for different stages of animals and animal-to-animal.

8.5 Marketing of duckweed

Further interesting approaches will be practiced to create duckweed- marketing. This has been envisaged to materialize in the local areas as it has been practicizing in Vietnam since a few years -ago. Undoubtedly a cash-flow from such a market would stimulate village people to clean up the huge number of polluted ponds for duckweed production, In this case duckweed collection centers (dealers/ whole sellers) may be established to either sell duckweed directly or after drying for fish, duck, poultry or even ruminants or to blend duckweeds for the use in compounded feed. For meeting up the above situation, Bangladesh spends a huge amount of money in importing the feed. To ensure the supply of duckweed feed at grass root level, assistance or co-operat.ion would be taken from block supervisors or NGO workers. Using methods of the feed would be demonstrated to the local people for proper utilization. Under the sub heading following works will be conducted by following the methods of Skillcorn *et al.* 1993.

1. Use different methods to process duckweeds
2. Make different feed for fish, shrimp, prawn, poultry, and livestock
3. Use different system for marketing of duckweeds.

8.6 Duckweeds and Bangladesh

Duckweeds in Bangladesh belong to different 5 genera: *Lemna, Spirodela*. *Wolffia.Wolffiella, Landoltia* of these *Spirodela* is the largest and *Wolffiella* is the smallest. The plant body consists of green dorso-ventral scale-like shoots. The plants do not posses leaves and the flat green shoot performs the function of leaf. One (as in *Lemna*) or several (as in *Spirodela*) adventitious roots come out from the ventral surface of the flattened stem. The apex of each root is converted by a few layered sheath (root cap), which is visible to the unaided eyes. The roots are not found in *Wolffia.*

Propagation is mostly vegetative through the budding of daughter fronds out of reproductive pouches or cavities. Under normal growth conditions the fronds live for no more than a few weeks. Flowering and fruiting are rare in most species. When condition is ideal, in terms of water temperatures, PH. incident light and nutrient concentrations they complete in terms of biomass production, with the most rigorous photosynthetic terrestrial plants doubling their biomass in between 16 hours and 2 days, depending on condition. There are commonly found in still or sluggish water. The often form large floating mats in ponds, marshes, lakes and quiet stream. These ecosystems are very common in Bangladesh ecology as a whole.

Prior to 1989 duckweed had been used only in commercial applications to treat waste water in North America: In 1989 staff of a non-governmental organization based in Columbia, Maryland, The PRISM Group initiated a pilot project in Bangladesh to develop fanning systems for duckweed and to test its value as a fish feed.

Bangladesh could be genuinely termed the home of duckweed. Taking Bangladesh as an example, the organized production of duckweed could provide in sufficient quantities to replace at a minimum 80% of the protein meals required by the small poultry producer of a simple and economic system of collection/sun drying and marketing could be put in place. There are thousands of hectares of derelict ponds polluted to eutrophication levels in Bangladesh alone, that could potentially be cleaned of much of their pollutants and resurrected for duckweed aqua-culture and fish farming at the family farm level. In these systems the objectives would, be largely to provide -protein of high biological value for the families of small farmers, who often have no animal protein in their diets. A typical one hectare duckweed wastewater treatment plant will yield up to one metric ton of harvest will produce approximately 100 kg of fish, or 100 kg of dried high protein duckweed meal.

The Mirzapur- experimental programme in Bangladesh represents the first effort, to apply existing knowledge on duckweed growth and cultivation in developing a practical farming system. By closely tying a viable and efficient duckweed end-use (feeding-fish) to duckweed production, the Mirzapur experimental programme has shown that duckweed farming can be profitable.

The profitability of duckweed production is especially sensitive to two factore: (i) the cost of fertilizer and (2) the sale price of fresh duckweed. The projected rates of return of the Mirzapur experimental programme of Bangladesh on both investments (one hectare of duckweed-fed carp culture and 0.5 hectare of the unit of duckweed production) compare favorable with any alternative investments in the agricultural sector in Bangladesh.

In mini pond ecosystem of PRISM at Mirzapur in Tangail district the experiments of EBBL are going on. In the experiment plan both inorganic and organic ponds are selected. Urea, Murate of Potas arid T.SP are given in inorganicponds, in organic pond hospital garbage and sewage materials are mixed and used for the nutrition source.

This research work brings the duckweeds from the status "weeds" to the status "bio-resource", It makes the duckweed productivity sustainable in question of quality and protection. It. also brings the productivity and management system within the capability and captivity not only the rural people but also the poorest people of the society. This attempt popularizes the duckweed production both economically and environmentally. Sustainable duckweed production system will help us to build our economy particularly in the rural areas of the country. So, the proposed project will construct rural economy and social hopefulness among the lowest income group of Bangladesh villages.

By working on the subject of duckweed productivity and aquatic system in Bangladesh EBBL, has identified some important points to be dealt with,

1. Productivity possibility is high in Bangladesh for duckweeds.
2. There are some major factors that responsible for stunting the growth of duckweed. These have identified as the constraint factors.
3. It is possible to make duckweed productivity sustainable in Bangladesh for up-lifting rural economy.
4. .It is also feasible-to involve local people in the slogan of" duckweeds could be the wealth" in the environmental sound ways.

To meet the government policy (MDG)

Bioresource management and the involvement of rural people through poverty alleviation in environmental friendly way, findings of the work found to contribute in the policy making strategies of the government of Bangladesh.

This could help in the achievement of millennium development goals. Duckweed culture in our country is profitable for following reasons-

- It increases employment opportunity for educated and uneducated manpower specially the employment opportunity for female in the rural areas.
- Lowering of fish production costs by increased reliance on duckweed as cheap fish feed, reduction of expensive supplementary fish feed inputs, replacement of costly inorganic fertilizers by cheaper organic domestic waste and cow dung as nutrient sources used for duckweed production.
- Integration of duckweed production management and aquaculture strategy in existing farming systems.
- Utilization of the large areas of ponds or swamps those are presently eutrophic because of man's activities in the country.
- Development of small industries based on duckweed and marketing infrastructure for storage and preservation of fish to facilitate access of fish producers to the rural and urban markets.
- Cultivation of both duckweed and non-duckweed-eating fish species like climbing perch and silver carp, in the same pond.
- Only duckweed production (no fish production) in derelict pond of the village.
- The productivity and management system within the capability and captivity not only the rural people but also the poorest people of the society.
- Application of biological control of pyralid pest in the pond by using Anabas testudineus.

CHAPTER- 9
SUMMARY & CONCLUSION

Chapter- 9
Summary & Conclusion

9.1 Summary

Two biotic aspects (duckweed and pyralid) have been chosen in the present study to be used for clarify the (plant-insect) relationship and doing welfare of society and to prove them as eco friendly resources.

Duckweed is with high proteinous thalus plant body and is used as fish feed, poultry feed, and as organic manure. More over it is used in economic development by providing good access to nature conservation. Pyralid is the key pest of duckweed which has a great impact on duckweed productivity. By the attack of the insect, the duckweed growth becomes stagnant.

- We observed in the experiment, the duckweed biomass growth was doubled in eight days both in Inorganic and organic pond in field condition.

- In the life-cycle study of the insect it is revealed that the incubation period for hatching time varies from 4-7 days. Temperature has the great effect on egg hatch, larva and pupal development. The pyralid insect associated with the duckweed fronds for egg laying for the first time in its life-cycle stages, and then it starts and shows convenient to use duckweed as host plant. Developmental stage of pyralid insect was found directly dependent in the host plant (duckweed).This makes a vital association for permanent source supply food and shelter.

- In the experiment of abundance of larva/pupa and adult of the pyralid, we observed, larval/pupal abundance was more in Inorganic pond than the organic pond. In the organic pond, all the medical waste-waters were used as duckweeds nutritional supply. The nitrogenous fertilizers or compound found helpful in the growth of duckweed. Abundance of pyralid pest was found highly related with healthiness of duckweed productivity.

- The experiment of nature of injury on duckweed fronds and roots, we noticed that, number of fresh duckweed was higher in OP, as in this station duckweeds were less infected by the pyralid insect.

- In the case of infested fronds, percentage of infestation was higher in the IP, in IP, farmers use insecticide for pest control and also use inorganic fertilizer for duckweed nutrition supply.

- The comparison between infested fronds with infested roots in IP, it was found that fronds infestation was more serious and vast than the root infestation. The pyralid mostly attacked the fronds and stopped their multiplication. In OP, fronds infestation was not significant but the roots infestation was higher.

- In the case of loss assessment of the duckweeds growth due to pyralid insect, it is found that, the growth of duckweed was highly affected by pyralid pest attack and it causes a great damage on its productivity both in the Inorganic and Organic pond. Larval and pupal case making process had an impact on duckweed productivity. In both cases with the infestation of pyralid insects the numbers of duckweed fronds were reduced in case making attacks.

9.2 Conclusion:

The results obtained from experiment can play a significant role in aquatic ecosystem and in the development of the socio-economic condition of our rural people. Findings of the research may also be acted in poverty alleviation of Bangladesh, specially the employment opportunity for the local gender-issue in the rural area. This can be used as integration of duckweed production management and aquaculture strategy in existing farming systems. But it needs public awareness regarding the significance of duckweeds production and the pyralid-duckweed association in the aquatic ecosystem.

CHAPTER-10

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Chapter 10
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CHAPTER-11

APPENDIX

Chapter 11 Appendix 1 Raw Data on duckweed biomass growth in Inorganic pond

Trap no.	Time of Release			Time of Examination						Remarks
	Date	Time (A.M)	Duckweed mass(g)	Date	Time (P.M.)	Duckweed mass(g)	Duckweed Increase in Mass(g)	Average Duckweed increase	Percentage of increase	
1 2 3	8-9-07	10.30	20 (1st Day)	9-9-07 (2nd day) (24 hours)	1.00	25.10 27.10 26.10	5.1 7.1 6.1	6.1	30.5	Temparature = 32.6^{0}C Humidity = 36.2%
4 5 6	8-9-07	10.30	20	10-9-07 (3rd day) (48 hours)	2.00	26.30 27.50 25.30	6.3 7.5 5.3	6.3	31.5	
7 8 9	8-9-07	10.30	20	11-9-07 (4th day) (72 hours)	12.00	23.50 26.50 24.50	3.5 6.5 4.5	4.8	24	
10 11 12	8-9-07	10.30	20	12-9-07 (5th day) (96 hours)	3.00	25.60 27.30 24.30	5.6 7.3 4.30	5.7	28.5	
13 14 15	8-9-07	10.30	20	13-9-07 (6th day) (120 hours)	1.00	30.9 32.10 36.7	10.9 12.10 16.7	13.2	66	
16 17 18	8-9-07	10.30	20	14-9-07 (7th day) (144 hours)	1.00	24.6 27.6 29.3	4.6 7.6 9.3	7.1	35.5	
19 20 21	8-9-07	10.30	20	15-9-07 (8th day) (168 hours)	1.00	34.3 40.2 43.2	14.3 20.2 23.2	19.2	96	
22 23 24	8-9-07	10.30	20	16-9-07 (9th day) (192 hours)	4.00	44.55 59.8 65.9	24.5 39.8 45.9	36.73	183.65	

Appendix 2 Raw Data on duckweed biomass growth in Organic pond

Trap no.	Time of Release			Time of Examination						Remarks
	Date	Time (P.M)	Duckweed mass(g)	Date	Time (P.M.)	Duckweed mass(g)	Duckweed Increase in Mass(g)	Average Duckweed increase	Percentage of increase	
25	8-9-7	4.30	20	9-9-07	2.00	22.5	2.5	2.0	10	
26			(1st Day)	(2nd day)		20.9	.9			Temparature
27				(24 hours)		22.7	2.7			= 32.6^0C
28	8-9-7	4.30	20	10-9-07	3.00	25.1	5.1	4.7	23.5	
29				(3rd day)		23.8	3.8			Humidity
30				(48 hours)		25.4	5.4			= 36.2%
31	8-9-7	4.30	20	11-9-07	1.00	25.4	5.4	3.2	16	
32				(4th day)		21.9	1.9			
33				(72 hours)		22.3	2.3			
34	8-9-7	4.30	20	12-9-07	4.00	24.7	4.7	7.3	36.5	
35				(5th day)		27.5	7.5			
36				(96 hours)		29.7	9.7			
37	8-9-7	4.30	20	13-9-07	2.00	24	4	7.3	36.5	
38				(6th day)		30.3	10.3			
39				(120 hours)		27.7	7.7			
40	8-9-7	4.30	20	14-9-07	1.00	28.8	8.8	6.9	34.5	
41				(7th day)		28.1	8.1			
42				(144 hours)		23.8	3.8			
43	8-9-7	4.30	20	15-9-07	1.00	39.3	19.3	16.2	81	
44				(8th day)		36	16			
45				(168 hours)		33.5	13.3			
46	8-9-7	4.30	20	16-9-07	5.00	56.0	36	24.6	123	
47				(9th day)		31.6	11.6			
48				(192 hours)		46.2	26.2			

Appendix 3

Larval hatching time		
Month	Larval hatching time	Average time of larval hatching
Jan	5 days	Min-5 days
	7 days	Max-7 dayd
	7 days	Ave-6.5 days
	7 days	
April	5 days	Min-5
	6days	Max-6
	6days	ave-5.5 days
	5 days	
	3 days	Min-3
July	4 days	Max-6
	5 days	Ave-4.5 days
	6 days	
	5 days	Min-5
October	6 days	Max-6
	5 days	Ave-5.5 days
	5 days	

Appendix 4

Behavioral activity of the pyralid insect

Month /Year	Date	Alive	dead	Flying	Average	Resting	Average	Mating	Average	Male	Average	Female	Average
Jan'07	10.1.07							1		1		7	
	20.1.07			2		1		1		1		2	
	30.1.07			2	1.3	1	1	2	1	1	1	1	3.3
				4		2		4		3		10	
	G.total												
Feb'07	10.2.07			2		1		2		11		1	
	20.2,07			5	3.3	1	1	2	2	9	8.3	12	6
	28.2.07			3		1		2		5		6	
	G.total			**10**		**3**		**6**		**25**		**18**	
March'07	10.3.07			3	3	4	**3.3**	1	**2**	18	17.6	11	10.3
	20.3.07			3		3		2		20		10	
	30.3.07			3		3		2		15		10	
	G.total			**9**		**10**		**5**		**53**		**31**	
April'07	10.4.07			4		3		2		15		15	
	20.4.07			3	3.3	3	3	2	1.6	11	12	10	11.6
	30.4.07			3		3		1		10		10	

				10		**9**		**5**		**36**		**35**	
	G.total												
May'07	10.5.07			10		6		5		50		25	
	20.5.07			7	8.3	6	6	4	4	50	54.6	30	30
	30.5.07			8		6		3		64		35	
	G.total												
June'07	10.6.07			8		5		4		30		20	
	20.6.07			8	7.6	5	4.6	3	3.3	20	23.3	15	16.6
	30.6.07			7		4		3		20		15	
				23		**14**		**10**		**70**		**50**	
	G.total												
July'07	10.07.07			10		6		4		25		15	
	20.7.07			9	9	5	5	3	3.3	20	23.3	15	13.3
	30.7.07			8		4		3		25		10	
				27		**15**		**10**		**70**		**40**	
	G.total												
August'07	10.8.07			10		3		5		35		20	
	20.8.07			10	10	5	4.3	4	4.3	25	26.6	20	20
	30.8.07			10		5		4		20		20	
				30		**13**		**13**		**80**		**60**	
	G.total												

Septem'07	10.9.07			8		2		6		30		15	
	20.9.07			9	8.3	2	2.6	4	4.3	20	23.3	15	13.3
	30.9.07			8		4		3		20		10	
				25		**8**		**13**		**70**		**40**	
	G.total												
October'07	10.10.07			7		2		4		15		15	
	20.10.07			7	7	2	2	4	4	12	12.3	10	11
	30.10.07			7		2		4		10		10	
				21		**6**		**12**		**37**		**35**	
	G.total												
Novem'07	10.11.07			5		2		3		12		12	
	20.11.07			4	4.3	1	1.3	3	3	10	10.6	10	10
	30.11.07			4		1		3		10		8	
	G.total			**13**		**4**		**9**		**32**		**30**	
December'07	10.12.07			2		1		2		8		8	
	20.12.07			1	1.3	1	1	2	2	8	7	8	7
	30.12.07			1		1		2		5		6	
				4		**3**		**6**		**21**		**21**	
	G.total												

Appendix 5

Data on Larval Cases (IP)						
Date	**Length**	**Width**	**L M**	**W M**	**No. of Fronds**	**Average No. of Fronds**
8-5-06	20	8			10	
15-5-06	15	7			14	
22-5-06	14	5	15.5	6.5	7	11.75
29-5-06	13	6			8	
1-6-06	16	7			10	
8-6-06	18	6	13.75	6	12	9.25
15-6-06	11	6			8	
22-6-06	10	5			7	
1-7-06	14	7			12	
9-7-06	12	6	11.5	6.5	10	7.25
16-7-06	6	3			2	
23-7-06	14	10			5	
1-8-06	12	10			12	
8-8-06	11	7	12.6	6.2	5	7.4
15-8-06	8	3			4	
22-8-06	13	4			6	
29-8-06	19	7			10	

Data on Larval Cases (IP)						
Date	**Length**	**Width**	**L M**	**W M**	**No. of Fronds**	**Average No. of Fronds**
2-9-06	15	7			7	
9-9-06	15	6	13.75	6.25	8	7.75
16-9-06	10	5			7	
23-9-06	15	7			9	
1-10-06	13	5			10	
10-10-06	15	5	15.25	5.75	12	10.5
17-10-06	18	3			10	
24-10-06	15	10			10	
1-11-06	18	10			15	
8-11-06	19	7	19.75	8.5	8	11.25
15-11-06	22	8			12	
22-11-06	20	9			10	
1-12-06	16	7			9	
8-12-06	18	8	16.8	7	10	9.2
15-12-06	15	7			11	
19-12-06	19	8			9	
23-12-06	16	5			7	

Data on Larval cases (Ip)

Date	Length	Width	L M	W M	No. of Fronds	Average No. of Fronds
1-1-07	17	7			8	
9-1-07	12	8	14.75	7.5	10	9.25
16-1-07	19	9			11	
24-1-07	11	6			8	
1-2-07	14	5			7	
8-2-07	10	6	12	6	7	9
16-2-07	13	6			12	
24-2-07	11	7			10	
1-3-07	12	6			6	
8-3-07	10	6	10.25	6	8	6.25
16-3-07	9	4			4	
24-3-07	10	8			4	
1-4-07	15	6			9	
9-4-07	16	5	15.25	5.5	7	8.5
16-4-07	14	3			8	
24-4-07	16	8			10	

Appendix 6

Data on Larval Cases (OP)						
Date	Length	Width	L M	W M	No. of Fronds	Average No. of Fronds
8-5-06	15	9			15	
15-5-06	14	8	15.5	8	7	10.75
22-5-06	13	5			9	
29-5-06	20	10			12	
1-6-06	16	12			16	
8-6-06	14	7	16	9.5	8	12
15-6-06	16	11			16	
22-6-06	18	8			8	
1-7-06	13	7			14	
9-7-06	17	8	13.75	7.5	9	10
16-7-06	13	7			9	
23-7-06	12	8			8	
1-8-06	21	6			22	
8-8-06	15	10	15.8	8	13	13
15-8-06	14	10			12	
22-8-06	15	5			8	
29-8-06	14	9			10	

Data on Larval Cases (OP)						
Date	Length	Width	L M	W M	No. of Fronds	Average No. of Fronds
2-9-06	14	7			10	
9-9-06	14	10	14.75	8.25	9	
16-9-06	13	7			12	
23-9-06	18	9			12	
1-10-06	22	20			13	
10-10-06	7	6	15.75	13.5	7	13.25
17-10-06	20	16			20	
24-10-06	14	12			13	
1-11-06	12	9			11	
8-11-06	18	17	15.5	12.25	19	14.5
15-11-06	17	11			14	
22-11-06	15	12			14	
1-12-06	18	16			14	
8-12-06	12	12	13.2	11.4	10	11.8
15-12-06	16	10			9	
19-12-06	7	8			13	
23-12-06	13	11			13	

Data on Larval Cases (OP)						
Date	**Length**	**Width**	**L M**	**W M**	**No. of Fronds**	**Average No. of Fronds**
1-1-07	12	7			12	
9-1-07	12	5	12.25	7.75	10	9
16-1-07	10	12			6	
24-1-07	15	7			8	
1-2-07	18	10			10	
8-2-07	14	12	16.25	10.75	12	10
16-2-07	15	11			12	
24-2-07	18	10			11	
1-3-07	15	10			9	
8-3-07	17	11			8	
16-3-07	12	10			10	
24-3-07	18	12			13	
1-4-07	19	10			12	
9-4-07	20	15	16	12.75	12	11.5
16-4-07	12	12			10	
24-4-07	13	14			12	

Appendix 7

Data on pupal cases (Ip)						
Date	Length	Width	L M	W M	No. of Fronds	Average No. of Fronds
8-5-06	18	8			12	
15-5-06	13	11	14.5	7.5	12	
22-5-06	15	6			10	
29-5-06	12	5			6	
1-6-06	8	5			12	
8-6-06	15	4	11	5.5	8	10
15-6-06	8	4			12	
22-6-06	13	4			8	
1-7-06	14	10			10	
9-7-06	6	3	8.5	5.75	2	6
16-7-06	7	5			4	
23-7-06	7	5			8	
1-8-06	11	6			10	
8-8-06	17	10	13.6	8	9	7.4
15-8-06	13	8			6	
22-8-06	15	10			7	
29-8-06	12	6			5	

Data on pupal cases (Ip)						
Date	Length	Width	L M	W M	No. of Fronds	Average No. of Fronds
2-9-06	12	4			9	
9-9-06	10	5	11.25	4.5	9	9.75
16-9-06	15	6			15	
23-9-06	8	3			6	
1-10-06	11	5			6	
10-10-06	12	5	12.75	6.25	10	7.75
17-10-06	20	10			8	
24-10-06	8	5			7	
1-11-06	14	5			6	
8-11-06	19	10	17	8.75	8	6.2
15-11-06	15	10			6	
22-11-06	20	10			11	
1-12-06	11	4			8	
8-12-06	10	7	12	6	7	5.4
15-12-06	9	6			5	
19-12-06	10	8			4	
23-12-06	8	5			3	

Data on Pupal Cases (Ip)						
Date	**Length**	**Width**	**L M**	**W M**	**No. of Fronds**	**Average No. of Fronds**
1-1-07	12	5			6	
9-1-07	14	5	13.25	5.5	7	7
16-1-07	15	4			9	
24-1-07	12	8			6	
1-2-07	10	6			9	
8-2-07	9	5	9.25	5	6	7.25
16-2-07	8	4			4	
24-2-07	10	5			10	
1-3-07	12	6			9	
8-3-07	9	3	9.75	4.5	3	6.25
16-3-07	8	4			4	
24-3-07	10	5			9	
1-4-07	12	6			10	
9-4-07	10	5	9.75	4.75	9	8
16-4-07	9	4			6	
24-4-07	8	4			7	

Appendix 8

Data on pupal cases (Op)						
Date	Length	Width	L M	W M	No. of Fronds	Average No. of Fronds
8-5-06	18	10			12	
15-5-06	13	6	14.75	10	12	11.5
22-5-06	15	8			10	
29-5-06	13	16			12	
1-6-06	13	11			9	
8-6-06	11	5	10.75	6.25	12	8.25
15-6-06	9	4			6	
22-6-06	10	5			6	
1-7-06	13	8			7	
9-7-06	11	5	10.75	5.5	9	7
16-7-06	9	3			4	
23-7-06	10	6			8	
1-8-06	8	4			4	
8-8-06	11	5	13.75	6.25	9	7.8
15-8-06	12	7			11	
22-8-06	15	6			10	
29-8-06	7	3			5	

Data on pupal cases (Op)						
Date	Length	Width	L M	W M	No. of Fronds	Average No. of Fronds
2-9-06	19	10			13	
9-9-06	16	10	17.5	9.25	12	12
16-9-06	18	10			11	
23-9-06	17	7			12	
1-10-06	17	13			10	
10-10-06	7	4	14.5	9.75	3	8
17-10-06	16	12			8	
24-10-06	18	10			11	
1-11-06	17	9			8	
8-11-06	16	10	14.25	9.25	7	7.5
15-11-06	13	9			7	
22-11-06	11	9			8	
1-12-06	12	7			10	
8-12-06	10	5	11.5	6.25	9	9.75
15-12-06	11	4			8	
19-12-06	13	9			12	
23-12-06	12	5			10	

Data on Pupal Cases (Op)						
Date	**Length**	**Width**	**L M**	**W M**	**No. of Fronds**	**Average No. of Fronds**
1-1-07	11	8			9	
9-1-07	15	10	12	9	10	8.5
16-1-07	12	10			7	
24-1-07	10	8			8	
1-2-07	8	3			6	
8-2-07	7	4	10.25	7	4	7
16-2-07	14	10			10	
24-2-07	12	11			8	
1-3-07	11	9			9	
8-3-07	8	5	8	5.7	10	7
16-3-07	5	3			4	
24-3-07	8	6			5	
1-4-07	10	8			10	
9-4-07	11	10	12	9.75	6	9.75
16-4-07	15	11			13	
24-4-07	12	10			10	

Appendix 9

Adult abundance in station-1(in organic pond)									
	Month /Year	Date	Alive	dead	Flying	Resting	Mating	Total no	Average
	May'06	8.05.06	31	18	31			49	
		16.05.06	37	20				57	
		24.05.06	20	16				36	41.75
		31.05.06	15	10				25	
								167	
		G.total.							
	June'06	1.06.06	2	101				103	
		9.06.06	17	46				63	
		17.06.06	15	40				55	61
		25.06.06	1	22				23	
								244	
	July'06	3.07.06	10	85				95	
		11.07.06	12	119				31	
		19.07.06	5	87				88	61.5
		27.07.06	7	25				32	
								246	
	August'06	4.08.06	10	110				120	
		12.08.06	1	129				130	
		20.08.06	22	40				62	124.75
		28.08.06	12	175				187	
								499	
	Sep'06	6.09.06	5	40				45	
		14.09.06	7	45				52	48.25
		22.09.06	8	51				59	
		30.09.06	2	35				37	
								194	
	Oct'06	8.10.06	9	42	9			51	
		16.10.06	56	116	17			172	
		24.10.06	46	130	15			176	138.75

		31.10.06	36	120	17			156	
								555	
	Nov'06	1.11.06	5	70				75	
		9.11.06	4	113				117	
		19.11.06	4	55				59	79.75
		27.11.06	8	60				68	
								319	
	Dec'06	5.12.06	3	53				56	
		13.12.06	2	74				76	
		21.12.06	5	54				59	64.25
		29.12.06.	4	62				66	
								257	
	Jan'07	6.01.07	1	40				41	
		14.01.07	1	35				36	46.75
		22.01.07	3	58				61	
		30.01.07	1	48				49	
								187	
	Feb'07	8.02.07	0	11				11	
		16.02.07	1	16				17	
		22.02.07	4	60				64	36.25
		28.02.07	3	50				53	
								145	
	March'07	2.03.07	2	95				27	
		10.03.07	0	132				132	
		18.03.07	1	84				85	80.5
		27.03.07	2	76				78	
								322	
	April'07	4.04.07	15	120				135	
		12.04.07	20	205				225	
		20.04.07	10	75				85	135
		28.04.07	10	85				95	
								540	

Appendix 10

			Adult abundance in station-2(organic pond)					
Month /Year	Date	Alive	dead	Flying	Resting	Mating	Total no	Average no
May'06	8.05.06	6	3	3			9	
	16.05.06	0	1				1	
	24.05.06	3	12				15	7
	31.05.06	0	3				3	
							28	
	G.total.							
June'06	1.06.06	4	3				7	
	9.06.06	2	3				5	
	17.06.06	4	6				10	7.5
	25.06.06	4	4				8	
							30	
July'06	3.07.06	0	1				1	
	11.07.06	0	2				2	
	19.07.06	0	5				5	3
	27.07.06	0	4				4	
							12	
August'06	4.08.06	0	2				2	
	12.08.06	0	2				2	2.5
	20.08.06	0	2				2	
	28.08.06	0	4				4	
							10	
Sep'06	6.09.06	0	4				4	
	14.09.06	0	0				0	3.87
	22.09.06	3	5				8	
	30.09.06	2	0				2	
							14	
Oct'06	8.10.06	5	0				5	
	16.10.06	0	0				0	3.5
	24.10.06	0	2				2	

	31.10.06	0		0				0	
								7	
								14	
Nov'06	1.11.06	1		10				11	
	9.11.06	1		14				15	12.75
	19.11.06	0		12				12	
	27.11.06	0		13				13	
								51	
Dec'06	5.12.06	0		7				7	
	13.12.06	0		9				9	
	21.12.06	4		2				6	6.25
	29.12.06.	1		2				3	
								25	
Jan'07	6.01.07	0		1				1	
	14.01.07	0		1				1	1.75
	22.01.07	0		3				3	
	30.01.07	0		2				2	
								7	
Feb'07	8.02.07	1		4				5	
	16.02.07	1		3				4	
	22.02.07	5		8				13	6.5
	28.02.07	1		3				4	
								26	
March'07	2.03.07	1		4				5	
	10.03.07	4		6				10	
	18.03.07	5		1	5			6	8.12
	27.03.07	4		8				12	
								33	
April'07	4.04.07	3		18				21	
	12.04.07	5		18				23	
	20.04.07	9		23				32	25
	28.04.07	4		20				24	
								100	

Appendix 11

Adult Emergence pattern in rearing Bucket(adult found in 8cm2 block in rearing bucket(station-1)

Month /Year	Date	Adult Found in no	Total No	Average	St. Deviation	Remarks
September' 03	20.09.03	1	2	0.25	0.46291005	
	21.09.03	0				
	22.09.03	0				
	23.09.03	0				
	24.09.03	0				
	25.09.03	0				
	26.09.03	1				
	27.09.03	0				
October'03	20.10.03	0	1	0.125	0.35355339	
	21.10.03	0				
	22.10.03	0				
	23.10.03	0				
	24.10.03	0				
	25.10.03	0				
	26.10.03	1				
	27.10.03	0				
November'03	20.11.03	0	0	0	0	
	21.11.03	0				
	22.11.03	0				
	23.11.03	0				
	24.11.03	0				
	25.11.03	0				
	26.11.03	0				
	27.11.03	0				
December'03	17.12.03	0	1	0.125	0.35355339	
	18.12.03	0				
	19.12.03	0				
	20.12.03	0				

	21.12.03	0				
	22.12.03	1				
	23.12.03	0				
	24.12.03	0				
Jan'04	20.01.04	0	1	0.125	0.35355339	
	21.01.04	0				
	22.01.04	0				
	23.01.04	0				
	24.01.04	1				
	25.01.04	0				
	26.01.04	0				
	27.01.04	0				
Feb'04	17.02.04	0	1	0.125	0.35355339	
	18.02.04	0				
	19.02.04	0				
	20.02.04	0				
	21.02.04	0				
	22.02.04	0				
	23.02.04	1				
	24.02.04	0				
March'04	17.03.04	0	0	0	0	
	18.03.04	0				
	19.03.04	0				
	20.03.04	0				
	21.03.04	0				
	22.03.04	0				
	23.03.04	0				
	24.03.04	0				
April'04	20.4.04	0	1	0.125	0.35355339	
	21.04.04	0				
	22.04.04	0				
	23.04.04	1				
	24.04.04	0				
	25.04.04	0				

	26.04.04	0				
	27.04.04	0				
May'04	17.05.04	0	1	0.125	0.35355339	
	18.05.04	0				
	19.05.04	0				
	20.05.04	1				
	21,05.04	0				
	22.05.04	0				
	23.05.04	0				
	24.05.04	0				
June'04	17.06.04	0	1	0.125	0.35355339	
	18.06.04	0				
	19.06.04	0				
	20.06.04	0				
	21.06.04	0				
	22.06.04	1				
	23.06.04	0				
	24.06.04	0				
July'04	18.07.04	0	2	0.25	0.46291005	
	19.07.04	1				
	20.07.04	0				
	21.07.04	0				
	22.07.04	1				
	23.07.04	0				
	24.07.04	0				
	25.07.04	0				
August'04	17.08.04	0	2	0.25	0.46291005	
	18.08.04	0				
	19.08.04	1				
	20,08.04	0				
	21.08.04	1				
	22.08.04	0				
	23.08.04	0				
	24.08.04	0				

Appendix 12

Adult Emergence pattern in rearing Bucket(adult found in 8cm2 block in rearing bucket(station-2)

Month /Year	Date	Adult Found in no	Total No	Average	St. Deviation	Remarks
September' 03	20.09.03	1	3	0.375	0.517549	
	21.09.03	0				
	22.09.03	0				
	23.09.03	0				
	24.09.03	1				
	25.09.03	0				
	26.09.03	1				
	27.09.03	0				
October'03	20.10.03	0	2	0.285714	0.46291	
	21.10.03	1				
	22.10.03	0				
	23.10.03	1				
	24.10.03	0				
	25.10.03	0				
	26.10.03	0				
	27.10.03	0				
November'03	20.11.03	0	1	0.125	0.353553	
	21.11.03	0				
	22.11.03	0				
	23.11.03	1				
	24.11.03	0				
	25.11.03	0				
	26.11.03	0				
	27.11.03	0				
December'03	17.12.03	0	0	0	0	
	18.12.03	0				
	19.12.03	0				
	20.12.03	0				
	21.12.03	0				

	22.12.03	0				
	23.12.03	0				
	24.12.03	0				
	20.01.04	0				
	21.01.04	0				
	22.01.04	0				
	23.01.04	0				
Jan'04	24.01.04	1	1	0.125	0.353553	
	25.01.04	0				
	26.01.04	0				
	27.01.04	0				
	17.02.04	1				
	18.02.04	0				
	19.02.04	0				
	20.02.04	0				
Feb'04	21.02.04	0	1	0.125	0.353553	
	22.02.04	0				
	23.02.04	0				
	24.02.04	0				
	17.03.04	0				
	18.03.04	0				
	19.03.04	0				
	20.03.04	0				
March'04	21.03.04	0	0	0	0	
	22.03.04	0				
	23.03.04	0				
	24.03.04	0				
	20.4.04	0				
	21.04.04	0				
	22.04.04	0				
April'04	23.04.04	1	1	0.125	0.353553	
	24.04.04	0				
	25.04.04	0				
	26.04.04	0				

	27.04.04	0				
May'04	17.05.04	0	1	0.125	0.353553	
	18.05.04	0				
	19.05.04	0				
	20.05.04	1				
	21,05.04	0				
	22.05.04	0				
	23.05.04	0				
	24.05.04	0				
June'04	17.06.04	0	1	0.125	0.353553	
	18.06.04	0				
	19.06.04	0				
	20.06.04	0				
	21.06.04	1				
	22.06.04	0				
	23.06.04	0				
	24.06.04	0				
July'04	18.07.04	0	2	0.25	0.46291	
	19.07.04	1				
	20.07.04	0				
	21.07.04	0				
	22.07.04	0				
	23.07.04	1				
	24.07.04	0				
	25.07.04	0				
August'04	17.08.04	0	3	0.375	0.517549	
	18.08.04	0				
	19.08.04	1				
	20,08.04	0				
	21.08.04	1				
	22.08.04	0				
	23.08.04	0				
	24.08.04	1				

Appendix 13 **Duck weed growth estimation in earthen pot**

Date of collection:12.3.07 IP = 0% Infestation

Replicant No.	Size (mm) a x b 12/03/07	13/03/07	14/03/07	15/03/07	Absolute G.R 13/03/07	% of growth	M ± SD	Absolute G.R 14/03/07	% of growth	M ± SD	Absolute G.R 15/03/07	% of growth	M ± SD	Total Growth Average	Remarks
	Fronds development				Growth estimation										
	42	42	42	42	0			0			0				
	25	36	42	42	11			17			17				
01	20	36	20	20	16	30%	7.75	0	16.5%	4.25	0	20.3%	5.25	22.6%	
	16	20	16	20	04			0			4				
Total	**103**	**134**	**120**	**124**	**31**			**17**			**21**				
	42	49	49	42	7			7			0				
	16	36	42	42	20	33%	7.5	26	39.3%	8.75	26	39%	8.75	37%	
02	25	25	24	20	0			-1			-5				
	06	09	09	20	3			3			14				
Total	**89**	**119**	**124**	**124**	**30**			**35**			**35**				
	30	36	36	42	06			6	11%		12				
	36	36	36	30	0			0			-6				
03	20	25	25	25	05	11%	2.75	5			5	8.4%	2	10%	
	09	09	09	06	0			0			-3				
Total	**95**	**106**	**106**	**103**	**11**			**11**			**8**				

Appendix 14

Date ofcollection;12.3.07 IP = 25% Infestation

	Fronds development				Growth estimation										
Replicant No.	Size (mm) a x b 12/03/07(a)	13/03/07 (b)	14/03/07 (c)	15/03/07(d)	Absolute G.R 13/03/07(b-a)	% of growth	M ± SD	Absolute G.R 14/03/07(c-a)	% of growth	M ± SD	Absolute G.R 15/03/07(d-a)	% of growth	M ± SD	Total Growth Average	Remarks
	42	48	56	56	6			14			14				
	12	20	20	20	8			8			8				
01	56	56	35	56	0	16.5%	3.8	21	28.21%	6.5	0	24.5%	5.7	9.5%	
	20	30	15	35	10			-5			15				
	15	15	20	15	0			5			0				
	16	20	20	20	4			4			4				
	2	01	01	01	-1			-1			-1				
Total	**163**	**190**	**167**	**203**	**27**			**46**			**40**				
	42	56	56	56	14			14			14				
	2	6	6	6	4	29.0%	6.4	4	29.0%	6.4	4	40%	8.8	23.6%	
02	30	30	35	42	0			0			12				
	20	30	30	30	10			10			10				
	16	20	20	20	4			4			4				
Total	**110**	**142**	**147**	**154**	**32**			**32**			**44**				
	30	30	30	30	0			0			0				
	15	15	12	12	0			0			-3			15.4	
03	12	20	30	30	8	1.2%	2.3	8	6.3%	1	18	38.9%	6.16		
	6	12	20	20	6			6			14				
	20	16	20	20	4			-4			0				
	12	16	20	20	4			4			8				
Total	**95**	**109**	**131**	**133**	**14**			**14**			**37**				

Appendix 15 **Duck weed growth estimation in earthen pot**

Date ofcollection;12.3.07 IP = 50% Infestation

Replic ant No.	Fronds development				Growth estimation										
	Size (mm) a x b 12/03/07(a)	13/03/07 (b)	14/03/07 (c0	15/03/07(d)	Absolute G.R 13/03/07(b-a)	% of growth	M ± SD	Absolute G.R 14/03/07(c-a)	% of growth	M ± SD	Absolute G.R 15/03/07(d-a)	% of growth	M ± SD	Total Growth Average	Remarks
	56	64	64	56	8			8			0				
	35	42	40	35	7			5			0				
01	25	25	25	25	0	10.3%	5	0	11.2%	4.3	0	0%	0	7.1%	
Total	**116**	**131**	**129**	**116**	**15**			**13**			**0**	**0**			
	49	56	56	64	7			7			15				
	42	56	56	56	14	47.0 %	12	14	41.1 %	10.5	14	51.6 %	13.1	46.5%	
	24	42	30	36	18			6			12				
02	20	42	42	36	22			22			16				
	9	20	12	20	11			3			11				
	9	9	20	20	0			11			11				
Total	**153**	**225**	**216**	**232**	**72**			**63**			**79**				
	42	42	42	42	0			0			0				
	30	20	25	25	-10			-5			-5				
03	25	16	16	12	9	12.0 %	2.2	-9	-10.5 %	-2	13	6 .0%	1.1	2.5%	
	9	15	9	9	6			0			0				
	9	20	9	9	11			\0			0				
	9	9	9	9	0			0			0				
	9	9	9	9	0			0			0				
Total	**133**	**131**	**115**	**115**	**16**			**-14**			**8**				

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Appendix 16

Duck weed growth estimation in earthen pot

Date ofcollection;12.3.07

IP = 75% Infestation

Replicant No.	Fronds development				Growth estimation										
	Size (mm) a x b 12/03/07(a)	13/03/07(b)	14/03/07 (c0	15/03/07(d)	Absolute G.R 13/03/07(b-a)	% of growth	M ± SD	Absolute G.R 14/03/07(c-a)	% of growth	M ± SD	Absolute G.R 15/03/07(d-a)	% of growth	M ± SD	Total Growth Average	Remarks
	42	56	56	56	14			14			14				
	1	1	2	2	0			1			1				
01	30	42	42	42	12	30.71%	7	12	31.5%	7.2	12	31.5%	7.2	31.2%	
	25	30	30	30	5			5			5				
	16	20	20	20	4			4			4				
				4											
Total	**114**	**149**	**150**	**151**	**35**			**36**			**36**				
	42	42	42	42	0			0			0				
	42	42	42	42	0	4.3 %	1.3	0	4.3 %	1.3	0	4.3 %	1.3	4.3%	
02	8	12	12	12	4			4			4				
Total	**92**	**96**	**96**	**96**	**4**			**4**			**4**				
	42	56	56	56	14			14			14				
	2	6	6	6	4			4			4				
03	1	2	2	2	1	%		1	42.8 %	5.5	1	41.5 %	5.3	44.1%	
	20	30	24	24	10			4			4				
	12	20	20	20	8			8			8				
			2	1				2			4				
Total	**77**	**114**	**110**	**109**	**37**			**33**			**32**				

Appendix 17

Duck weed growth estimation in earthen pot

Date of Collection: 12/03/07 IP = Larva

Replicant No.	Fronds Size (mm) axb 12/03/07	No. of Fronds	Fronds Size (mm) axb 13/03/07	No. of Fronds	Fronds Size (mm) axb 14/03/07	No. of Fronds	Fronds Size (mm) axb 15/03/07	No. of Fronds	Absolute GR 13/03/07	%of growth	M ± SD	Absolute GR 14/03/07	%of growth	M ± SD	Absolute GR 15/03/07	%of growth	M ± SD	Total Growth Average	Remarks
01	84	10	84	10	104	8	96	8	0			20			12				
02	84	10	98	10	100	14	119	7	14	32.60%	29.66	16	9.8%	9	35	6.22	5.6	33.0%	
03	105	12	180	10	150	6	80	7	75		±	45		±	-30	%	±		
Total	273	32	362	30	354	28	295	22	89			27			17				

Appendix 18

Duck weed growth estimation in earthen pot

Date of Collection: 12/03/07 IP = pupa

Replicant No.	Fronds Size (mm) axb 12/03/07	No. of Fronds	Fronds Size (mm) axb 13/03/07	No. of Fronds	Fronds Size (mm) axb 14/03/07	No. of Fronds	Fronds Size (mm) axb 15/03/07	No. of Fronds	Absolute GR 13/03/07	%of growth	M ± SD	Absolute GR 14/03/07	%of growth	M ± SD	Absolute GR 15/03/07	%of growth	M ± SD	Total Growth Average	Remarks
01	200	20	242	20	238	17	210	14	42			38			10				
02	224	14	180	13	216	13	216	15	-44	-7.81%	21.66	-8	-8.29%	-23.0	-8	-	-55.33	-12..01%	
03	408	22	345	22	280	22	240	18	-63		±	-128		±	-168	19.95	±		
Total	832	56	767	55	734	52	666	47	-65			-69			-166	%			

Appendix 19

Compiled data on the impact of larval cage making process on duckweed productivity in Inorganic and organic pond

	Ip-larval cage								Op-larval cage							
Replicant no.	Cage size(mm) axb 12/3/07	No .of fronds	Cage size(mm) axb 13/3/07	No .of fronds	Cage size(mm) axb 14/3/07	No .of fronds	Cage size(mm) axb 15/3/07	No .of fronds	Cage size(mm) axb 12/3/07	No .of fronds	Cage size(mm) axb 13/3/07	No .of fronds	Cage size(mm) axb 14/3/07	No .of fronds	Cage size(mm) axb 15/3/07	No .of fronds
01	84	10	84	10	104	8	96	8	225	13	200	14	225	10	200	10
02	84	10	98	10	100	14	119	7	250	20	200	18	144(pupal cage)	16	150	220
03	105	12	180	10	150	6	80	7	105	10	168	10	100	08	70	08
Total	273	32	362	30	354	28	295	22	580	43	568	42	469	34	320	38

Appendix 20

Compiled data on the impact of Pupal cage making process on duckweed productivity in Inorganic and organic pond

	Ip- pupal cage								Op-Pupal cage							
Replicant no.	Cage size(mm) axb 12/3/07	No .of fronds	Cage size(mm) axb 13/3/07	No .of fronds	Cage size(mm) axb 14/3/07	No .of fronds	Cage size(mm) axb 15/3/07	No .of fronds	Cage size(mm) axb 12/3/07	No .of fronds	Cage size(mm) axb 13/3/07	No .of fronds	Cage size(mm) axb 14/3/07	No .of fronds	Cage size(mm) axb 15/3/07	No .of fronds
01	200	20	242	20	238	17	210	14	253	15	210	17	210	14	210	12
02	224	14	180	13	216	13	216	15	170	24	180	20	180	20	153	14
03	408	22	345	22	280	22	240	18	216	24	240	20	240	19	240	19
Total	832	56	767	55	734	52	666	47	639	63	630	57	630	53	603	45

Appendix 21

Impact of Larval and pupal cage making process on duckweed growth in inorganic pond and Organic pond

Pond	Initial larval cage Duckweed size	Duckweed growth in larval cages(mm)2			Initial pupal cage (duckweed) size	Duckweed growth in pupal cages(mm)2		
		Day 2 and 1(24 hours)	Day 3 and 2(48 hours)	Day 4 and 1(72 hours)		Day 2 and 1(24 hours)	Day 3 and 2(48 hours)	Day 4 and 1(72 hours
Ip	91.0	29.61	26.33	7.33	277.33	-21.66	-32.66	-55.33
	Growth %	32.54	28.93	8.05	Growth %	-7.81	-11.78	-19.95
Op	193.33	-4.0	-37.0	-86.66	213.0	-3.0	-3.0	-12.0
	Growth %	-2.07	-19.14	-44.82	Growth %	-1.41	-1.41	-5.63

Appendix 22

Duck weed growth estimation in earthen pot

Date of Collection: 12/03/07

OP = 0 % Infestation

	Fronds development				Growth estimation										
Replicant No.	Size (mm) a x b 12/03/07	13/03/07	14/03/07	15/03/07	Absolute G.R 13/03/07	% of growth	M ± SD	Absolute G.R 14/03/07	% of growth	M ± SD	Absolute G.R 15/03/07	% of growth	M ± SD	Total Growth Average	Remarks
	70	64	56	64	-6			-14			-6				
	49	49	42	56	0		-3	-7		7	7	9%	4	10%	
01	15	12	16	20	-3	7%	±	1	15%	±	5		±		
				06				-20			6				
Total	**134**	**125**	**114**	**146**	**-9**			**20**			**12**				
	36	56	56	56	20			20			20				
	20	20	30	35	0			10		14	15		19		
02	20	20	30	30	0	27%	8	10	51%	±	10	66%	±	18%	
	9	12	12	20	3		±	3			11				
Total	**85**	**108**	**128**	**141**	**23**			**43**			**56**				
	64	81	81	72	17			17			8				
	49	56	49	42	7			0		28	-7		5		
03	12	16	16	20	4	22%	9	4	20%	±	8	12%	±		
			4	6	0		±	4			6				
Total	**125**	**153**	**150**	**140**	**28**			**25**			**15**				

Appendix 23 **Duck weed growth estimation in earthen pot**

Date of Collection: 12/03/07 OP = 25% Infestation

	Fronds development				Growth estimation										
Replicant No.	Size (mm) a x b 12/03/07	13/03/07	14/03/07	15/03/07	Absolute G.R 13/03/07	% of growth	M ± SD	Absolute G.R 14/03/07	% of growth	M ± SD	Absolute G.R 15/03/07	% of growth	M ± SD	Total Growth Average	Remarks
01	56	56	56	56	0			0			0				
	20	30	30	30	10		3 ±	10		3 ±	10	16%	3 ±	16%	
		1	1	1	1	16%		1	16%		1				
		1	1	1	1			1			1				
Total	76	88	88	88	12			12			12				
O2	42	56	56	56	14			14			14				
	12	20	20	20	08			8		7 ±	8		7 ±		
			1	1		42%	7 ±		41%			41%		41%	
Total	54	76	77	77	22			22			22				
03	56	56	56	56	0	n		0			0				
	4	6	12	16	2			6		2 ±	4		1 ±		
						4%	1 ±		10%			7%		7%	
	60	62	68	72	2			6			4				

Appendix 24 **Duck weed growth estimation in earthen pot**

Date of Collection: 12/03/07 OP = 50% Infestation

Replicant No.	Fronds development				Growth estimation										
	Size (mm) a x b 12/03/07	13/03/07	14/03/07	15/03/07	Absolute G.R 13/03/07	% of growth	M ± SD	Absolute G.R 14/03/07	% of growth	M ± SD	Absolute G.R 15/03/07	% of growth	M ± SD	Total Growth Average	Remarks
	64	56	56	64	-8			-8			0				
	20	20	20	20	0		2 ±	0		4 ±	0	4%	1 ±	7%	
	4	9	2	12	5	7%		8	10%		8				
	24	35	35	20	11			11			-4				
Total	**112**	**120**	**123**	**116**	**8**			**11**			**4**				
	36	42	35	56	6			-1			20				
	30	42	42	30	12			12		9 ±	0		9 ±		
02	35	25	30	25	-10	6%	3 ±	-5	22%		-10	21%		18%	7%-32%
	12	12	25	20	0			13			8				
	12	12	20	20	0			8			8				
Total	**125**	**133**	**152**	**151**	**08**			**27**			**26**				
	30	48	36	42	18			6			12				
	30	30	30	30	0			0		10 ±	0		9 ±		
03	16	20	30	20	4	32%	10 ±	14	33%		4	29%		32%	
	12	20	20	20	8			8			8				
	6	6	9	9	0			3			3				
Total	**94**	**124**	**125**	**121**	**30**				**31**			**27**			

Appendix 25

Duck weed growth estimation in earthen pot

Date of Collection: 12/03/07 OP = 75% Infestation

Replicant No.	Fronds development				Growth estimation										
	Size (mm) a x b 12/03/07	13/03/07	14/03/07	15/03/07	Absolute G.R 13/03/07	% of growth	M ± SD	Absolute G.R 14/03/07	% of growth	M ± SD	Absolute G.R 15/03/07	% of growth	M ± SD	Total Growth Average	Remarks
01	56	56	72	72	0	4%	1 ±	16	37%	7 ±	16	37%	7 ±	26%	
	1	3	06	06	02			5			5				
Total	**57**	**59**	**78**	**78**	**2**			**21**			**21**				
02	42	42	42	42	0	0%	0 ±	0	0%	0 ±	0	0%	0 ±	0%	-10%-37%
	30	30	30	30	0			0			0				
	2	2	2	2	0			0			0				
											0				
Total	**74**	**74**	**74**	**74**	**0**			**0**			**0**				
03	30	30	30	20	0	0%	0 ±	0	2%	1 ±	-10	33%	6 ±	-10%	
	20	20	20	12	0			0			-8				
	1	1	1	1	0			0			0				
			1	1	-			01			01				
								01			-17				
	Total	**51**	**51**	**52**		**34**	**0**				**02**			**-34**	

Appendix 26 **Duck weed growth estimation in earthen pot**

Date of Collection: 12/03/07 OP = Larva

Replicant No.	Fronds Size (mm) axb 12/03/07	No. of Fronds	Fronds Size (mm) axb 13/03/07	No. of Fronds	Fronds Size (mm) axb 14/03/07	No. of Fronds	Fronds Size (mm) axb 15/03/07	No. of Fronds	Absolute GR 13/03/07	%of growth	M ± SD	Absolute GR 14/03/07	%of growth	M ± SD	Absolute GR 15/03/07	%of growth	M ± SD	Total Growth Average	Remarks
01	225	13	200	14	225	10	200	10	-25			0			-25				
02	250	20	200	18	144 (Pupal cage.)	16	150	20	-50	-2.06%	-4 ±	-106	-19.13 %	-37 ±	-100	-27.58%	-53 ±	-16.25%	
03	105	10	168	10	100	08	70	08	63			-5			-35				
Total	580		568		469		320		-12			-111			-160				

Appendix 27 **Duck weed growth estimation in earthen pot**

Date of Collection: 12/03/07 OP = Pupa.

Replicant No.	Fronds Size (mm) axb 12/03/07	No. of Fronds	Fronds Size (mm) axb 13/03/07	No. of Fronds	Fronds Size (mm) axb 14/03/07	No. of Fronds	Fronds Size (mm) axb 15/03/07	No. of Fronds	Absolute GR 13/03/07	%of growth	M ± SD	Absolute GR 14/03/07	%of growth	M ± SD	Absolute GR 15/03/07	%of growth	M ± SD	Total Growth Average	Remarks
01	253	15	210	17	210	14	210	12	-43			-43			-43				
02	170	24	180	20	180	20	153	14	10	-1.40%	-3	10	1.40	-3	-17	-	-12	-	
03	216	24	240	20	240	19	240	19	24		±	24	%	±	24	5.63	±	2.81	
Total	639		630		630		603		-9			-9			-36	%		%	

Appendix 28 T –test result in biomass growth

Group Statistics

	TYPE	N	Mean	Std. Deviation	Std. Error Mean
G1.3	ip	3	26.1000	1.00000	.57735
	op	3	22.0333	.98658	.56960
G4.6	ip	3	26.3667	1.10151	.63596
	op	3	24.7667	.85049	.49103
G7.9	ip	3	24.8333	1.52753	.88192
	op	3	23.2000	1.91572	1.10604
G10.12	ip	3	25.7333	1.50444	.86859
	op	3	27.3000	2.50599	1.44684
G13.15	ip	3	33.2333	3.06159	1.76761
	op	3	27.3333	3.16596	1.82787
G16.18	ip	3	27.1667	2.37978	1.37396
	op	3	26.9000	2.70740	1.56312
G19.21	ip	3	39.2333	4.52806	2.61428
	op	3	36.2667	2.90918	1.67962
G22.24	ip	3	56.7500	10.99693	6.34908
	op	3	44.6000	12.27844	7.08896

Appendix-29 **Independent Samples Test in Biomass growth**

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
G1.3	Equal variances assumed	.053	.830	5.014	4	.007	4.0667	.81104	1.81487	6.31846
	Equal variances not assumed			5.014	3.999	.007	4.0667	.81104	1.81471	6.31862
G4.6	Equal variances assumed	.081	.790	1.991	4	.117	1.6000	.80346	-.63078	3.83078
	Equal variances not assumed			1.991	3.759	.122	1.6000	.80346	-.68824	3.88824
G7.9	Equal variances assumed	.410	.557	1.155	4	.313	1.6333	1.41461	-2.29424	5.56091
	Equal variances not assumed			1.155	3.811	.315	1.6333	1.41461	-2.37224	5.63890
G10.12	Equal variances assumed	.593	.484	-.928	4	.406	-1.5667	1.68754	-6.25202	3.11868
	Equal variances not assumed			-.928	3.276	.416	-1.5667	1.68754	-6.69014	3.55681
G13.15	Equal variances assumed	.006	.942	2.320	4	.081	5.9000	2.54275	-1.15979	12.95979
	Equal variances not assumed			2.320	3.996	.081	5.9000	2.54275	-1.16292	12.96292
G16.18	Equal variances assumed	.173	.699	.128	4	.904	.2667	2.08113	-5.51148	6.04482
	Equal variances not assumed			.128	3.935	.904	.2667	2.08113	-5.54917	6.08250
G19.21	Equal variances assumed	.728	.441	.955	4	.394	2.9667	3.10734	-5.66069	11.59402
	Equal variances not assumed			.955	3.411	.402	2.9667	3.10734	-6.28154	12.21487
G22.24	Equal variances assumed	.014	.911	1.277	4	.271	12.1500	9.51652	-14.27210	38.57210
	Equal variances not assumed			1.277	3.952	.272	12.1500	9.51652	-14.39816	38.69816

Appendix 30 T-test result in earthen container

Group Statistics

	TYPE	N	Mean	Std. Deviation	Std. Error Mean
L.0	ip	3	22.6800	15.58688	8.99909
	op	3	28.9000	31.99391	18.47169
L.25	ip	3	34.8333	8.94893	5.16667
	op	3	24.7167	15.47876	8.93667
L.50	ip	3	12.7000	34.35797	19.83658
	op	3	17.6667	12.88888	7.44140
L.75	ip	3	26.0667	19.39184	11.19588
	op	3	1.1667	35.06456	20.24453

Appendix 31

Independent Samples Test in earthen container

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
L.0	Equal variances assumed	3.141	.151	-.303	4	.777	-6.2200	20.54719	-63.26814	50.82814
	Equal variances not assumed			-.303	2.899	.783	-6.2200	20.54719	-72.92151	60.48151
L.25	Equal variances assumed	2.134	.218	.980	4	.383	10.1167	10.32272	-18.54379	38.77712
	Equal variances not assumed			.980	3.203	.395	10.1167	10.32272	-21.58968	41.82301
L.50	Equal variances assumed	3.998	.116	-.234	4	.826	-4.9667	21.18642	-63.78960	53.85627
	Equal variances not assumed			-.234	2.552	.832	-4.9667	21.18642	-79.60858	69.67525
L.75	Equal variances assumed	.578	.489	1.076	4	.342	24.9000	23.13415	-39.33070	89.13070
	Equal variances not assumed			1.076	3.119	.358	24.9000	23.13415	-47.16266	96.96266