

Technical Session - Aquatic Resources Technology

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Determination of a suitable growing medium and a commercial fertilizer for *Echinodorus parviflorus* ‘Tropica’ in the nursery level

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Introduction

Aquatic Plant varieties have unique morphology and habitats as commercially important aquatic plants. (Dissanayake, 2007). The most popular ornamental aquarium plants genera are *Anubias*, *Cryptocoryne*, *Echinodorus*, *Aponogeton*, *Hygrophyla*, *Bacopa*, *Hydrilla*, *Cabomba*, *Myriophyllum*, *Lagenandra*, *Vallisneria* and *Elodea*. Among these plant genera *Cryptocoryne*, *Lagenandra*, *Aponogeton* and *Echinodorus* have important characteristics as aquarium plants in Sri Lanka. *Echinodorus* species have attractive green to mid green submerged leaves arranged in a rosette with beautiful, white flowers occurring in an inflorescence (Muhlberg, 1982). Aquatic plants play a significant role in the freshwater ecosystems worldwide. With time ecosystem may collapse without aquatic plants due to wild collection. Therefore growing plants is solution for that. An aquatic plant growing medium was essential for that. The growing mediums contain sand, silt and clay proportion according to the ratio of the medium. Four different ratios were used as treatments (T). T1- Boggy soil: Bricks particles T2- 3:1, Boggy soil 3: Sand 1, T3-Boggy soil: Top soil -3:1, T4-Top soil were treatments. Growing medium should balance the aeration and water for maximum root growth and physically support for the plant. Practical size of the growing medium should be with adequate pore spaces between the particles (Bilderback, 2005)

Nutrition is a major factor for the plant growth. Therefore nutrient should be supplied in optimum level at the correct time as fertilizers.

Methodology

The present study was carried out to investigate the effect of growing medium and fertilizer for the growth of *Echinodorus parviflorus* ‘Tropica’ National Aquaculture Development Authority (NAQDA) Ornamental Fish Breeding and Training center in Rambadagalle Sri Lanka. Experiment one was conducted to find out a suitable nursery medium for the *E.parviflorus* ‘Tropica’ plant. Boggy soil, brick particles, sand and top soil were used. Using those growing substrate four types of media used as treatments (T), T1- Boggy soil: Bricks particles T2- 3:1, Boggy soil 3: Sand 1, T3-Boggy soil: Top soil -3:1, T4-Top soil were treatments. Experiment two four fertilizer mixture used as four treatment of fertilizer, T1-N: P: K -4:2:1, T2- N: P: K -5:2:3, T3- N: P: K -3:1:1 and T4- N: P: K -20:20:20 were used during this study.

Uniform *Echinodorus parviflorus* ‘Tropica’ about 4.5 cm -6.5 cm heights, same age plants were selected for the experiment. Old and rotted leaves were removed; leaving 5- 6 laves to remain. Old and rotted roots also were trimmed, leaving the only healthy roots. Initial weights between 0.5 g - 1.5 g of plants were selected. Experiment one and two results were analyzed by using Minitab 16 computer package and significant differences between treatments were identified using Analysis Of

Variance (ANOVA) produce at 5% probability level. In experiment one T4-Top soil and experiment two T4- N: P: K -20:20:20 were used as control of the both experiments.

Results

According to experiment one, Boggy soil 3: sand 1(T2) growing medium was most suitable growing medium among other used media for the *E.parviflorus* ‘Tropica’. In the experiment one, there was significant difference ($P < 0.05$) among four treatments regarding increment of plant height, weight, dry weight and root length. As indicated Table 1, the maximum growth was observed in T2.

Table 1. Influence of growing medium on Tropica plant growth

Substrate	Plant height difference (cm)	Plant weight difference (g)	Dry weight difference (g)	Root length difference (cm)
T1	4.2500	1.5503	0.0265	1.5633
T2	4.7767	1.623	0.0211	4
T3	3.6833	1.6993	0.02167	1.6667
T4	2.8367	0.6407	0.02517	1.5833

According to experiment two N: P: K -4:2:1(T1) fertilizer ratio was the suitable fertilizer ratio for *Echinodorus parviflorus* ‘Tropica’ plants. In the experiment two there was significant difference ($P < 0.05$) among four treatment regarding increment of plant height, weight, dry weight and root length. As indicated Table 2, the highest growing was observed in T1.

Table 2. Influence of fertilizer Tropica plant growth

Fertilizer	Plant height difference (cm)	Plant weight difference (g)	Dry weight difference (g)	Root length difference (cm)
T1	6.3693	2.2598	0.05697	4.6897
T2	4.0967	1.7111	0.05184	1.9496
T3	4.0332	1.5896	0.03873	1.8693
T4	3.9166	1.3958	0.02767	1.5703

Discussion

Based on the results obtained from the present study, it can be concluded that the parameters which measured the growth of the *Echinodorus paviflorus* variety Tropica. Considering the analyses carried out separately with four parameters, both experiments one and experiment two were able to found out a suitable growing medium and a suitable fertilizer mixture for enhancing the growth of *Echinodorus parviflorus* 'Tropica'.

Conclusions

Most suitable fertilizer ratio for growth of plant is N: P: K- 4: 2: 1 and most suitable growing medium is the medium consist of Boggy soil: Sand- 3: 1.for *Echinodorus parviflorus* 'Tropica'.

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Development of a suitable culture media for mass culture of *Moina macrocopa*

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Introduction

Live food organisms contain of all the nutrients such as essential proteins, lipids, carbohydrates, vitamins, minerals, amino acids and fatty acids (Das *et al.*, 2012). Mostly, *Artemia naupli* is cultured as live feed in large amounts in Sri Lanka. However, the high cost is a problem. In Sri Lanka, brine shrimp can be replaced by *Moina macrocopa*. It is a cost effective live feed and important to find out a cost effective culture medium to get the highest production of *Moina macrocopa*. Therefore, this research was carried out to develop a suitable culture medium for mass culture of *Moina macrocopa*.

Methodology

Two experiments were conducted to develop a suitable method for culturing *Moina macrocopa* in National Aquaculture Development Authority (NAQDA) at Rambadagalla. Experiment 1 was conducted to find out possible culture media and to determine its concentration for mass culture. Experiment 2 was conducted to find out the best culture medium and its concentration for mass culture of *Moina macrocopa*. All bottles and tanks used in experiments were cleaned, drained and sun dried for two days and then filled with water, left for two days before using. *Moina macrocopa* for all experiments were taken from stock culture developed in NAQDA Centre at Rambadagalla. Pure culture of *Chlorella vulgaris* (1×10^4 cells per 1 ml) was acquired from NAQDA Centre at Rambadagalla. Filtered tap water was used in both experiments. In experiment 1, five culture media; mineralized cow dung, steamed cow dung, 15 min. boiled chicken manure, 30 min. boiled chicken manure, and 1 hr. boiled chicken manure were prepared with four different concentrations such as 5 g l⁻¹, 10 g l⁻¹, 15 g l⁻¹ and 20 g l⁻¹. Different concentrations with various media tested with and without adding *Chlorella* into the medium. As control, a medium only with *Chlorella* and water was maintained. Three replicates from each treatment were maintained during experiment. Five individuals of *Moina macrocopa* were inoculated into each bottle. After that, top of the bottles were covered with a mosquito net to prevent entrance of undesired insects. They were allowed to stay 10 days and after that data were collected. Three samples from every tank were collected using 3 ml of fine dropping pipette. Samples were taken from the surface to bottom at three random points. Collected data (number of *Moina macrocopa*) were analyzed using Minitab 16 software with ANOVA, general linear model. According to the results of experiment 1, the positive culture media and their concentrations were used in experiment 2.

Selected treatments were prepared as same as in experiment 1. 150 individuals of *Moina macrocopa* were introduced into each tank. After ten days, 25 ml samples were taken as earlier and preserved using two drops of 1.007 g cm⁻³ Lugol's solution. Values of all tanks were recorded. Data were analyzed as in experiment 1.

Results and Discussion

According to the preliminary experiment, there was a significant relationship between number of *Moina macrocopa* and culture medium ($p < 0.05$). There was a significant relationship between medium and concentration to the number of *Moina macrocopa* ($p < 0.05$). There were no results of *Moina macrocopa* in both 15 g l⁻¹ and 20 g l⁻¹ of mineralized cow dung media. There were no results of *Moina macrocopa* in 15 g l⁻¹ and 20 g l⁻¹ of steamed cow dung media. Those media may be not favorable for growth of *Moina*. There were no results found in 15 min. boiled chicken manure and 30 min. boiled chicken manure media. The major reason for boiling chicken manure is to prevent the *Salmonella* effect. Low time duration for boiling might be not enough for destroy the undesirable pathogens. There may be not a favorable environment for growth of *Moina macrocopa* in both of those media. Fig. 1 shows the possible culture media to be developed for experiment 2.

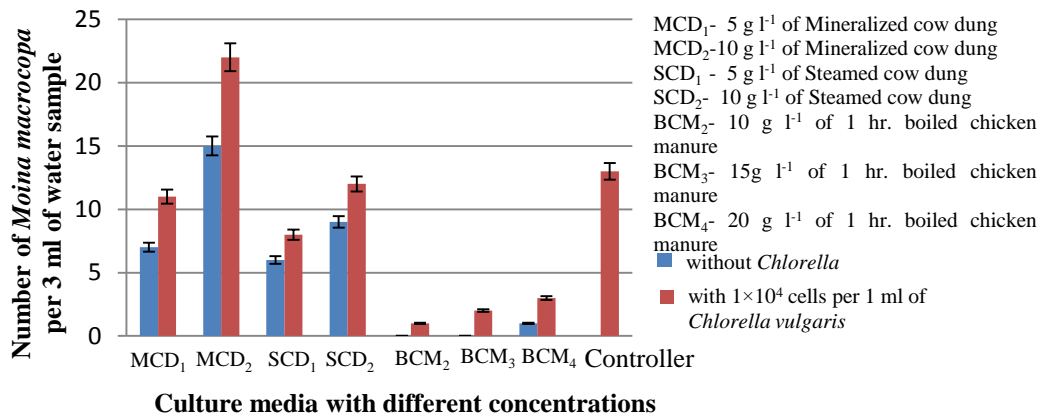


Figure 1: Suitable culture media and its concentrations for culturing *Moina macrocopa*

In experiment 2, according to ANOVA, general linear model, there was a significant relationship between total number of *Moina macrocopa* and medium ($p < 0.05$). Table 1 shows the mineralized cow dung media and steamed cow dung media had higher results than the 1 hr. boiled chicken manure media. According to Begum *et al.*, (2013), the survival rate of individuals in cow dung is higher than chicken manure and nutritional composition of cow dung compare to the chicken manure is higher. This would be the reason for higher total number of *Moina macrocopa* in cow dung media than the chicken manure media. According to Table 1, mineralized cow dung media was better than steamed cow dung media and that results were better than the controller. Nutritional deficiency and destruction of favorable microbes which can convert complex compounds into simple absorbable minerals due to steam can be the reason for lower results in steamed cow dung. Cow dung is freely available in Sri Lanka and it is low in cost in Sri Lanka. According to the analyzed data, there was no significant relationship between total count and *Chlorella* ($p > 0.05$). It means the selected culture media can be used with *Chlorella* or without *Chlorella*. But, Table 1 shows all positive resulted culture media gave higher yield with *Chlorella* than without *Chlorella*. *Chlorella* is a major food for *Moina*. Finally, it can enhanced the available food for *Moina*.

Table 1: Relationship of different concentrations of media and availability of *Chlorella* to the total number of *Moina macrocopa*

Medium	Concentration	Availability of 1×10^4 cells per 1 ml of <i>Chlorella vulgaris</i>	Mean \pm SE Mean
Mineralized cow dung	5 g l ⁻¹	With <i>Chlorella</i> Without <i>Chlorella</i>	090.00 \pm 0.33 084.22 \pm 0.22
	10 g l ⁻¹	With <i>Chlorella</i> Without <i>Chlorella</i>	140.00 \pm 0.50 129.78 \pm 0.28
Steamed cow dung	5 g l ⁻¹	With <i>Chlorella</i> Without <i>Chlorella</i>	065.00 \pm 0.41 050.11 \pm 0.35
	10 g l ⁻¹	With <i>Chlorella</i> Without <i>Chlorella</i>	099.89 \pm 0.35 072.00 \pm 0.29
1 hr. boiled chicken manure	10 g l ⁻¹	With <i>Chlorella</i>	007.89 \pm 0.26
	15 g l ⁻¹	With <i>Chlorella</i>	007.89 \pm 0.35
	20 g l ⁻¹	With <i>Chlorella</i> Without <i>Chlorella</i>	017.00 \pm 0.23 007.78 \pm 0.22
Controller		With <i>Chlorella</i>	100.78 \pm 0.47

Conclusion

10 g l⁻¹ of mineralized cow dung with *Chlorella vulgaris* can be used as a best culture medium to obtain highest total number of *Moina macrocopa* among the tested culture media.

Acknowledgement

I wish to express my gratitude to all the lecturers in Uva Wellassa University, Sri Lanka and all the members in Ornamental Fish Breeding and Training Centre, Rambadagalla, Sri Lanka.

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Evaluation of the attitude and awareness of the international resolution on responsible fishing: a case study on the multiday fishermen of Matara

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Introduction

Sri Lanka is an island, situated in the Indian Ocean between 6 – 10⁰ N latitude and 80 – 82⁰ E longitudes. This island has approximately 1700 km long coastline and sovereign power for the 21,500 km² territorial sea and an Exclusive Economic zone (EEZ) of 517,000 km² (MFAR, 2013). Therefore fisheries industry significantly contributes to the food security and the foreign exchange earnings of Sri Lanka. This IUU fishing is a serious threat to the sustainability of fisheries in both national jurisdictions and high seas. Therefore regional resolutions are implemented by the Indian Ocean Tuna Commission (IOTC) to reduce these IUU fishing activities. Although there are laws and regulations, many problems in the fisheries sector are caused due to lack of awareness of fishermen regarding these implemented national and international laws. Therefore identification of awareness of fishermen on these laws and regulations are very important before the implementation of awareness programs. This study was done with the objectives of investigating international resolutions which highly impact to Sri Lankan fisheries sector, investigate responses of fishermen on international resolutions, identify and suggest procedures which can improve the awareness and behaviors of fishermen on international resolutions.

Keywords: Illegal Unreported Unregulated (IUU) fishing, Indian Ocean Tuna Commission (IOTC), International Resolutions

Methodology

Matara fisheries district was selected as the research area. The sample for the case study was selected from multiday boat owners, crew members, skippers and other service providers of Matara fisheries district through the Stratified random sampling. The sample size was determined using “Moving average method”. Data was collected from both primary and secondary sources. Primary data was collected from selected sample, through the questionnaire and interviews. The questionnaire was prepared using international resolutions which developed by the IOTC. Both open ended questions and closed ended questions were included in the questionnaire. Secondary data was collected from sources of Department of Fisheries and Aquatic Resources and IOTC web site. Collected data was analyzed using “Likert method” (Likert, 1932) and one way ANOVA (Analysis of Variance) at 95% significant interval. “Minitab 16” software was used for analyzing all the collected data.

Results and Discussion

The sample size was selected as 105. According to the finalized results of the study, total mean of awareness and attitude regarding these international resolutions is 3.38 ± 1.58 . It means that the level of awareness and attitude of fishermen of Matara fisheries district on these international resolutions are medium. The statements used for the questionnaire have derived from the IOTC resolutions (IOTC, 2013). The current awareness of stakeholders on these international resolutions is helped to keep the Sri Lankan fishermen under the international resolutions. It helps to enhance the acceptance for Sri Lankan fish and fish products in the international market. Not only that but also the awareness on some resolutions are directly influenced on the management of fishery resources.

The community has a high level of knowledge ($3.67 \leq \text{Mean Likert scale} \leq 5.00$) on the statements of importance of registration of fishing vessel, importance of having a flag in the fishing vessel, importance to mark vessels according to the regulations (Resolution 01/02 relating to control of fishing activities), importance of establishing a vessel monitoring program (Resolution 06/03), idea about prohibition of bottom trawling and crossing sea boundaries without proper permission, requirement of permission from the department for landing harvest at another country or for exchanging harvest with the foreign vessels at sea (Resolution 12/05 on establishing a program for transshipment by large scale fishing vessels), prohibition of catching endangered shark species and sea turtles (Resolution 12/09 on the conservation of Thresher sharks and Resolution 12/04 on the conservation of marine turtles) and preference of carrying equipment in the vessel which was used for catching sea birds and sea turtles. The registration of fishing vessel and vessel marking according to the regulations are already in place in the national regulations (1980). Therefore all of them have to comply with the registration of fishing vessel and marking them according to the regulations for having other subsidies and insurance.

The awareness was medium ($2.34 \leq \text{Mean Likert scale} \leq 3.66$) on the statements of importance of maintaining a log book on board (Resolution 01/02), the requirement of providing information about harvest to the Department of Fisheries, willingness to support the government officers, agree to carry a department officer as an observer when they request, importance to inform navigation path for the department or harbor (Resolution 05/03 and Resolution 10/11). According to the attitude of some stakeholders, it is difficult to carry a department officer as an observer due to the limitation of space in the vessel and several other difficulties. The idea of some skippers was important to maintain a log book to have an idea in future regarding places and time of high densities of fish. It was considered as an additional trouble for their hard occupation by others. According to the responses of stakeholders, there are some people who unable to keep records on this log book due to inability of writing.

The overall awareness was very low ($1.00 \leq \text{Mean Likert scale} \leq 2.33$) on the statements of international trade barriers which are occurred to Sri Lankan fisheries sector due to the ignorance of international resolutions, prohibition of large scale driftnets on the high seas in the IOTC area (Resolution 12/12), closed area (Resolution 12/13). With the high sea fishing operation license, printed material including the statements regarding the Resolution 12/12 has received by the boat owners. Therefore regarding the prohibition of large scale driftnets on the high seas, there was awareness among some people specially with the boat owners and skippers. But even the response of these people was not agreed with the idea. According to them, 2.5 km length gill nets are not enough to recover their fuel cost. The awareness of fishermen was very low regarding the closed area (Coordinates 0° - 10° North, 40° - 60° East in the Indian Ocean during February month) for fishing (Resolution 12/13 for the conservation and management of Tropical Tunas stocks in the IOTC area of competence). Therefore the overall response for a closed area was seriously disagreed. But some of the stakeholders believe it is necessary to have a closed area for the sustainability of fishery resources.

Regarding six statements, there was a significant difference of the responses according to the types of stakeholders. The identified major reasons for this significant difference are difference of the participation level for the awareness programs and different attitudes among types of stakeholders. Compared to the crew members, the awareness of boat owners and skippers were high. The reason for this was identified as the high level of participation for the awareness programs while others are engaging in fishing activities. The awareness of other service providers was very low. Because they just consider on their occupation. It is better to use a media such as newspapers, television and mostly the radio which is much closer to them. Other than using the mass media for the awareness programs, it is better to display posters regarding these resolutions in the harbor premises, maintain a continuous dialogue between the stakeholders and the government. It is identified the necessity to improve their knowledge and literacy on new devices such as electronic means of communication.

The overall knowledge of fishermen of Beruwala is relatively in positive level (3.61 ± 1.28) about the international resolutions (Madhushani, *et al.*, 2013). But knowledge level of fishermen of Matara fisheries district regarding international resolutions is medium. Therefore the level of implementing awareness programs should be different from Beruwala to Matara. The required level of awareness programs is high for the Matara fisheries district than for the Beruwala. Although there was awareness regarding some resolutions in both Beruwala and Matara, they do not act according to them. Their negative attitude regarding these resolutions is the reason for this. Therefore while improving awareness regarding international resolutions, developing positive attitudes is very important. It is necessary to improve the common knowledge of stakeholders regarding the international resolutions and importance of these resolutions.

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Toxicity effects of trace metals on Zebra fish (*Danio rerio*) embryo

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Introduction

Water quality deterioration is a major problem in the most of the countries, due to organic and inorganic contaminants. Among all the toxicant trace metals are threaten to the aquatic ecosystem and organisms. Metals are natural component of aquatic ecosystem. Trace metals such as Copper (Cu), Zinc (Zn) and Chromium (Cr) are important for the metabolic and other biological activities of lives whereas Mercury (Hg), Lead (Pb), Cadmium(Cd) are biologically non-essential metal that can be toxic to biota even at very low concentration. High concentration of some essential trace metals can be toxic when it exceeds the limits(Ebrahimi and Taherianfard, 2011).High accumulation of trace metal in both biotic and abiotic components causes serious health consequences. Thus, assessment of their toxicity has become an important component of water pollution monitoring. Now in most of the toxicity studies Zebra fish (*Danio rerio*) embryo used as an alternative model for the fish acute toxicity to determine the toxicity of pollutants. Therefore this study was focused on determination of the acute toxicity of Cu, Zn, Cd, As, Pb and Hg that produce lethal effect on zebra fish embryos during four day period.

Materials and Methodology

Zebra fish breeding was carried out and eggs were collected using a small pipette. The stock solution of 1000 ppm of selected Cu, Zn, Pb, Cd, As and Hg were prepared a day before the test by dissolving Copper sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$), Zinc sulfate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$), Lead nitrate ($\text{Pb}(\text{NO}_3)_2$), Arsenic pentoxide (As_2O_5), Cadmium chloride ($\text{CdCl}_2 \cdot \frac{1}{2} \text{H}_2\text{O}$) and Mercury chloride (HgCl_2) in deionized water. The working treatment solution was prepared daily by serial dilution of the stock solution. Initially a range finding test was carried out in the nominal concentrations of (1000, 100, 10, 1 and 0.1 mgL^{-1}) for 96 hours. Ten eggs per concentrations were used. Deionized water was used as a negative control. Each treatment had three replicates. Acute Cu, Zn, Pb, As, Cd and Hg toxicity experiments were performed for a 4-day period using *Danio rerio* embryo. Ten test concentrations of Cu, Cd (0.025, 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4 and 10.0 mgL^{-1}), Zn, Pb, As (2.0, 4.0, 8.0, 16.0, 32.0, 64.0, 125.0, 250.0, 500.0 and 1000.0 mgL^{-1}) and Hg (0.002, 0.004, 0.008, 0.016, 0.032, 0.064, 0.125, 0.250, 0.500 and 1.0 mgL^{-1}) were prepared by diluting the stock solution in deionized water. Deionized water was used as negative control and as internal plate control. As a positive control concentration of 15% ethanol(Hassan *et al.*, 2008) was used with each embryo batch for testing. Fertilized zebra fish embryos were immersed in the test solutions before cleavage, by the 16 cell-stage. At least twice the number of eggs needed per treatment group (40 eggs) was randomly selected and transferred into the respective concentrations and controls within the 90 minutes of post fertilization. 24-well plates were filled with 2 mL per well freshly prepared test solutions. In each plate twenty wells were used for test concentrations and four were used as internal plate control. Another plate was used as positive control. The eggs in standard 24- well plate were covered by shelf adhesive foil and maintain at a temperature to $26 \pm 1 \text{ }^\circ\text{C}$. The mortality of the fish eggs were recorded at 24, 48, 72 and 96 hours of exposure using a stereo microscope with the indicator of lethality; coagulation of fertilized egg, lack of somite formation, lack of detachment of the tail and lack of heart beat as described in OECD/ OCDE 236, 2013; guideline for the test of chemical, Fish Embryo Acute Toxicity (FET) tests. Dead eggs were removed immediately. Three replicates were performed individually. In this study the acute toxic effect of each metal on the *Danio rerio* embryo was

determined by Probit Analysis LC₅₀ determination method. Data analysis was performed by using statistical software SPSS15.

Results and Discussion

According to the analysis in the range finding test, minimum concentration that can cause 100 % mortality was recorded. Based on the result obtained, range for As, Pb and Zn is below the 1000.0 mgL⁻¹, for Cd and Cu less than 10.0 mgL⁻¹ and for Hg less than 1.0 mgL⁻¹. The relationship between the metal concentration and mortality rate of each trace metal was recorded based on the four apical endpoints. It shows that mortality rate is increasing with the increasing concentration and time of exposure. Acute toxicity of As, Cd, Hg, Pb, Cu and Zn showed that mortality is directly proportional to the concentration of the trace metals. The probit analysis revealed that there is a significance difference between the trace metals and control group (P < 0.05). According to the analysis of median lethal concentration (LC₅₀), Hg is highly toxic to the *Danio rerio* embryo and followed by the Cu, Cd, Zn, As and Pb. The toxicity trend of LC₅₀ 96 hrs observed was Hg (0.0217 mgL⁻¹) < Cu (0.099 mgL⁻¹) < Cd (0.407 mgL⁻¹) < Zn (14.021 mgL⁻¹) < As (34.840 mgL⁻¹) < Pb (41.697 mgL⁻¹). LC₅₀ and upper and lower confidence limits revealed a decreasing trend from 24 to 96 hrs (Table 1). Fish embryo stage is highly sensitive to metal pollution. The chorion does not fully protect the embryo against metal penetration. In this study, the most toxic trace metal to *Danio rerio* embryo is Hg. The LC₅₀ values of Hg at 24, 48, 72 and 96 hrs were less than 0.04 mgL⁻¹. It shows that even at lower concentration it can cause high mortality rate on *Danio rerio* embryo.

Table 2: Summarized LC₅₀ value of trace metals on *Danio rerio* for a period of 24 – 96 hrs

Trace metals	LC ₅₀ (95% confident limits – lower, upper)			
	24hrs	48hrs	72hrs	96hrs
Hg	0.0397 (0.0324,0.0488)	0.0229 (0.0245,0.0367)	0.0218 (0.0182,0.0263)	0.0217 (0.0180,0.0260)
Cu	0.1735 (0.1498,0.2011)	0.1306 (0.1128,0.1512)	0.0991 (0.0844,0.1157)	0.0991 (0.0844,0.1157)
Cd	0.5660 (0.4339,0.741)	0.464 (0.3505,0.613)	0.418 (0.3152,0.550)	0.407 (0.3072,0.536)
Zn	23.083 (18.871,28.13)	17.080 (13.936,20.801)	14.021 (11.347,17.147)	14.021 (11.347,17.147)
As	42.915 (36.223,50.97)	38.313 (32.007,45.98)	34.840 (28.903,42.08)	34.840 (28.903,42.08)
Pb	113.8 (88.5,149.6)	63.90 (50.81,81.0)	43.75 (35.75,53.71)	41.70 (33.97,51.34)

In *Danio rerio* embryo toxicity test several sub-lethal and teratogenic endpoints were observed. In control no deformities were observed. Growth retardation, Shrinkage of chorion, Scoliosis, Pericardial edema, Yolk sac edema, Lack of pigmentation, Tail deformities, Hemorrhages, missing formation of lens and Lack of otoliths are the major deformities observed during the study. Growth retardation is mainly caused by growth inhibitors of Cd and Cu (Sikorska and Wolnicki, 2006). Skeletal deformities in fish are good bio indicators of pollution (Bengtsson, 1979; Lemly, 1997; cited in Curtis, 2004). Damage of the vertebral column expressed as curvature of the larval body axis is

caused by all heavy metals toxification (Jeziarska *et al.*, 2000; Nguyen and Janssen, 2002; Hallare *et al.*, 2005; cited in Osman, 2007). The tail deformities genetically resulting from the inability of treated embryos to express the *evenskipid* gene (Osman, 2007). Pigmentation is controlled by Melanocyte Stimulating Hormone (α MSH) and Melanin-Concentrating Hormone (MCH). Pigmentation changes in fish are often due to stress induced (Nguyen and Janssen, 2002; cited in Osman, 2007).

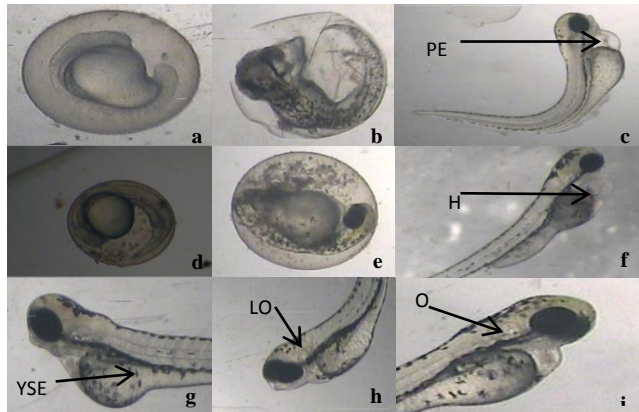


Figure 2: Sub-lethal and teratogenic endpoints ; Growth retardation (a), Shrinkage of chorion (b), Scoliosis and Pericardial edema (c), Lack of pigmentation (d), tail deformities (e), Hemorrhages (f), Yolk – sac edema (g), Lack of otoliths (h), Normally developed *Danio rerio* embryo after 96 hpf

Conclusion

In the present study, a comparison of LC₅₀ values, sub-lethal and teratogenic effects indicated that Hg is highly toxic to *Danio rerio* embryo followed by Cu, Cd, Zn, As and Pb. The LC₅₀ value of each trace metal is increasing with increasing concentration and time of exposure. This study indicates that *Danio rerio* embryo is a potential indicator for trace metal pollution.

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Development of micropropagation protocols for two aponogeton species of Sri Lanka (*Aponogeton crispus* and *Aponogeton natans*)

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Introduction

Sri Lanka being a tropical country contributes for a highly diversified flora and fauna. These climatic conditions have become a critical factor for the occurrence of highly diversified aquatic flora as well. *Aponogeton* is genus of aquatic plants which belongs to the family Aponogetonaceae. According to Bruggen there are four *Aponogeton* species occur in Sri Lanka (Dassanayake and Fosberg, 1987). Among these species *Aponogeton jacobsenii* and *A. rigidifolius* are endemic to Sri Lanka while *A. natans* and *A. crispus* are native plants (Wijesundara and Shantha Siri, 2004). They are having a high demand as an aquarium decorative plant in the export market. This study was carried out to develop a micropropagation protocol for mass production of *A. crispus* and *A. natans* and *A. jacobsenii* species.

Methodology

The study was carried out at tissue culture laboratory of Royal Botanic Gardens, Peradeniya. Mother plants were collected from different areas of Sri Lanka. Experiments were done to determine hormonal effect on shoot initiation and multiplication using rhizomes of *Aponogeton crispus* and *A. jacobsenii*; leaf and leaf stalks of *A. natans* and *A. jacobsenii* and seeds of *A. crispus* and *A. natans*. For the Sterilization of *A. crispus* and *A. jacobsenii* rhizomes were kept under running tap water for 3 hours and dipped in a fungicide for 30 minutes. Then disinfected using 20 % NaOCl (Clorox) with 2 drops of Tween twenty for 10 minutes and washed with 0.1 % HgCl₂ for 7 minutes. Finally rhizomes were washed 5 times thoroughly with distilled water per 5 minutes. For seeds sterilization seeds were kept under running tap water for 10 minutes, disinfected using 5 % Clorox with 2 drops of Tween twenty for 15 minutes and washed 3 times with distilled water. Three sterilization procedures were carried out for leaves and leaf stalks. Firstly leaves kept under running tap water for 1 ½ hours and dipped in fungicide (topsin) for half an hour. Then washed with 5 % of NaOCl (Clorox) for 10 minutes and washed with 0.1 % HgCl₂ for 3 minutes. Finally leaves washed 3 times with distilled water. Again sterilization procedure was tested by using 5 % NaOCl for 5 minutes and 0.1 % HgCl₂ for 2 minutes. As the final method leaves were sterilized with 2 % of NaOCl for 2 minutes 0.1 % HgCl₂ for 1 minute. Basal full strength MS medium supplemented with 20 mgL⁻¹ of sucrose and 7 gL⁻¹ of agar was used. pH was adjusted to 5.6. Different levels of BAP and IAA hormones were tested for the experiments (Figure 1, 2, 3). Cultures were maintained under controlled condition of 26 °C +/- 2 °C temperatures and white fluorescent light with 16 hour photoperiod for shoot regeneration. Ten replicates per each treatment were maintained and media without adding hormones used as the control. Experiment was arranged in factorial Complete Randomized Design (CRD). Data analyzed using ANOVA and Tukey's Test using MINITAB 17 software.

Results and Discussion

In the study only rhizome culture of *Aponogeton crispus* and seed culture of *A. crispus* and *A. natans* were succeeded. Shoot initiation was not observed in rhizome culture of *Aponogeton jacobsonii* within six week time period. Leaf and leaf stalk culture was unsuccessful due to over sterilization. The effects of the hormone concentration on shoot regeneration of *Aponogeton crispus* had shown a significant difference ($p < 0.05$). Maximum mean number of shoot initiation was observed in culture medium T6 (Figure 1). Minimum number of shoot initiation was observed in T7 (Figure 1). Shoot regeneration was not observed in hormone free MS medium. There was a significant different between T1, T4 and T6 (Figure 1).

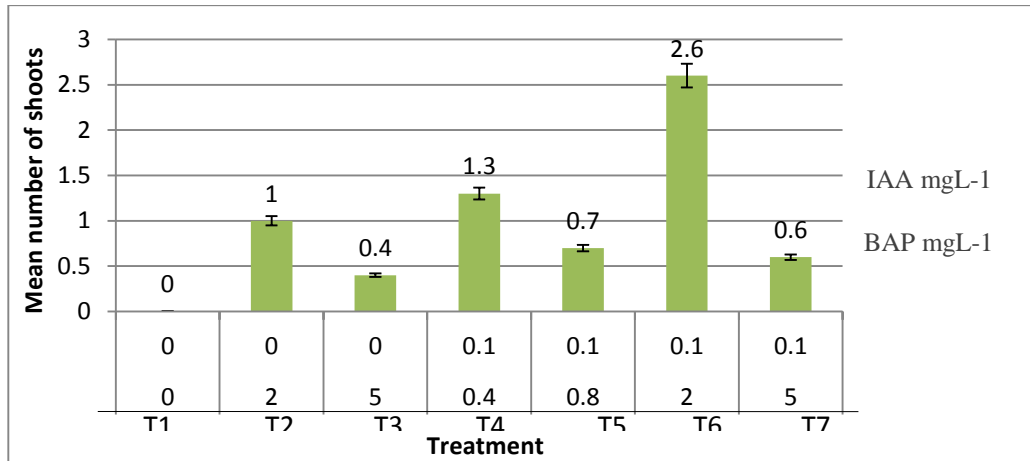


Figure 3 : Effect of hormone concentration on shoot initiation of *Aponogeton*

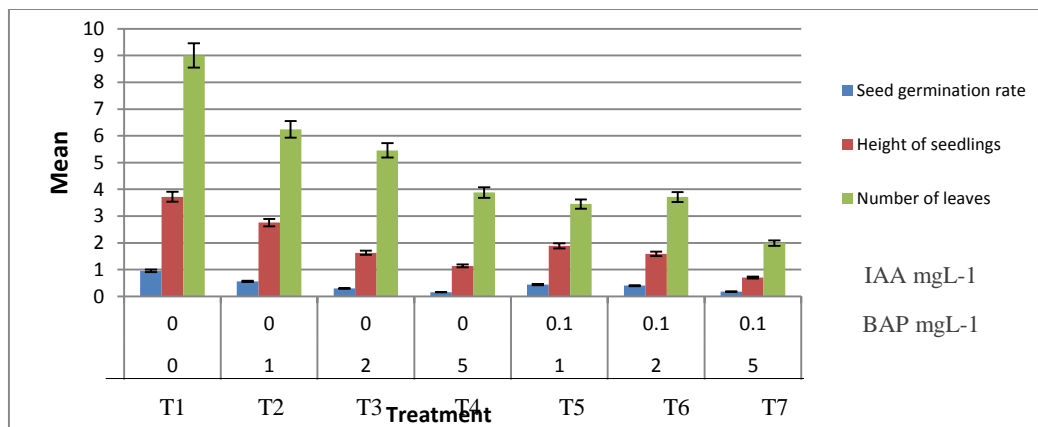


Figure 4: Effect of different hormone concentration for Seed culture of *Aponogeton natans*

Seed culture of *Aponogeton natans* and *A. crispus* were succeeded. The data analysis of *Aponogeton natans* seed culture had shown a significant difference ($p < 0.05$) in mean of seed germination rate, mean height of seedlings and mean number of leaves. Highest mean of seed germination rate was observed in hormone free MS media (T1). Minimum mean number of seed germination was observed in medium supplemented with 5 mgL⁻¹ of BAP. There was a significant difference among T1, T2 and T4. The maximum mean height of seedlings and the maximum mean number of leaves were observed in hormone free MS medium followed by T2, T3, T4 and T6 (Figure 2). The minimum height of

seedlings and the minimum mean number of leaves were observed in T7 medium which was supplemented with high concentration of BAP (5 mgL^{-1}) and IAA (0.1 mgL^{-1}). (Figure 2)

There was a significant difference in treatments for seed germination ($p < 0.05$) of *A. crispus*. The maximum seed germination was recorded in hormone free MS medium (T1). The minimum seed germination was observed in T4 medium which was supplemented with 1 mgL^{-1} of BAP and 0.1 mgL^{-1} of IAA. The maximum mean height of seedlings and the maximum mean number of leaves were observed in hormone free MS medium (T1). The minimum mean height of seedlings and the minimum mean number of leaves were observed in medium which contained 1 mgL^{-1} of BAP and 0.1 mgL^{-1} of IAA. (Figure 3)

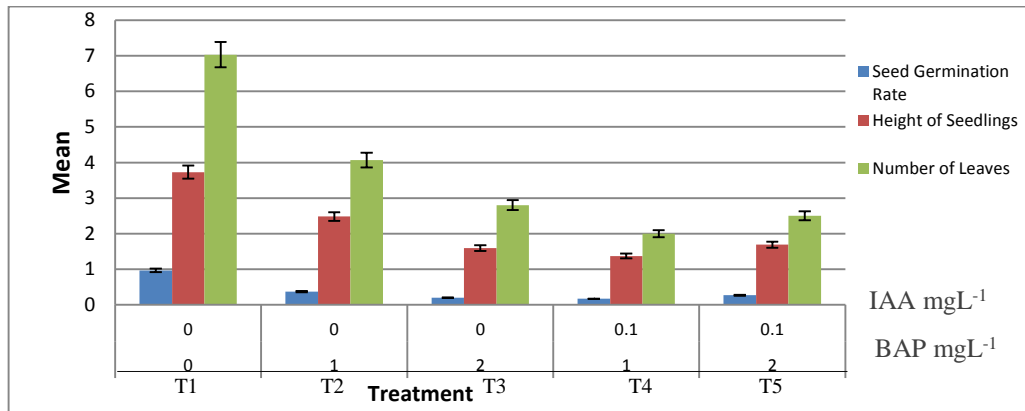


Figure 3: Effect of different hormone concentration for Seed culture of *Aponogeton crispus*

Medium supplemented with 2 and 5 mgL^{-1} of BAP were used for shoot multiplication. Data analysis of *A. crispus* and *A. natans* had shown a significant difference ($p < 0.05$) among hormone treatments. Maximum was obtained in the medium supplemented with 2 mgL^{-1} of BAP. The toxicity caused by an excess of growth regulators in the culture medium, or the extended period of time in which the culture was exposed to them, might lead to genetic, physiological and morphological changes, resulted in a reduction of the proliferation rate in vitro (Narayanaswamy, 1977). It is therefore important to evaluate their effects on plant regeneration.

Conclusion

Among selected hormone concentrations 2 mgL^{-1} of BAP and 0.1 mgL^{-1} of IAA is the most suitable combination for shoot regeneration of *A. crispus*. MS medium without hormones is more effective for seed culture of *A. crispus* and *A. natans*. Culture medium supplemented with 2 mgL^{-1} of BAP is more suitable for multiplication of seedlings of *A. natans*.

Acknowledgement

I'd like to convey my sincere gratitude to Dr. S. A. Krishnerajah, Deputy Director of Floriculture Research and Development. Also to all the staff members of Tissue culture laboratory at Royal Botanic Gardens, Peradeniya.

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Consumption pattern of fish among households in Batticaloa District

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Introduction

Fisheries sector in Sri Lanka provides livelihood for more than 2.5 million coastal communities as well as providing more than 50% of animal protein requirement of people in the country (NARA, 2012). The fact that fish is relatively cheap compared with meat, beef, mutton, poultry, and pork, which also contains protein of high biological value tends to make it preferred to other sources of animal protein (Adeniyi *et al.*, 2010). In Batticaloa District presence of a long seacoast and the mile long lagoon provides a good fishing environment. It leads to high availability and production of both inland and marine fish (Dist. Planning Secretariat, 2013). About 85% of people in Batticaloa District consume fish as their major protein food (Devadawson and Jayasinghe, 2014). Therefore, this study was designed to determine the quantity of fish consumed, expenditure on fish and preferences for various fish varieties by households in Batticaloa District.

Methodology

Data related to frequency of fish purchases, price of different fish varieties, preference of fish varieties and other fish purchasing details were collected from 120 respondents at 3 rural and 3 urban markets in 6 DS Divisions in the Batticaloa District. Purposive sampling technique was used to select the respondents and a pre tested and well-structured questionnaire was used to collect data. The data was analyzed using SPSS Ver.22.0 software.

Result and Discussion

The data revealed that the majority of the respondents (66%) were consuming both marine and inland fish varieties, while 24% of the respondents consume marine fish only and 10% consume inland fish only. It was also evident from the data that about 34% of the respondents had some specific reasons for the avoidance of certain fish types in their meal. Avoidance of marine fish varieties in fish purchase occurs only due to the high market price compared to inland fish. In case of inland fish avoiders, 82% of them avoid due to the unfavorable odor emanating during the cooking process, 62% of them avoid due to polluted and unsatisfactory sanitary conditions prevalent in fishing areas and rest (13%) avoids inland fish due to unpalatable taste.

In purchasing fish about 26% of the consumers considered only the desirable characters of fish, around 68% considered both price of fish and fish characters equally and only 6% considered the price of fish in purchasing decisions. Freshness of fish is the important fish character considered in fish purchasing. Around 97% of consumers were very specific about the freshness of fish they purchase. About 60% consumers were concerned about taste of the fish they purchase and 43% of consumers concerned about the allergic condition of fish to their family members and a quarter of the respondents (28%) pay attention to the appearance of the fish which include firmness of flesh, bone content and thickness of skin.

Table 1: Consumption pattern of Marine Fish Varieties (N=108)

Fish varieties	Percentage of Consumers purchasing	Frequency of purchases per month / family	Quantity purchased (Kgs/visit)	Mean Price (Rs./kg)	Preference (% of consumers)
1. Arukula (<i>Scomberomorus cavalla</i>)	36.11	1.23	0.56	1026.15	26.9
2. Kelawalla (<i>Tuna sp.</i>)	38.89	2.10	0.58	775.00	32.4
3. Paarai (<i>Carangoides malabaricus</i>)	66.67	2.47	0.60	673.75	37.0
4. Balaya (<i>Thunnus albacores</i>)	39.81	2.23	0.58	349.77	13.0
5. Soodai (<i>Sardinella sp.</i>)	45.37	2.06	0.62	245.51	2.8
6. Thalapath (<i>Istiuphorus platypterus</i>)	20.37	1.10	0.51	718.64	13.0
7. Keeri (<i>Amplicaster sp.</i>)	58.33	2.66	0.57	372.38	13.9
8. Neththali (<i>Anchoviella sp.</i>)	61.11	2.50	0.56	350.30	28.7
9. Sura (<i>Chaenogalus sp.</i>)	7.41	1.38	0.69	593.75	6.5
10. Seela (<i>Sphyraenabarracuda.</i>)	56.48	2.40	0.58	320.98	18.5
11. Kumbula (<i>Rastrelliger sp.</i>)	54.63	2.94	0.56	419.83	25.9
12. Thirukkai (<i>Dasyatis sp.</i>)	15.74	2.41	0.66	457.65	6.5

According to Table 1, in Batticaloa District, popular marine fish variety was *Carangoides malabaricus*. About 67% of the consumers purchased *Carangoides malabaricus* fish for their meal at an average of about 2-3 days per month. Fish purchased at high frequency in a month by respondents was *Rastrelliger sp.* (55% at 3 days/ month interval). The data clearly showed that no appreciable changes were observed on mean consumption of fish varieties and it was very independent with the quantity purchased and variety selected. The mean consumption of marine fish varieties at a single visit in study area was 0.59 kg. Data revealed that the high priced marine fish variety *Scomberomorus cavalla*, and mean market price was Rs.1,025 per kg. Cheapest marine fish variety in the study area was *Sardinella sp.* (Rs. 245 per kg). In the study area the respondents mostly preferred varieties of fish were 37% Paarai (*Carangoides malabaricus*), 32% Kelawalla (*Tuna sp.*) and 29% Neththali (*Anchoviella sp.*). The mean expenditure on marine fish purchases per family per month was Rs.3,042.

As shown Table 2, in the consumption pattern of inland fish varieties, about 72% of the consumers consumed *Oreochromis mossambicus*, 65% of them consumed *Etroplus suratensis* at an average of 3 times per month. The average quantity of inland fish variety purchased was more or less similar to all varieties. The mean quantity of inland fish variety purchased was 0.57 kgs per single visit.

According to the data, the high priced inland fish variety in the study area was *Ophicephalus sp.* (Rs.511 per kg) followed by *Cyprinus carpio* (Rs.504 per kg). In the study area, consumers most preferred varieties of fish were 44% *Oreochromis mossambicu (Tilapia)*, 25.3% *Seththal (Etropluss uratensis)* and 24% *Otti (Siganus sp.)* due to their reasonable prices and frequent availability. It was found that the mean expenditure on inland fish purchases per family per month was Rs.1,077.

Table 2: Consumption pattern of Inland Fish Varieties (N=91)

Fish varieties	Percentage of Consumers purchasing	Frequency of purchase / mth. Per family	Quantity purchased (Kgs/visit)	Mean Price (Rs./kg)	Preference (% of consumers)
1. <i>Tilapia (Oreochromis mossambicus)</i>	72.53	3.27	0.59	284.09	43.96
2. <i>Keluthi (Arius sp.)</i>	29.67	2.33	0.69	236.48	8.79
3. <i>Viral (Ophicephalus sp.)</i>	14.29	1.08	0.63	511.54	6.59
4. <i>Seththal (Etropluss uratensis)</i>	64.84	3.00	0.61	283.39	25.27
5. <i>Kayal (Liza sp.)</i>	26.37	1.71	0.53	346.67	12.09
6. <i>Koduwa (Ephinephalus sp.)</i>	19.78	1.56	0.57	383.89	6.59
7. <i>Otti (Siganus sp.)</i>	40.66	2.05	0.58	398.65	24.18
8. <i>Sallal (Etroplus aculates)</i>	20.88	3.00	0.51	242.11	3.30
9. <i>Kanayan (Cyprinus carpio)</i>	13.19	2.33	0.52	504.17	10.99
10. <i>Manalai (Mugil cephalus)</i>	13.19	2.17	0.44	281.67	3.30

Conclusions

Majority of the households were consuming both marine and inland fish varieties in the study area and they mostly consider the price of fish and desirable fish characters together during purchases. Price, freshness, allergic content and taste of fish were considered in purchasing decisions while freshness of fish was the important fish character considered in fish purchasing. Average quantity of fish purchased at a single market visit did not differ significantly between marine and inland fish varieties and was about 0.57 kg per household /visit. While the expenditure by households on marine fish purchases was almost three times higher than that on inland fish purchases. Hence promotion of sales of both marine and inland fish varieties could help households meet their consumption demands. Especially the promotion of inland fish culture or aquaculture could enhance production of inland fish and the level of fish protein intake among households at a cheaper cost.

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Isolation and incorporation of Nitrogenous compounds from Yellow Fin Tuna (*Thunnus albacares*) to produce a fish flavored vegetable burger

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Introduction

Fish processing industry is increasing continuously in the world *Thunnus albacares* is a one of the major fish used by many processing companies. Value added products are produced using tuna which include tuna steaks, tuna loin, tuna fillets, tuna blocks and canned tuna. At processing, trimmings are resulted as waste and discharged without any utilization. Hence, maximum utilization of fish waste is important. There are many nitrogenous compounds present in fish flesh. Nitrogenous compounds play an important role in flavor and taste of fish. Fish flavor components are non-protein-nitrogen compounds such as ammonia, monomethylamines, dimethylamines, trimethylamines, trimethylamonia bases (trimethylamine oxide and betaines), and guanidine derivatives such as creatine and argenine (Teerasuntonwat and Raksakulthai, 1995). Soya bean and chick pea can be used to produce vegetable burger since both contain high amounts of protein. Soya bean contains 38% to 42% protein (Balasubramaniyan and Palaniappan, 2004). Chickpea has significant amounts of all essential amino acids and is rich in nutritionally important unsaturated fatty acids such as linoleic and oleic acid (Jukanti, 2012). The objectives of this study was to find out the ways to maximize the utilization of fish waste generated in fish processing industry and to use them to extract flavor compounds in order to incorporate it in to a vegetable burger.

Methodology

Vegetable burger was prepared using soya and chick pea as the main ingredients. Dried soya bean was steamed at 80°C for 20 minutes and ground using a grinder (IS 4250, Jaipan family mate, India). Weighed ingredients were mixed and the pulp was made. Prepared mixture was then cooked in a steamer (WP5525, WIPRO, China) at 80°C for 20 minutes. Ingredients level of the burger was determined by preliminary sensory evaluations keeping soy and chick pea flour levels constant. For determination of best combination of soya and chick pea flour, 5 recipes of vegetable burger were prepared by decreasing the soya level from 100% to 0% and increasing the chick pea level from 0% to 100% while keeping the other ingredients constant. Thirty untrained panelists were used to select the best formula for the burger. Fish flavor was extracted according to the method of Teerasuntonwat and Raksakulthai (1995) with some modifications. Yellow fin tuna trimmings were cut in to small pieces and ground using the grinder (Jaipan family mate) with 1% (w/v) NaCl (Fluka, England). Blended samples were transferred in to a 1000 mL beaker (PYREX, England) and heated at 60°C for 15 minutes using a stirrer (SR No:67702, VELP® SCINTIFICA, Europe). Heated samples were filtered using Whatman No: 4 filter papers. Filtration was dialysed to remove salt. Extracted fish flavor was kept under freezing condition and used instead of water (28%) in vegetable burger preparation.

For determination of best concentration to extract volatile compounds series different concentrations (w/v) of NaCl (0.1%, 1%, 5% and 10%) were prepared. Vegetable burger was prepared using the recipe developed and separated dialysis solutions. Best NaCl concentration was determined by a sensory evaluation test using 30 untrained panelists. Sensory evaluation data were statistically analyzed using non parametric Friedman test in Minitab 16. Lipid oxidation, pH value and proximate composition were determined in triplicate during 30 days of storage at 4°C. Microbiology tests were

done for *Escherichia coli*, *Salmonella*, *Staphylococcus* and total plate counts. Crude protein, crude fat, moisture and ash contents of fish flavored vegetable burger were analyzed using AOAC standard methods (2002) with some modifications. The cost of product was calculated for the best treatment selected from the final trial.

Results and Discussion

Majority of the panelist did not accepted the chick pea containing recipe ($p < 0.05$). Therefore, only soya flour was selected as the plant protein source of the vegetable burger. At the same time cost analysis results showed that 100% soya containing recipe was cheaper than chick pea containing recipe. Hence, vegetable burger recipe was finalized. Finalized vegetable burger recipe containing 55% (w/w) of soya flour, 5% (w/w) of wheat flour, 1.5% (w/w) of chili powder, 1% (w/w) of pepper, 2% (w/w) of garlic, 1.6% (w/w) of salt, 5.9% (w/w) of vegetable oil, and 28% (w/w) of water. Then several trials were carried out to determine the best dilution series. Then NaCl:fish= 1:1 ratio was selected as the best dilution series by sensory evaluation tests.

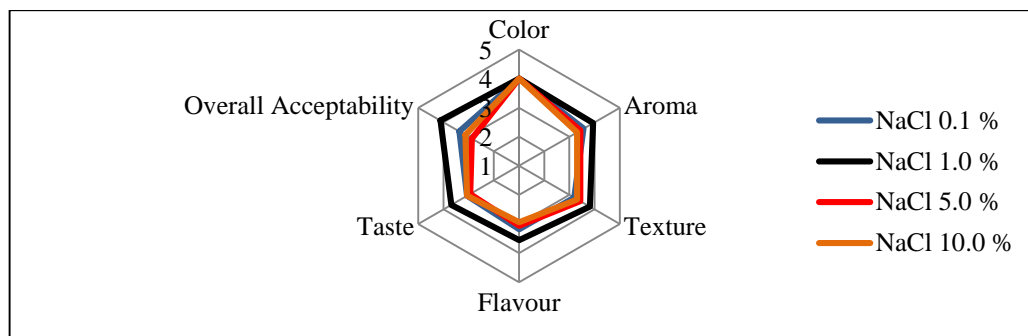


Figure 1: Sensory evaluation for determination of best NaCl concentration

According to Figure 1; 1% (w/v) of NaCl gave the highest organoleptic properties compared to rest of treatments ($p < 0.05$). Therefore to separate protein and other volatile compounds 1% (w/v) with 1:1 dilution can be considered as the best NaCl concentration.

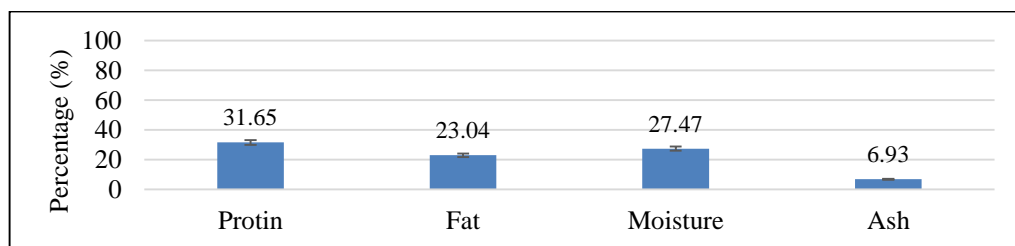


Figure 2: Proximate composition of the developed vegetable burger

According to the proximate analysis results, the fish flavored vegetable burger is rich in protein and fat content. Vegetable oil such as soy bean, nuts and rapeseed containing poly unsaturated ($\omega 3$) fatty acids (Linolenic acids). Soy bean containing 7 % of α -linolenic acid and 18 carbon omega-3 fatty acids with 3 double bonds. ω -3 fatty acids prevent from the cardio vascular disease and ω -3 fatty acids such as docosahexaenoic acid are incorporated in to neural tissues, notably brain and retina. Hence poly unsaturated fatty acids are healthier than saturated fatty acids such as animal fat (Nettleton, 1995). It proved that this fish flavored vegetable burger is healthier than a meat origin burger.

There was no significant increase in pH during storage at 4°C. The pH value range of the burger was 6.29-6.8 during storage time. Soy protein has a relatively high pH value compared to the meet protein. Lean meat has approximately pH of 6.0. Therefore increasing the levels of soy protein have a tendency to increase the pH value (Hoogenkamp, 2005).

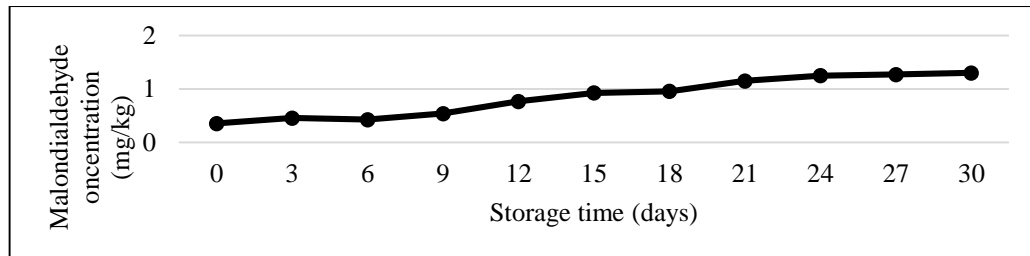


Figure 3: Changes in lipid oxidation value with the storage

There was a significant increase in lipid oxidation during the storage at 4°C for 30 days. Polyunsaturated fatty acids oxidized readily because their double bonds are unstable. Oxidation of unsaturated fats produces a variety of compounds that smell and taste rancid. Saturated fats are more resistant to oxidation (Whitney *et al.*, 2011). Soya bean is rich in lipoxygenase and unsaturated fatty acids. Mechanical destruction and the presence of water or heat can accelerate the rate at which lipoxygenase catalyze unsaturated lipid oxidation (Riaz, 2006). Therefore increase of the oxidation due to the continuous oxidizing process of the poly unsaturated fatty acids of the soya bean. But according to the results, level of oxidation was within the acceptable level. Therefore, the product developed is suitable even after 30 days of storage even though the lipids oxidized during storage.

There was no growth of hazardous microorganism in the sample during the time of testing. According to SLSI specification for quick frozen whole fish, fish fillets, steaks and minced fish products microbiology test were done. There were only positive results in total plate count but levels did not exceed the SLSI recommended limits

Conclusion

The best dilution series for fish flavor extraction is 1:1 ratio of fish and NaCl (1% w/v). Fish flavored vegetable burger was a nutrient rich low cost product.

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Induced breeding of Silver Dollar (*Metynnis hypsauchen*) using ovaprim

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Introduction

Production of ornamental fish is a rapidly growing sector of the aquaculture industry (Tlustý, 2001). Among the ornamental fish production in Sri Lanka, exotic ornamental fishes have a significant demand in the market. Silver Dollar (*Metynnis hypsauchen*) which was originated from South America is such kind of exotic ornamental fish in Sri Lanka that a higher demand has been achieved. Silver Dollar is not breeding very often in Sri Lanka since it takes a longer spawning period. To avoid that problem, the fish can be bred artificially. Among all the artificial breeding methods, induced breeding by hormone administration is the most reliable method (Yanong, *et al.*, 2013). In this study attempts were made to develop induced breeding of Silver Dollar (*Metynnis hypsauchen*) in Sri Lanka using inducing hormone "Ovaprim".

Materials and method

Sexually matured and healthy Silver Dollar brooders were selected based on the external features. Eighteen pairs in same age were randomly collected and conditioned. Then Ovaprim as a single dose by intramuscular injection at a dosage of 0.2 ml kg⁻¹, 0.3 ml kg⁻¹, 0.4 ml kg⁻¹, 0.5 ml kg⁻¹ and 0.6 ml kg⁻¹ of body weight was administered to the brooders. Natural spawning was also allowed without inducing by Ovaprim as a control. After the hormonal injection, the best range of Ovaprim dose to have least response time and better breeding performance of Silver Dollar was determined based on response time (hours). Relative fecundity, post mortality rate of brooders and water quality parameters in experimental tanks were also monitored. Data analysis was done by one way ANOVA and Tukey test.

Results and Discussion

The effects of different doses on the breeding performance of Silver Dollar are shown in Table 1. Salmon gonadotropin releasing hormone analogue sGnRH_a (Ovaprim) successfully induced spawning in Silver Dollar (*Metynnis hypsauchen*). Five different Ovaprim doses supported the spawning activity and the breeding performance was favored by lower and middle inclusion level of Ovaprim dose in the experiment.

Ovaprim is a well-known commercial spawning aid which is mostly used in induced breeding of fish (Anonymous, 2012). It has been used in successful manner for several fish families (Hill *et al.*, 2005). In the present study, all the brooders spawned, except the brooders which were injected with 0.6 ml kg⁻¹ of body weight Ovaprim. Among those 6 treatments, the least response time was recorded with 0.3 ml kg⁻¹ of body weight Ovaprim as 5.66 hours. The maximum response time was observed in naturally spawned pairs as 632 hours (27 days). According to the literature, 0.5 ml kg⁻¹ of body weight is the standard Ovaprim dose for fish (Hill *et al.*, 2005). However, in the case of Silver dollar, 0.3 ml kg⁻¹ of body weight is the best dose to have the minimum response time (Table 1).

Table 1: Breeding performance of Silver dollar induced with Ovaprim

Parameter	Dose 1 (0 ml kg ⁻¹ OP)	Dose 2 (0.2 ml kg ⁻¹ OP)	Dose 3 (0.3 ml kg ⁻¹ OP)	Dose 4 (0.4 ml kg ⁻¹ OP)	Dose 5 (0.5 ml kg ⁻¹ OP)	Dose 6 (0.6 ml kg ⁻¹ OP)	P value
RT	632±	6.33±	5.66±	9.50±	7.00±	0.00±	0.000
(hrs)	146.60 ^a	0.57 ^b	0.28 ^b	0.50 ^b	0.50 ^b	0.00 ^b	
RF	4.63±	3.61±	2.19±	5.22±	6.43±	0.00±	0.000
	1.86 ^{ab}	1.32 ^{ab}	1.20 ^{bc}	0.30 ^a	0.50 ^a	0.00 ^c	

[Values are presented as means ± S.D., means in each row with different superscripts are significantly different from each other. (OP: Ovaprim; RT: Response time; RF: Relative fecundity)]

The maximum relative fecundity was observed with 0.5 ml kg⁻¹ of body weight Ovaprim (Table 1). Dose range between 0.4ml kg⁻¹ - 0.5 ml kg⁻¹ of body weight could be identified as the better range to have a higher fecundity. Because of that, further studies should be followed to identify the best dosage which is occurred between 0.4 ml kg⁻¹ - 0.5 ml kg⁻¹ of body weight Ovaprim. Spawning has not occurred with 0.6 ml kg⁻¹ of body weight Ovaprim (Table 1). It indicates that, dosage beyond 0.5 ml kg⁻¹ of body weight Ovaprim might not be effective in breeding of Silver Dollar. The use of Ovaprim as a spawning aid in ornamental fish was surveyed in the United States, and they have found that some species may not be responsive to the GnRHa in Ovaprim or may require application under a different protocol (Hill *et al.*, 2005). Based on the literature and the obtained results of the present study, a comparatively medium level of Ovaprim dose (0.4ml kg⁻¹– 0.5 ml kg⁻¹) can be recommended for a higher relative fecundity.

The survival rate of brooders was 100 % after Ovaprim was injected. According to the observation, the hormone dosage range which was used for the present study might not be harmful and there was no negative effect to Silver Dollar. Achionye and Obaroh, (2012) have found that procedure of injection, quality of the hormone and degradation of water quality during holding and handling of fish affect to the post mortality of brooders. At the present study, conditioning and domesticating brooders before hormone injecting, maintaining water quality, supplying nutritious feeds, using quality hormone and reduced handlings of fish due to the single dose administration to both sexes might have affected for this decreasing of post mortality of brood fish (More *et al.*, 2010). There was no any significant difference (P > 0.05) in water temperature, Dissolved oxygen and pH in six different treatment tanks.

Since a successful result could be obtained through the study, following further studies and providing the facilities for practicing induced breeding of Silver Dollar using Ovaprim can be done to make Silver Dollar available to breeders and producers for mass scale production. Because, considering the relatively simple technique involved, this activity has the potential to create adequate job opportunities, increase export earnings as well as develop the ornamental fish industry in Sri Lanka.

Conclusions

Minimum spawning time in Silver Dollar can be achieved by 0.3 ml kg⁻¹ of body weight and maximum relative fecundity can be obtained with 0.5 ml kg⁻¹body weight Ovaprim. From the

available references along with the present study on the induced breeding of the Silver Dollar, it was observed that better breeding performances were achieved from a comparatively lower dosage of Ovaprim.

Acknowledgement

The acknowledgement of authors is given to Uva Wellassa University and National Zoological Gardens, Sri Lanka for their support and encouragement for success of the research.

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A comparative study on the effectiveness of gillnet and longline fishing methods used by multi-day fishermen in Matara fisheries district

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Introduction

The fisheries sector of Sri Lanka is a primary source of animal protein production. According to the high rate of population growth in Sri Lanka, fish food demand is increasing. To fulfill this increasing demand, there should be an effective fishing method for high rate of exploitation and exploited resources should be high quality and high value for the better utilization. In the late 1980s, Sri Lankan state introduced multiday offshore fishing vessels for the development of Sri Lankan offshore fisheries (Kariyawasam, 2010). The gillnet fishery and the longline fishery is the common fishing methods used in the deep sea fishing in Sri Lanka. According to the DFAR statistics in 2013, Matara fisheries district is one of the districts which provide high fish production to the nation. The gillnet fishery is most commonly used fishing method in multiday boats fishermen in Matara fisheries district and they do not engage in longline fishery very much. The identification of the suitable fishing methods is important to increase production level, quality of the production and income of the multiday fishermen. Therefore the present study is focused on comparison of the effectiveness of gillnet fishing and longline fishing methods as a deep sea fishing method used by multiday fishermen in Matara district.

Materials and Methodology

The data were collected from multiday fishing boats in “Dondra” fisheries harbor from 1st of May to 14th of June 2014. The sample size was determined by “Moving average method” and the total landings and fishing methods of 66 multiday boats were collected accordingly. Catch and effort data, income of the fishermen and quality of the landing were collected using prepared data sheets. The catch and effort data collection sheet was consisted of data regarding the duration of the fishing, the fishing techniques (gear) used in the trip, total catch per day, the species composition of the catch in number and/ or weight, gear information (length of net, mesh size, number of hooks per long line, soaking time,) vessel information (storage facilities, hauling technique, length of boats). The income data collection sheet was consisted of species composition, total weight of each fish species and price of the fish in particular day. Organoleptic survey has been done in order to determine the quality of the fish yield of each boat. According to the organoleptic evaluation, nature of the fish skin, nature of the gill, eye appearance and consistency of flesh were evaluated. The quality of the fish has been evaluated by scoring them according to the level of quality. Then mean of the score of the quality parameter was calculated to determine quality of the harvest in each multi-day boat. The collected data have been analyzed by using “Microsoft excel-2010” and compared with “One-way ANOVA table” by using “Minitab 16” software.

Results and Discussion

According to the study, there were 3 types of main fishing methods which were used by multi-day fishermen in Matara fisheries district. They are, gillnet, longline and combination of gillnet and longline fishing methods. There were 39.4% multiday fishing boats which used only gill net, 22.7% multiday fishing boats which used only long line and 37.8% fishing boats which used a combination of gillnet and long line. Mainly tuna and tuna like species were targeted in the study. The total catches of the different fishing gears were taken as weight of harvest per boat day. According to the results, the mean catch per boat day of the gill net, long line and combination of the longline and gill net were 133.7 kg, 94.2 kg, and 165.1 kg respectively. Therefore the multiday boats which used combination of gillnet and longline fishing method gained significantly higher yield than that of gillnet and longline fishing methods. The lower mean catch per boat day was gained by the longline fishing method.

When considering main fish species which were caught by each fishing gear, the mean catches per boat day of Skipjack tuna (*Katsuwonus pelamis*) were 62.11 kg, and 64.76 kg respectively for gill net, and combination of the gill net and longline. In Matara fisheries district there were no multiday fishermen who used longline fishing method to catch skipjack tuna. The mean catches per boat day for yellow fin tuna (*Thunnus albacares*) were 7.05 kg, 79.39 kg and 70.56 kg respectively for gillnet, longline and combination of gillnet and long line. Similarly the mean catches per boat day of frigate tuna (*Auxis thazard*) were 12.29 kg, and 70.56 kg in gillnet, and combination of gillnet and longline respectively. There was no frigate tuna catch in long line fishery. According to this result, mainly long line fishing gear was used to harvest yellow fin tuna. The skipjack tuna and frigate tuna were harvested by using gillnet fishing method.

When considering income of the multiday fishermen, the mean of the total income of multi-day fishermen who harvested fish using gill net, longline and combination of gillnet and longline is Rs 300,577.00, Rs 1,251,567.00 and Rs 1,068,474.00, respectively. The highest income was gained by the multi-day fishermen who used longline fishing method and the lowest income was gained by fishermen who used gillnet fishing method, among the three fishing methods.

According to the organoleptic survey data, the quality of the fish in gill net, long line and combination of gill net and long line fishing methods were 1.99 ± 0.41 , 2.32 ± 0.31 and 2.04 ± 0.39 , respectively. The quality of the fish was high in fish which were harvested by longline and quality was low in fish which were harvested by gillnet.

In the ANOVA test, there was not significant different between gear categories and the total catch per boat day ($P > 0.05$). But, there was a significant different between gear categories and catch per boat day of tuna and tuna like species ($P < 0.05$). Similarly, there were significant differences between gear categories and income of the fishermen and also gear categories and quality of fish ($P < 0.05$). According to these result, it shows gear categories are not significantly affect on the total catches per boat day but it significantly affect for the catches of tuna and tuna like species, income of the fishermen and quality of fish.

According to the above results, the gillnet fishing method has recorded, high catch, low income and low quality fish and long line fishing method has recorded low catch, high income and high quality fish while combination of gillnet and long line fishing method has recorded high catch, medium income and medium quality fish.

But the ANOVA result showed total catch per boat day was not significantly affected by fishing gear categories. Therefore, though they have similar amount of fish harvest, multi-day boat fishermen who used longline fishing method has had high income and high quality fish than other two types of fishing methods. The analysis of catch composition of tuna and tuna like species showed that long

line fishing method is much more species selective fishing gear than other two types of fishing methods. It is used to catch only target fish species which having high commercial value. And also, the amount of fish discarded by the longline is less than that of gillnet due to harvest of high quality fish in longline fishing method. The reason is that the fish remain alive for much longer period when hooked than when gilled (Santose *et al.*, 2002). Because of that reason, the quality of the fish that harvested by longline is higher than gillnet fishing method. Because of their high quality, the value of the fish increases and fishermen obtained higher income with the longline fishing method.

Conclusion

When considering all these aspects, it can be suggested that the longline fishing method is an effective fishing method for multi-day fishermen in deep sea fishing at Matara fisheries district comparatively. And the longline fishing method can be used to harvest other targeted fish species by changing bait types and hook size.

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A review of export trade of indigenous aquatic plants species in Sri Lanka and their conservation issues

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Introduction

Aquatic plants are adapted to aquatic environments and are required special adaptations for living submerged in water or at the water's surface. In addition to various ecological and industrial values, most of aquatic plants are having ornamental value. Due to the ornamental value of the aquatic plants, they have a huge demand and are exported from Sri Lanka. Along with ornamental fish industry, aquatic plants are introduced and exported as a simultaneous industry. Present study was intended to analyze and evaluate the trade of ornamental aquatic plants in Sri Lanka with a particular focus on indigenous species. The objectives of the study are determine the exported species and their quantities, the actual foreign exchange earnings, identify the conservation issues related to indigenous species, identify the trends to occur irregularities in exportation procedure and propose suitable.

Materials and Methods

Exported aquatic plants species data and their quantities were extracted from the Customs Goods Declaration Forms (CusDec) submitted by the ornamental aquatic plants exporters to the Air Cargo Terminal in Katunayake under the Department of Sri Lanka Customs. The Customs Goods Declaration Forms submitted during the period of one year from 1st March 2013 to 28th February 2014 were analyzed. A questionnaire was also used to gather information regarding the conservation issues through ornamental aquatic plants exporters, Custom officers at frontier and local villagers.

Results and Discussion

During the one year period from 1st March 2013 to 28th February in 2014, a total of 218 species of aquatic plants has been exported to 43 countries from Sri Lanka. Among the total, 176 species were indigenous, 1 species was endemic. When considering the total quantities of exported indigenous aquatic plants during the one year period, the most common species exported was the *Dracaena sanderiana white* (168185 individuals) and *Lobelia cardinalis "small leaf"* (4 individuals) was the species exported in least quantities. During the one year study period, 1504531 individuals of aquatic plants and 2047620 all types of live plants have been exported from Sri Lanka. When considering the proportions of species exported during one year period, the endemics consist of 0.04% (685 individuals) and other indigenous species consisted of 80.91% (1217353 individuals) among all other aquatic plants. The proportion of indigenous aquatic plants species consisted of 59.45% and endemics consisted of 0.03% among exported all types of live plants from Sri Lanka. And the proportion of exported aquatic plants to all live plants is 73.47% from Sri Lanka during my study period.

The foreign exchange earned from ornamental aquatic plant industry has shown a considerable level of earnings. The all individual export prices of species ranged from US \$ 0.14 to US \$ 12.99. Among all exported indigenous aquatic plant species, *Echinodorus grisebachii* has earned highest amount (SL Rs. 84,051,603.55) while *Dracaena sanderiana* baskets have brought in the least earning (SL Rs. 199.06) during the concerned time period.

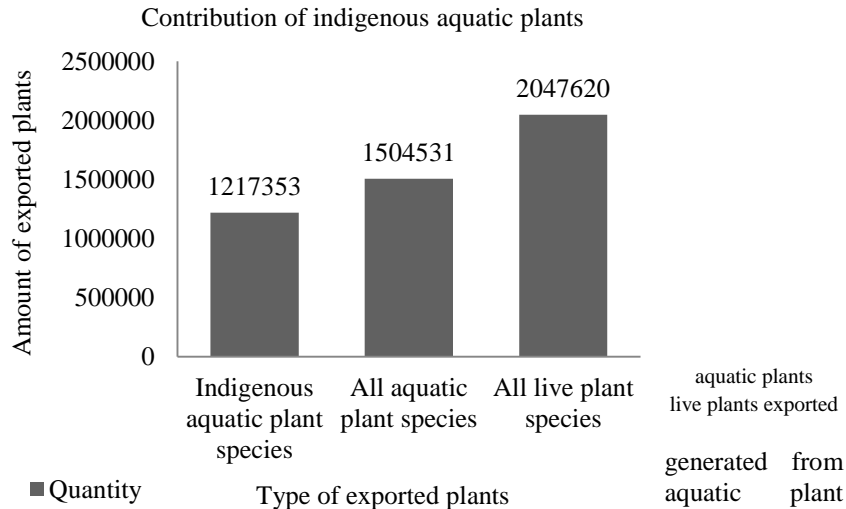


Figure5: Indigenous contribution to the all

Total income the ornamental trade during one year period was SL Rs.546,950,172.67 (US \$ 813,735.45). When considering the earnings, contribution of indigenous aquatic plant species was SL Rs. 447,667,856.28 (US \$ 3,373,279.00) and it was 80.16% from total export of ornamental plants. The earnings obtained from the endemic aquatic plant species was SL Rs. 499,075.86 and contribution is 0.091% for the aquatic plant industry. The contribution of the endemic plants to the all live plants exported is negligible (0.089%). Finally, the contribution of the ornamental aquatic plants for all exported live plants is 97.94%.

There were only 13 exporters who actually engaged in exportation of live ornamental aquatic plants during my study period. From that, all exporters were identified as indigenous aquatic plant exporters who are occasionally export endemic species based on the foreign demand. The exporters are not extracting plants from the wild and contribution of nurseries production of plants for export is 100%.

Since, in spite of all precautionary measures are taken by Biodiversity, Cultural and National Heritage Protection division of Sri Lanka Customs, maximum advantage of loopholes in regulations is taken by smugglers through false declarations and misleading terms. According to the approximate calculations of previous offences committed by exporters who were found guilty in the Customs detections (As per the information found in Casefiles), SriLanka Customs had detained (“Kekatiya”) *Aponogeton crispus* (US \$ 730,325) and *Cryptocoryne species* (US \$ 1800) on the suspicion of violation of regulations under the Forest Ordinance and Custom Ordinance which were attempted to export through BIA, Katunayake without having permission. Those smuggled aquatic plants have collected from several tanks in Puttalam and Kurunegala districts.

The sustainability of the ornamental aquatic plants industry and the conservation of endemic and indigenous aquatic plants can be mandated and committed by enforcement of existing laws and legislations. The greatest thing is long run economical gains obtained through the protection of ecosystems than any short term economic return earned from smuggling, over exploitation like undesirable activities. If the involvement of the government authorities is in a sufficient condition,

the due revenues from the trade can be increased. But the legal status behind the export of endemic plants species hampers their development and therefore, investments are worthless until legal status are cleared and positively regulated. Adequate culture techniques are not practiced by the exporters to boost the industry with new technology and conservation of the endangered species. The major factors which are responsible for the depletion of water plants from the natural environment are deforestation, constructions, sand and gem mining, bad practices of fish harvesting methods, agricultural and industrial wastes, over exploitation and invasive species. Therefore the government should involve for collaborate all those parties for a sustainable trade of aquatic plants in Sri Lanka and awareness should be created among all stake holders of ornamental aquatic plants industry including officers at frontiers, exporters, farmers, students, conservationists and all related agencies.

Conclusion

During the period of one year from 1st March 2013 to 28th February 2014, 176 aquatic plants species were indigenous out of all 218 species identified. The quantity of exported indigenous aquatic plants species has shown a considerable proportion to exported aquatic plants species, 80.91%. It is noteworthy to highlight that 73.47% of the entire export quantity of annual live plants trade consist of aquatic plants species. The calculated actual foreign exchange earnings from exported indigenous aquatic plants species was 80.16%. The main causative factors should be minimized to address conservation issues such as constructions, deforestation, sand and gem mining, industrial and agricultural wastes and invasive species. Based on the gathered information from the exporters, there are no exporters who practice wild collection of endemic species. The irregularities at the exportation procedure are taken place basically due to false declarations and misleading terms. Therefore, the laws and regulations should be enforced and monitored to avoid misconducts and corruptions.

Acknowledgement

Firstly I would like to convey my greatest gratitude to Head, Department of Animal Science Dr. S.C. Jayamanne and to my internal supervisors, Mrs. B. V. A. S. M. Bambaranda and Dr. S. C. Jayamanne. Then special thanks all the staff members of the Aquatic Resources Technology degree program. And I convey my special gratitude to my external supervisor Mr. R.D.A.M.G. Niyarepola, Deputy Director of Customs who strengthened me with his advice and guidelines during my research period. Also, I want to thank Dr. W. M. H. K. Wijenayake, for his kind guidance and support during my research.

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Development of garment leather from Yellowfin tuna (*Thunnus albacares*) skin

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Introduction

Leather is defined as hide or skin with its original fibrous structure more or less intact, tanned to prevent putrefaction (Covington, 2009). Due to tanning, skins that have been processed to prevent putrefaction retain its characteristics such as flexibility and toughness. Hides and skins from cattle, buffalo, sheep, pig, goat, horse, crocodile, snake and fish are used for leather production. When considering the fish leather, fish skins are used for production of leather after tanning and re-tanning processes. Texture of fish leather depends on pocket size of the scales. Presently, carp, pacific salmon, bass, sturgeon, shark, tuna, catfish, salmon, tilapia and several other fish species are taken for leather production. Garment leather is tanned with chrome and treated with softeners. The quality of the garment leather should be thin enough to use on garments and it should feel softer and smoother than any other types of leather. These types of leathers are made from the top-grain of a hide. Good stitch tensile strength and light weight are some other characters of garment leathers. Cow hide and skins from deer, pig and lamb are commonly used for garment leather manufacturing. But there is a potential to develop garment leather from fish skin similar to other garment leathers. The present study was carried out to add value to waste generated during the Yellowfin tuna (*Thunnus albacares*) fish processing and promote a fish leather production in Sri Lanka through developing garment type leather using discarded skins. At present, hides and skins from cattle, buffalo, sheep and goat are used for leather production. In addition, fish species including carp, pacific salmon, shark, tuna, catfish and tilapia are taken for leather production in the world. The objectives of this study were to find out the best fat liquor percentage to obtain maximum softness of chrome-tanned Yellowfin tuna fish leather and to find out the best tanning method for garment leather production from Yellowfin tuna skin.

Methodology

The current study was carried out at the tannery of Ceylon Leather Product PLC (CLP), Mattakkuliya. Tuna skins were collected from the processing factory of Jay Sea Food (Pvt) Ltd in Ja-Ela. Two experiments were carried out to find out best fat liquor concentration and best tanning method. In experiment 1, yellowfin tuna skins were treated with 33% basic chromium sulphate and five different concentrations (12%, 14%, 16%, 18% and 20%) of fat liquors (on weight of pelt). In experiment 2, yellowfin tuna skins were treated with four different tanning methods (Full chrome tanning, full vegetable tanning and two types of semi chrome tanning methods - vegetable tanned skins directly tanned with chrome and vegetable tanned skins tanned with chrome after stripping with NaHCO_3). Before initiating the experiments pre-trial was conducted to find out the optimum conditions for liming. Six pieces of raw skins were immersed in solutions of 0.25%, 0.5% and 1% Na_2S , 6% Ca(OH)_2 and 200% water (on weight of skins). One day after, skins were taken out and scales and flesh were removed. Then, skins were kept for another 5 days in a new 6% Ca(OH)_2 solution. Weight

and the physical conditions (scale pockets, colour and plumpness) of the skin were observed daily. After identifying the optimum conditions for liming 40 skins were subjected to 8 production process steps (liming, de-liming, pickling, tanning, basifying, fat-liquoring, fixing, drying and dyeing). Experiment 1 was done in fat-liquoring step and experiment 2 was done in tanning step. Then, the dried leathers were dyed and waxed. Finally softness, feel, tensile strength, tear strength and stitch tear strength were measured in developed leathers. Physical evaluation was done to check softness and feel by ten expertise. Tensile strength, tear strength and stitch tear strength were done using universal testing machine. This experiment was designed according to Complete Randomized Design (CRD). The collected data were analyzed using Friedman test and one-way ANOVA in MINITAB 16 and SPSS 22 statistical analyzing software to find out the significant difference between treatments. Mean separation was done using pairwise comparison.

Chemicals percentages were weighted according to the weight of skins, used in experiment 1 and 2.

Results and Discussion

According to pre-trial, 0.5% Na₂S solution was identified for descaling with 6% Ca(OH)₂ and 200% H₂O. For liming it was identified that immersing for 4 days is the best method in 6% Ca(OH)₂ and 200% H₂O solution.

In experiment 1 (from the five different concentrations of fat liquors), there was a significant effect on treatment method on tensile strength, tear strength and stitch tear strength ($P < 0.05$). Maximum tensile strength and tear strength values were observed in 16% fat-liquored leather with average values of 23.46 ± 6.06 N/mm² and 401.59 ± 77.75 N/mm, respectively meanwhile 18% fat-liquored leather showed the highest stitch tear strength (187.91 ± 5.39 N/mm). There was a significant treatment effect on softness of leather ($P < 0.05$) and on feel of leather ($P < 0.05$). According to the ranking values, treatment 4 (18% fat liquor) showed the best response for softness (Ranking value = 46.5) and feel (Ranking value = 47.0) compared with the other treatments.

While adding fat-liquors, it improves the tensile strength of leathers (Tex Biosciences, 2008). But increasing the fat liquor concentration further leads to decreasing of the ability to make fine emulsion as well as reduction of the ability of fat liquor penetration in to collagen fiber. Hence, softness is reduced when increasing the fat liquor concentration therefore, the hardness of leather is increased (Gutterres and Melo dos Santos, 2009). It may be the reason for reduction of tensile strength.

Increasing and again decreasing of the values of tear strength and stitch tear strength may be due to the decreasing of the ability to make fine emulsion. Hence, ability of fat liquor penetration in to collagen fibers was decreased. The reason for increasing softness might be fat liquor which acts as a lubricant in between collagen fibers (Gutterres and Melo dos Santos, 2009). Reason for increasing and again decreasing the softness maybe due to the decreasing of the ability to make fine emulsion. Therefore, the ability of fat liquor penetration in to collagen fibers is decreased. Hence, it can be suggested to use 18% fat liquor concentration to produce garment type leather from yellowfin tuna skin.

From the four tanning methods studied in experiment 2, there was no significant effect of treatment on tensile strength ($P > 0.05$). But full chrome tanned leather showed the highest value for tensile strength (22.56 ± 0.86 N/mm²). When considering the tear strength there was no significant effect of treatment ($P > 0.05$). Highest value of tear strength showed the full chrome tanned leather (373.75 ± 23.20 N/mm). But there was a significant effect of treatment on stitch tear strength ($P < 0.05$). Highest value of stitch tear strength showed the full chrome tanned leather (187.91 ± 5.39 N/mm). There was a significant treatment effect on softness of leather and on feel of leather ($P < 0.05$). In addition, the highest ranking value for softness (30.0) was observed in full-chrome tanned leather. Hence, it can

be suggested to use full chrome tanning with 18% fat-liquor concentration to produce garment type leather from yellowfin tuna skin.

There was no effect from fat liquor concentration and surface treatment on tensile strength, tear strength, stitch tear strength, softness and feel due to equal fat liquor concentration (18%) and surface treatment (wax). Reason for no significant effect of treatment on tensile strength and tear strength might be due to the reason that tensile strength and tear strength are only dependent on the fiber structure of the skin. Fish skin has a cross fiber structure (Hebrank and Hebrank, 1986). Reason for high value for stitch tear strength might be due to the high amount of covalent bonds between chromium sulphate and collagen fibers in full chrome tanned leather. Vegetable tanned leather hardness was higher than the chrome tanned leather. Hence, softness is higher in full chromed tanned leather than the vegetable tanned leather. When considering the tanning agents chromium sulphate makes covalent bonds with collagen fibers and mimosa acts as a filling agent between collagen fibers.

Conclusion

According to the results obtained in this study, the best fat-liquor concentration was 18% to prepare soft garment leather from yellowfin tuna skin. The most effective tanning method was the full chrome tanning compared to full vegetable tanning and semi tanning methods. Using this combination a marketable garment leather from yellowfin tuna skin can be produced. This could be used to produce commercially valuable products such as ready-made garments.

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Balancing the benefits of protein content and the risks of trace metal toxicity exposure from Skipjack tuna (*Katsuwonus pelamis*) consumption in Sri Lanka

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Introduction

Fish is considered as an excellent source of protein that can provide immense health benefits to human being. Protein is the major nutrient in fish consumption and it is highly digestible and consist all the essential amino acids. However, recent claims that marine fish are contaminated with trace metals exceeding the recommended maximum allowable limits have raised concerns among consumers regarding fish consumption. This may lead to rejection of marine fish both by local and export markets (Liyanage, 2009) as fish contaminated with toxic trace metal can lead to acute and chronic effects in human being. In the present study, protein content and major toxic trace metal concentrations in skipjack tuna (*Katsuwonus pelamis*) which is a major commercial marine fish species were studied with the aim of assessing benefits and risks in consumption of skipjack tuna in Sri Lanka.

Materials and Methods

Samples of skipjack tuna fish (n = 44) were collected to represent all fish landing site areas around Sri Lanka during April-July, 2014. Concentrations of toxic trace metals Hg, Cd, Pb and As were analysed individually for all the samples while the protein content analysis was carried out for composite samples that were prepared based on gender and standard length of each fish. Crude protein content was analysed according to 928.08, AOAC 2000 standard method. Crude protein content was determined using UDK 132 (VELP Scientifica, Usmate, Italy) semi-automated Kjeltex system. All composite samples were analysed in triplicates. Hg, Cd, Pb and As trace metal concentrations were analysed by Atomic Absorption Spectrophotometer (AAS; Varian240 FS, Varian Inc., Australia) following the standard method in AOAC 1998. All analyses were strictly adhered with quality control procedures. Protein content of skipjack tuna was assessed in terms of benefits with reference to its Recommended Dietary Allowance (RDA) value whereas the toxicity of each trace metal was assessed based on the stipulated Provisional Tolerable Weekly Intake (PTWI) with the Probable Weekly Intake (PWI) values. Average consumption of skipjack tuna flesh in Sri Lanka was considered as 2.8 g/person/day (MFARD, 2013) and the average body weight of a Sri Lankan adult person was assumed as 55 kg. In addition, resulted mean toxic trace metal concentrations were compared with the established maximum allowable limits for toxic trace metals in Sri Lanka and European Union standards for skipjack tuna.

Results and Discussion

In order to determine the recovery percentage in crude protein analysis, spiked samples with $(\text{NH}_4)_2\text{SO}_4$ were used and the recovery values were maintained within the acceptable range of 90-110%. The method of trace metal analysis was evaluated for its suitability in terms of their respective Limit Of Detection (LOD) and recovery levels using spiked samples and certified quality control materials. Calculated recovery values for all the trace metals were within the expected recovery range of 80%-120%.

The mean standard length of the analysed skipjack tuna fish was 47.4 ± 3.9 cm and the range was 36-56 cm whereas the mean total weight was 2.2 ± 0.5 kg and it had a variation of 1.1 - 4.2 kg. Among the analysed specimens 24 were males and 20 were females.

Table 1: Protein content (%) of the flesh of skipjack tuna and other major tuna species*

	Skipjack tuna ^a	Yellowfin tuna ^b	Bigeye tuna ^b
Crude protein	24.13±2.01	23.52±0.61	23.72±0.16

* Data are expressed as mean±SD on a fresh weight basis

^a The present study

^b Peng *et al.*, 2013

As per the results obtained, skipjack tuna is a good source of protein (Table 1). The resulted percentage value for protein content of skipjack tuna was compared with the values recorded by Peng *et al.*, 2013 for other major commercially important tuna species; yellowfin and bigeye tuna (Table 1). This shows that skipjack tuna is similar in terms of protein content; the major targeted nutrient in fish, with yellowfin and bigeye tuna. The resulted percentage value in this study for crude protein content in skipjack tuna slightly differs with the results of certain previous studies. This could be due to the variation of protein content in fish according to the seasonal changes as described by Clucas and Ward, 1996. Although skipjack tuna is a rich source of protein, the obtained value for the contribution for RDA value was lower (1.2%). The major reason to gain this lower value is the average skipjack tuna consumption in Sri Lanka is still a lower value (2.8 g/person/day).

Table 2: Provisional Tolerable Weekly Intake (PTWI) and Probable Weekly Intake (PWI) values of Hg, Cd, Pb and As

Toxic trace metal	PTWI* (mg/kg of body weight)	Provisional Tolerable Weekly Intake (mg)	Probable Weekly Intake (mg)
Hg	0.005	0.275	0.0025
Cd	0.007	0.385	0.0003
Pb	0.025	1.375	0.0001
As	0.015	0.825	0.0180

* WHO/FAO Joint Expert Committee on Food Additives and Contaminants

According to the results of the present study, all the recorded mean values for toxic trace metal concentrations were lower (0.13 ± 0.06 Hg, 0.02 ± 0.01 Cd, 0.01 ± 0.01 Pb and 0.92 ± 1.12 As in mg/kg). All the recorded mean values were well below the established maximum allowable limits for toxic trace metals in Sri Lanka and European Union standards in terms of seafood safety. The resulting of lower concentrations for all the toxic trace metals could be due to the reason that skipjack tuna is a

short lived animal which has a less potential for bioaccumulation. All the calculated PWI values were well below the estimated PTWI values (Table 2). This indicates that skipjack tuna does not contain a health risk on human due to trace metal toxicity.

In recent past several researchers have claimed that most of the major and popular marine food fish such as yellowfin tuna, bigeye tuna, sword and certain marlin fish have an increased risk of trace metal toxicity (Kojadinovic *et al.*, 2007; Jinadasa *et al.*, 2014). In addition, the market values of these major marine food fish are very high with compare to skipjack tuna (MFARD, 2014). As per the results of this study, skipjack tuna is a good source of protein which does not contain any health risk due to trace metal toxicity and can be accessed by consumers for a cheaper price.

Conclusion

Skipjack tuna is a good protein source as same as the majorly attracted other tuna species such as yellowfin and bigeye tuna by the fish consumers. Skipjack tuna does not pose any health risk due to trace metal toxicity by Hg, Cd, Pb and As.

Acknowledgement

National Aquatic Resources Research and development Agency (NARA) is acknowledged for the financial assistance and the staff of analytical chemistry laboratory, NARA is acknowledged for their assistance in sample analysis.

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Seashell processing: An emerging industry in Kinniya divisional secretariat division of Trincomalee district

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Introduction

The seashell processing industry functions by grinding the seashells for production of lime for building construction purposes and for making poultry feed (Fisheries Year Book, 2007). The low income people in the Kinniya Divisional Secretariat (DS) division collect seashells to earn money for their daily living. The people who are engaged in this industry earn sufficient income (Sunday Observer, 2012). Seashell deposits are available in Kakkamunai village of Kinniya DS division, which is located closer to the mouth of Thampalagamam Bay, which is enriched with bivalves. Shell mining has taken place for last three decades in a sustainable manner. There is a high demand for shells from the poultry feed industry, thus generating a good income from this activity (Minerals Year Book, 2007). In this context a survey was carried out to study this emerging industry in Kinniya DS division of Trincomalee district.

Methodology

This study was carried out during the months of April and May, 2014 in ten villages in Kinniya DS division. Using random sampling procedure, a total of 90 seashell processors were selected, which includes collectors, grinders, transporters, loaders and mill owners and a structured interview schedule was used to collect the information through personal interview at their home and seashell processing mills. Collected data were analyzed using the SPSS package.

Result and Discussion

Personal and socio-economic characteristics of seashell processors in Kinniya DS division of Trincomalee district revealed that all the seashell processors (100%) were males. Young age and middle age categories were same (40%). 80% were under primary level of education. Majority (68.9%) of the respondents depended mainly on seashell industry. More than half (54.5%) of seashell processors belonged to medium income group of Rs.20, 000 to Rs. 40,000 per month. Majority of respondents (87.8%) were part time workers. Majority (85.6%) of respondents had 5 to 10 years experience in seashell processing. Only 11.1% respondents had organizational membership; because the mill owners only had the membership with social organizations. The seashell processors have not participated in any extension activity related to seashell processing.

All the respondents (100%) indicated that seashell collection was the most difficult work in seashell processing. Among the people who involved in seashell collection, most of them obtained medium income of Rs.1000 - Rs.1500 per day. Most of people who involved in seashell grinding obtained high income (Rs. 420 per bag) from seashell grinding per day. Majority (91.1%) of the respondents involved in seashell industry were rural people. All the respondents (100%) were in the view that the overall business condition of the industry is good. All (100%) of respondents reported that the ground seashell bags were marketed directly to the consumers. The demand for ground seashells is high in Kurunagale district. Kandy, Matala, Puttalam, Kalutara, Colombo, Avissawella and Galle are the other places getting ground seashells from Kinniya mills.

Economic status of the respondent before and after joining with seashell industry

Table 01: Distribution of respondents according to their economic status before and after working in seashell industry

Category	Before working in the seashell industry (%)	After working in the seashell industry (%)
Upper class	0.00	14.5
Upper middle class	02.2	61.1
Lower middle class	31.1	23.3
Poor	54.5	01.1
Very poor	12.2	00.0

Source: Field survey, 2014

Table 01 provides the comparison of the distribution of respondents according to their economic status before and after working in the seashell processing industry. The results indicates that majority (54.5%) of the respondents were under poor category of economic status before working in the seashell industry followed by lower middle class (31.1%), very poor (12.2%) and upper middle class (2.2%) respectively. There was no one under upper class category among the respondents before working in this seashell industry.

Table 01also indicates that majority (61.1%) of the respondents were under upper middle class category after working in this seashell industry followed by lower middle class (23.3%), upper class (14.5%) and poor (1.1%) respectively. It is good to note that there was no one under very poor category after joining with the seashell industry.

Socio-economic conditions of the respondents before and after working in seashell industry

Before the establishment of this industry, employment, income and the living standard of the respondents were in low level. But, after the establishment of this seashell industry the employment, income, living standard and the overall socio-economic status were improved for all categories of respondents (Owners, Collectors, Grinding persons, Loading persons and Transporters). This leads to reduction in poverty level of the people who were involved with seashell industry.

The shell mining activities should be maintained at a sustainable level to prevent the environmental effects and future negative impacts. For that Natural Aquatic Resources and Development Agency (NARA) has given a maximum limit to the seashell processors. They cannot exceed the limit of 20,000 packs of shells per month. The Government has made this restriction to protect the natural resources. Exceeding this limit will cause severe environmental problems by the lapse of time. And these resources should be protected for the next generation. Or else this industry will have a natural death.

Conclusions

From to the study conducted it can be concluded that all the seashell processors involved in this industry were males and majority of respondents were under primary level of education. More than half of seashell processors belonged to medium income group. Majority of respondents had 5 to 10 years experience in seashell processing. The seashell processors were not participated in any

extension activity related to seashell processing. Majority of respondents involved in seashell industry were rural people and majority of them were poor before working in this seashell industry and presently majority were under upper middle class. The living standard and the overall socio-economic status of people were low before the establishment of this seashell industry, but after the establishment of this seashell industry those conditions were improved. And the poverty level was decreased after the establishment of this seashell industry. Over seashell mining leads to environmental adverse effects. Therefore, to prevent those effects shell mining should be maintained at a sustainable level.

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Effect of growth regulators on in-vitro multiplication of *Lagenandra ovata* and *Lagenandra lancifolia*

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Introduction

Sri Lanka is a country which consists with number of endemic aquatic plants. These endemic aquatic plants are having high demand in aquatic plant industry (Galapitagedra, n.d.). Due to the lack of effective propagation methods plant collectors collect plant from wild to fulfill the market demand. It leads to the depletion of natural plant stock and bio diversity. *Lagenandra* species only can observe in Sri Lanka, Southern India and Bangladesh (Dassanayake *et. al.*, 2001). In Sri Lanka there are seven species and six species are considered as endemic. Red List of International Union for the Conservation of Nature in 2013, categorized five of those endemic species under the highly threatened category. Main purpose of this study is to develop a proper method for micro propagation of *Lagenandra ovata* and *Lagenandra lancifolia* to overcome inadequate supply and depletion of natural plant stock. Present study was carried out to evaluate effect of different hormone concentrations in basal media for shoot initiation and multiplication of rhizome explants, to identify the best explant of *L. lancifolia* for micro propagation and to identify the best medium for *L. ovata* seed culture.

Methodology

Present study was carried out at Royal Botanic Gardens, Peradeniya. Seven experiments were conducted in order to achieve the objectives of the study. Explants of *L. ovata* (rhizome and seeds) and *L. lancifolia* (rhizome and smaller plantlets) were sterilized using standard procedures. *L. ovata* rhizomes were placed in Ms Semi-solid media with different cytokinins such as BAP, Kinetin and TDZ with the presence of IAA. Different concentrations of BAP and Kinetin such as 0.4, 0.8, 2, 5 and 8 mg^l⁻¹ and 0.4, 0.8, 1.6 and 2 mg^l⁻¹ of TDZ were used. Grown plants of *L. ovata* were transferred in to multiplication media with 1, 2 and 3 mg^l⁻¹ BAP hormone concentrations. Smaller plantlets of *L. lancifolia* were placed in MS semi solid media with and without growth regulators. Different concentrations of cytokinins such as 0.4 and 0.8 mg^l⁻¹ of BAP and Kinetin concentrations and IAA were added to the medium. Grown Plantlets of *L. lancifolia* were transferred in to multiplication medium with 1, 2 and 3 mg^l⁻¹ BAP hormone levels. Survival rate of *L. lancifolia* plantlets and rhizomes were measured weekly in order to identify the best explant. The best medium for *L. ovata* seed germination was identified by placing seeds in different media such as; solid medium, semi-solid medium, liquid medium and sterilized distilled water medium. After the germination seeds were transferred in to solid or semi-solid medium for further growth.

Results and Discussion

This study shows the importance of growth regulators for the shoot initiation of *L. ovata* rhizome culture. According to the one way ANOVA, there was a significant effect ($p < 0.05$) of growth

regulators such as BAP, Kinetin and TDZ on shoot initiation. The highest mean number of shoot initiation of *L. ovata* rhizomes was observed at 0.4 mg^l⁻¹ Kinetin with the presence of 0.1 mg^l⁻¹ IAA. The second highest mean number of shoot initiation was observed at 0.8 mg^l⁻¹ TDZ with the presence of 0.1 mg^l⁻¹ IAA. According to the data lower concentrations of growth regulators stimulate shoot initiation highly. Highest shoot multiplication was observed at 2 mg^l⁻¹ BAP level. According to the one way ANOVA there was a significant effect of hormone treatments for the shoot multiplication ($p < 0.05$).

Table 1: Effect of different BAP hormone concentrations for the mean number of new shoot regeneration after three weeks of culture establishment

Treatment	BAP hormone concentration (mg ^l ⁻¹)	Mean number of new shoot regeneration
Control	0	0.000 ^b
T ₁	1	1.000 ^b
T ₂	2	2.667 ^a
T ₃	3	0.667 ^b

Means that do not share a letter are significantly different

As indicate by the table there was a significant difference between treatment 2 and all other treatments. Hormone free MS media did not show any shoot initiation or multiplication. The highest seed germination of *L. ovata* was observed in sterilized distilled water medium at the second week of culturing. Low contamination possibility and low cost are main advantages of sterilized distilled water medium. There was a significant difference of seed germination between sterilized distilled water and all other treatments.

Table 2: Mean number of seed germination in different media after two weeks of culture establishment

Treatment	Media type	Mean number of seed germination
T ₁	Solid media	2.400 ^c
T ₂	Semi- Solid media	2.600 ^{bc}
T ₃	Liquid media	4.800 ^b
T ₄	Sterilized distilled water	8.200 ^a

Means that do not share a letter are significantly different

The best shoot initiation of *L. lancifolia* smaller plantlet culture was observed at 0.4 mg^l⁻¹ Kinetin with the presence of 0.1 mg^l⁻¹ IAA hormones.

Table 3: Effect of different BAP hormone concentrations for mean number of new shoot regeneration of *L. lancifolia* after three weeks of culture establishment

Treatment	BAP hormone concentration (mg l ⁻¹)	Mean number of new shoot regeneration
Control	0	0.000 ^c
T1	1	1.333 ^b
T2	2	2.667 ^a
T3	3	1.000 ^b

Means that do not share a letter are significantly different

As indicated by the above table there was a significant difference in new shoot regeneration of both treatment 1 and 2 when compare to the other treatments. The highest shoot multiplication of *L. lancifolia* was observed at 2 mg l⁻¹ BAP level. Therefore treatment 2 was considered as the best treatment for new shoot regeneration of *L. lancifolia*. The survival rate of *L. lancifolia* rhizome was below 30% and survival rate of plantlets was above 80% at the fifth week of culture establishment. Therefore, smaller plantlets of *L. lancifolia* were recommended as the best explants source.

Conclusion

Hormone treatments should be used for the shoot initiation of *L. Ovata* rhizome cultures. According to which obtained 0.4 mg l⁻¹ Kinetin with presence of 0.1 mg l⁻¹ IAA suitable or both *L. ovata* rhizomes and *L. lancifolia* smaller plantlets culture. The maximum shoot multiplication was observed at 2 mg l⁻¹ BAP level. Smaller plantlet of *L. lancifolia* is recommended as the best explants source for micropropagation based on the survival rate. Best medium for *L. ovata* seed germination is sterilized distilled water.

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A preliminary study on the effectiveness of organic fertilizers for the survival rate of *Catla catla*

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Introduction

Fish can be considered as one of the main sources of animal protein (26.2%) in human diet (Khan *et al.*, 2004). Fish also become a popular source of food in Asia and developing countries. Both aquaculture and fisheries activities conducting in marine and inland waters, cater the protein requirement of people in Sri Lanka. Indian and Chinese Carp species are commonly used today in inland aquaculture. *Catla catla* (Catla) is a zooplankton feeding Indian major carp species which was introduced to reservoirs in Sri Lanka to uplift the inland fishery production. This species has become a very popular fish species among the fish farmers due to higher growth rate, ability to co-exist with other major carps and consumer preference. Aquaculture Development Center (AQDC), Udawalawa belongs to National Aquaculture Development Authority (NAQDA) is producing fish seeds of carp species including Catla, for the development of inland aquaculture and fisheries. The problem identified in fish seed production in the AQDCs was the low survival rate of *Catla* at rearing of post larvae (PL) to fry stage. Moreover, it was observed that survival rate in mud ponds is lower than the survival rates in cement tanks. In the AQDC Udawalawa, cow dung is commonly used for fertilization of rearing tanks and ponds. This study was carried out to find out what the best effective organic fertilizer for the higher survival rate and growth of *Catla catla*. Cow dung, *Leucaena leucocephala* (Ipilpil) and *Oriza sativa* (rice) straw were selected as organic fertilizers as they are of low cost and readily available in the area of the study.

Materials and Methods

The experiment was conducted in nursery ponds (mud ponds) and nursery cement tanks in AQDC, Udawalawa. A mud pond and a cement tank which were already fertilized during five days (as normal practice in the AQDC) using cow dung (250g/m²) were selected and plankton densities (individuals per liter) were recorded by assuming ponds were reached optimum plankton density. Mean value of those densities was calculated and used as baseline value. Dried cow dung (250g/m²) was selected as control for the study as it was the normal practice in the AQDC. Rice straw (30g/m²) and dried Ipilpil (30g/m²) were the selected treatments for the study. These are the commonly used fertilizer concentrations in the field. Initially, the time taken to reach the plankton density to the baseline value was recorded for Rice straw and Ipilpil fertilizer types.

The surrounding of three mud ponds was cleaned and four hapa net cages were fixed to the bottom of the three mud ponds to prepare four replicates. All the four replicates were fixed in same way to maintain the same volume of water. Firstly the ponds were filled up to 50 cm with water. Complete Randomized Design (CRD) was conducted as the experimental design.

Four days old PL in a single cohort, who spent seven days in hatchery were stocked in the morning in cement tanks and hapa net cages in mud ponds. The recommended stocking density in tanks and ponds was 250-300 PLs per square meter (FAO, 2014). Three hundred PL were stocked in cement tanks per square meter and 250 PL per square meter were stocked in hapa net cages in mud ponds. Altogether 54 000 PL were stocked in nine cement tanks including 6 000 PL in each tank (20 m²) and 6 000 PL were stocked in 12 hapa net cages fixed in three mud ponds including 500 PL in each cage (2 m²). Harvesting of fry (2.5 cm) was done after three weeks rearing time period. Total length (TL) and weight were measured weekly using randomly taken samples (10% of population) of PLs from each tank and happa, until harvesting. Analytical balance (± 0.001 g) was used in measuring the weights of PL. Venire caliper (± 0.01 cm) was used for measuring the total length of PL. Average weight and average TL was calculated using the data obtained.

Temperature and pH were measured daily using electronic pH meter and thermometer. Dissolved oxygen (DO) level was observed using Winkler method to keep the treatment units at the optimum DO level during the study period. Secchi disk values were taken weekly by using secchi disk. Percentage survival rate, percentage weight gain (PWG) and percentage length gain (PLG) were calculated (Okunsebor and Ayuma, 2011). Obtained data were analyzed using analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of MINITAB 16 and Excel 2010 office package.

Results

The highest value of survival rate could be observed in the treatment of rice straw as 80.02 % ($P < 0.05$) in cement tanks. The highest value of survival rate in mud ponds could be observed in the treatment of rice straw as 36.45 % ($P = 0.05$). The highest percentage length gain (PLG) (309.29 \pm 2.50 cm) and the highest percentage weight (PWG) gain (4667 \pm 252 g) were observed in the treatment of rice straw in cement tanks ($P < 0.05$). Further the highest PWG (14950 \pm 173) and the highest PLG (305.73 \pm 2.60) were observed in the mud ponds fertilized by rice straw ($P < 0.05$). In considering the values of plankton count, the highest mean value of phytoplankton number in cement tanks could be observed in the ponds fertilized by cow dung (control). The lowest mean value was observed in the ponds fertilized by rice straw. In mud ponds also the same results were obtained at the date of stocking PL for rearing up to fry. The highest zooplankton count in cement tanks could be observed in the ponds fertilized by rice straw while the lowest value was observed in the ponds fertilized by rice straw. In mud ponds also the highest zooplankton count was observed in the treatment of rice straw at the date of stocking PL. As *Catla catla* was a zooplankton feeder the highest survival rate, the mean values of highest PWG and highest PLG were observed in the treatment unit of rice straw that included highest zooplankton amount in the water. The highest zooplankton amount in the water could provide more live feed and it might be the reason for the highest survival and growth of fry at harvesting. The highest secchi disk value was observed in the treatment of rice straw throughout the study period in both cement tanks and mud ponds.

Discussion

European Inland Fisheries Advisory Commission indicates that turbidity can have a harmful impact on freshwater fish by reducing food supplies and affecting gill function, killing them or reducing their growth rate, preventing successful development of fish egg and larvae and affecting the efficiency of methods for catching fish (MPCA, 2008). Very high phytoplankton blooms create high turbidity and it causes negative effects on survival of larvae. In this study also shows that both cement tanks and mud ponds fertilized by rice straw shows lower phytoplankton and higher zooplankton community. Fluten *et al.* 2002 found that feeding and growth rates reduced due to more turbid water. The lower turbidity could be observed in the treatment of rice straw than two other treatments. Catla PL can easily find out their live feed in low turbid water. It was commonly found copepods, daphnia and rotifers as zooplankton in water sampled in the mud ponds and cement tanks fertilized by rice straw.

That might be the reason for highest survival rate and growth (PWG and PLG) of *Catla catla* as a zooplankton feeder in the units fertilized by rice straw.

Shahabuddin et al., 2012 mentioned that rice straw extract showed allelopathic activity to *Microcystis* to improve the water quality. Few researches have been explored the potential of using rice straw to improve water quality, algal control and enhance *Tilapia* fish production. It was found that covering pond dikes with rice straw reduced the clay turbidity and enhanced growth of *Tilapia*. Therefore, use of rice straw should be one of the best alternatives for water quality management and microbial production. Above mentioned details will cause low turbidity, improve water quality, maintain phytoplankton density and leads to high survival and better growth of *Catla* fry. PL could find their feed of zooplankton easily in clear water.

As mentioned by Kasper, 2012 most fish survive 2-5 ppm DO level, but the growth may be retarded if the above level continues for some period. Throughout the study period the DO level was higher than 5 ppm. It emphasizes that rice straw might not cause for the reduction of DO and rice straw could provide favorable condition for higher growth and survival of *Catla catla*. Therefore in fertilizing ponds or cement tanks using rice straw in rearing *Catla catla* (PL to fry), provides live feed through better zooplankton growth and maintain better water quality with lower turbidity. Ultimately it leads to the better growth and higher survival of *Catla catla* fry comparing with other two fertilizers

Conclusion

The highest survival rate could be observed in PL to fry rearing in the mud ponds as well as in cement tanks that were fertilized with Rice straw and the highest growth rate could be observed in the mud ponds and in cement tanks that were fertilized with Rice straw

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Bio assay on effectiveness of the chemical hydrolyzation for denaturing agrochemical contaminated wastewater

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Introduction

Pesticides provide the primary means for controlling organisms that compete with man for food and fiber, livestock and crops. Global insecticide use in 2007 has been estimated 404 000 metric tons of active ingredient (Grube *et al.* 2011). The agricultural sector is the primary user of pesticides, consuming over four million tons of pesticides annually (Chen *et al.* 2009 and Chevillard *et al.* 2012). Most agrochemicals imperviousness to microbial degradation and has tendency to bio-accumulate in the soil fauna and flora. Water contamination has turned into a significant danger to the presence of living life forms in aquatic environment and aquatic organisms are highly susceptible for the agrochemical lethality. Many studies have shown the toxicity effect of agrochemical, but few studies have done to investigate the effectiveness of those treatment methods. Since the usage of agrochemical cannot be banded, best thing is finding a suitable method to detoxify them and understand the effectiveness of the particular method. Hydrolysis is a chemical reaction in which natural constituents respond with water and break into more diminutive (and less toxic) compounds. Fundamentally, hydrolysis is a destructive technology in which the original molecule forms two or more new molecules (EPA, 1993). Hydrolysis could be a viable treatment technology for agrochemical wastewater. In this study the effectiveness of the alkaline hydrolysis was estimated by using field data which were taken from the effluent treated plant (ETF) of agrochemical formulation and repacking industry, and also a bio assay was used to analyze the effect to the aquatic species from the treatment method.

Methodology

To check the effectiveness of “Alkaline Hydrolysis” method, samples were collected from a wastewater effluent treated plant in pesticide repacking and formulation industry. Samples were collected from raw water and treated tanks and measured Chemical Oxygen Demand (COD), Total Suspended Solid (TSS) and pesticide active ingredients (Glyphosate, MCPA, Profenofos). The samples were analyzed according to the American Public Health Association (APHA 2540 D, 2014) standard methods. All analysis were carried out at Environment Technology Section (ETS) and Chemical and Microbiological Laboratory (CML) section in Industrial Technology Institute (ITI). Those parameters were compared and checked the reduction efficiency. To check the effect to the aquatic ecosystems after applying the treatment “Guppy” (*Poicelia reticulatae*) were used for a bio assay. Behaviors and mortality rates were evaluated after introducing them to the treated effluent. One hundred fifty specimens of *P. reticulatae* with mean length of 2.5 ± 0.5 cm and mean weight 0.2 ± 0.5 were collected from the drainage canals with scoop nets and carried to the laboratory in a doubled polythene bags half filled with water from the source. They were kept in fifteen holding tanks (30X30X30 cm). One quarter 1/4 were filled with de chlorinated tap water and allowed to acclimatize to experimental environment condition: 30° C, pH 7.8 for 1 week before applying treated effluent. Ten fish per tank were stocked (With active animals in each) Physico-chemical parameters such as DO, Temperature. pH of the test media were

measured before and during the experiment period using Horiba Water Quality Checker. Mortality assessment was carried out for 24 h to 96 h of intervals. Fishes were assumed to be dead when there was no body or opercula movement. Statistical data analysis was done in the MINITAB (version 16.0) statistical software package. All the data were analyzed statistically using one way ANOVA (analysis of variance) table to detect difference among locations ($p < 0.05$).

Results and Discussion

Results which were obtained by the field data, it shows “Alkaline Hydrolysis” is effective in treating agrochemical contaminated water. When considering the statistics of COD comparison, it indicates a clear difference of mean values, coefficient of variance is nearly the same indicating the span of data is almost the same over the mean values. Therefore it can be concluded that raw effluent has a higher COD than the treated water samples. Further when considering pesticide analysis, it has shown raw wastewater which contained high amount of pesticide active ingredients has decreased and became non detectable after treating. This clearly showed “Alkaline Hydrolysis” has the ability to lower the toxicity. When considering the bio assay all the physico chemical conditions of the test media during the toxicity tests were fairly constant. The p^H ranged between 7.5-7.8, Dissolved Oxygen (DO) was between 6.5 and 7 mg L⁻¹ while temperature ranged between 28.0 and 31 °C over 96 hours toxicity evaluation. The results of the toxicity test of treated effluent on *P.reticulata* in 24, 48, 72 and 96 h of exposure showed mortality shown in Figure 1.

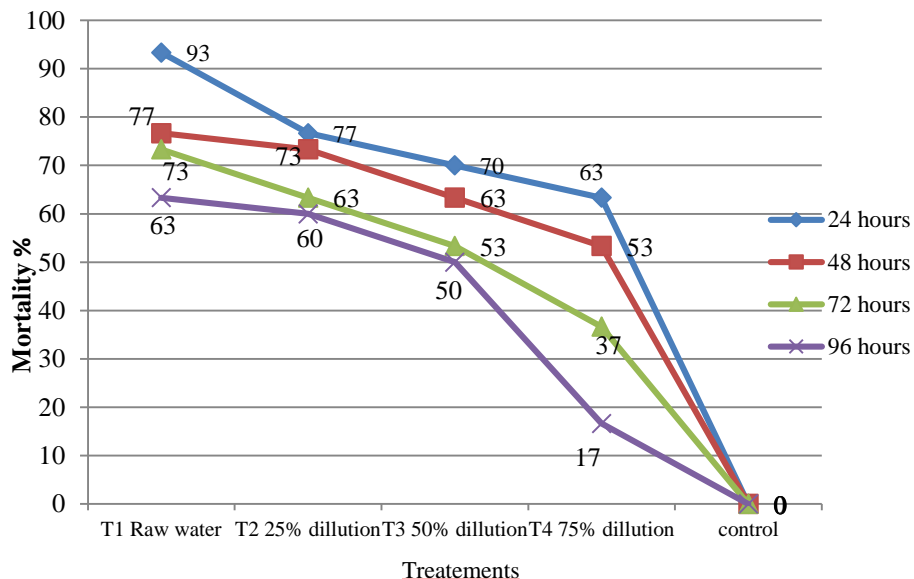


Figure 01: Treatments Vs Mortality

No adverse behavioral changes or any mortality was recorded in the control fish tanks throughout the period of bio assay. Symptoms of toxicosis observed in the behavioral of fish exposed to test media. Before the eventual death species showed lack of balance erratic swimming and restlessness. In the study highest mortality was recorded, in less diluted effluent and lowest exposure time (24 h), lowest mortality was recorded in highest dilution (75%) and longest exposure time (96 h). The findings in this study has revealed that when discharging the agrochemical contaminated waste water after hydrolyzation, it should be mixed with rain or storm water and keep the contaminated water in the maturation tank for further degradation. Because in the study it has shown highest dilution and highest exposure duration caused minimum

mortality. According to the results which were obtained from bio-assay to avoid the effect to the ecosystem, dilution should be done. Therefore before discharging treated water to the outer ecosystems, it should be subjected to proper dilution. Then the negative effect to the ecosystems can be minimized. This study showed that at 96 h exposure in high dilution (75%) caused minimum mortality. Toxicity has shown to increase with lowering the dilution. The exposure of *P.reticulata* to treated wastewater which was contaminated by agrochemical (Profenofos) exhibited aggressive behavior, rapid gulping water, increased opercular movements. *P.reticulata* was stressed progressively with the time before death. Analysis of Variance (ANOVA) showed that there was significant difference ($p < 0.005$) in the quantal response at 24, 48, 72 and 96 hours of exposure in each dilution level. The findings in this study have revealed that agrochemical is toxic to fish and suitable treatment method can detoxify the toxicity of them. Establishing proper treatment methods are highly recommended for contaminated areas.

Conclusion

Study is suggested toxicity depends on dilution and exposure time. Alkaline hydrolyzation is one of the best treatment methods that can be applied to the agrochemical contaminated areas. Most suitable option that can be taken to alter the problem is keeping the treated effluent in a maturation tank for one month like period and mixed that with rain or storm water with a suitable dilution factor before discharge to the natural environment. Therefore the toxicity and remaining active ingredients can be degraded naturally with the time. And by the time it will be subjected to natural hydrolysis also. This will reduce further bioaccumulation in ecosystems.

Acknowledgement

Laboratory facilities provided by the Industrial Technology Institute is acknowledged.

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Preliminary study on mangrove diversity in Irakkandy lagoon, Trincomalee

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Introduction

The term 'mangrove' describes both the ecosystem and the plant families that have developed specialized adaptations to live in the tidal environment (Tomlinson, 1986). Preliminary study on diversity of the mangrove stands at Irakkandy lagoon (Trincomalee) was investigated to document the status of the mangrove forest and the mangrove distribution in relation to the soil salinity variation. Due to the past two decades war dilemma and present developmental activities increase the pressure on mangrove ecosystem at an alarming rate Eastern region of Sri Lanka. In addition, Tsunami has collectively contributed to the destruction of mangroves at large in the Eastern province. In this backdrop, this research aims to analyse the diversity of mangrove in the Irakkandy lagoon which further attempts to provide some suggestions to protect mangrove and its ecosystem.

Methodology

Fifteen transect lines were laid perpendicular to the shore in different sites of the lagoon and sampling was conducted from May 2014 to July 2014 at selected locations. The precise locations were determined by portable GPS unit (ETREX 10) and hydro physico-chemical parameters of each site were recorded over high tide and low tide. While measuring the mangrove diversity, Temperature and pH were checked using Multiple Test Kit (Thermo scientific) and turbidity was measured using Turbidity meter (Hach model (2100q)) in Nephelometric Turbidity Units (NTU). Salinity was measured using a Refractometer (Erma Hand Refractometer, Salinity: 0-100) in units parts per thousand (ppt). Data on floristic composition was identified using standard identification keys. Moreover height of the species was measured by Suunto Clinometer. Three soil samples were collected along the transect line of each site from the edge of the lagoon to end of the mangrove existence. Soil salinity was calculated according to Gibbs, 2000. Shannon-Wiener diversity index and Pielou's evenness index incorporated in the Primer software version 6.1.2 and Minitab ver.16 used for data analysis and statistical analysis.

Results and Discussion

Five different true mangrove species and nine mangrove associate plants were identified from the study site. *Avicennia marina* was the dominant species with Height (H) of 1.39 ± 2.54 m followed by *Lumnitzera racemosa* (3.13 ± 1.92 m), *Excoecaria agallocha* (3.28 ± 2.662 m), *Rhizophora apiculata* (3.28 ± 4.79 m) and *Heritiera littoralis* was found as rare species with Height of (5.27 ± 2.21 m) respectively.

Figure 1 describes the calculation of Shannon–Wiener index obtained for each transect which express the number of different species in a particular area.

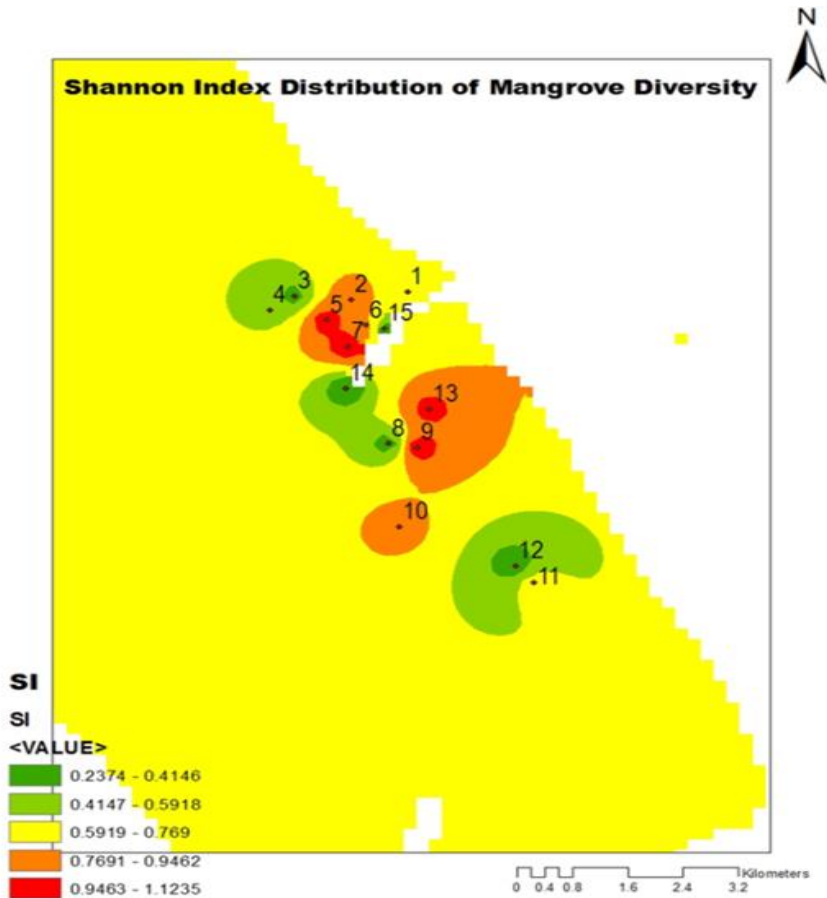


Figure 1: Shannon-Wiener Index of different Transects

The highest values (1.16) of Shannon - Wiener index shows high diversity representing diverse and equally distributed community in transect 7 while lowest value (0.22) of Shannon - Wiener index in transect 14 represents less diverse mangrove community. Transect 11 could be described as being richer-insofar as most species present are more evenly represented by numbers of individuals since the species evenness (e) value is larger (1). Transect 14 where some species are represented by many individuals, and other species are represented by very few individuals has a low species evenness (0.16).

The wide salinity tolerance range (1-16 ppt) was observed in *Avicennia marina*. Pinto (1982) has indicated that the presence of a *Rhizophora* border on the shore may be due to its morphological adaptations in resisting water currents with the help of prop roots. Presence of a *Rhizophora* border instead of an *Avicennia* border in transect 2 may be due to the depth and slope as well as due to the lack of sandy soil and poor aeration.

The water salinity increases in high tide due to the sea water inclusion towards the lagoon and low in low tide as sea water extrude towards the sea. There is a positive moderate linear relationship between mangrove species and distance from the shore (ANOVA, $P < 0.05$). In Irakkandy Lagoon, mangrove forest experiencing total diurnal inundation is dominated by *Avicennia marina* while *Excoecaria*

agallocha dominated sites that are not completely inundated. Amarasinghe *et al.* (2013) has found that *Avicennia marina* do not grow in fresh water and may be obligate halophytes. Also *Excoecaria agallocha*, survives well in fresh water and may not have obligatory requirement for salt beyond trace amount.

There is a significant difference between soil salinity and distance from the shore (ANOVA, $P < 0.05$). Low frequency and duration of tidal inundation can be cited as the probable reason for low soil salinity at the landward sites (Joshi and Ghose, 2003). As indicated by the results, decreasing salinity with increasing distance is not observed in some places. The reason can be the evaporation occurred when the temperature is raised. In contrast, frequent inundation permanently saturates the soil with seawater salt content.

There is a negative weak linear relationship between soil salinity and height of the mangrove tree (ANOVA, $P < 0.05$) since low-saline mangrove forests usually show a more luxuriant growth than the high-saline ones (De Silva and de Silva, 1998). There is a negative moderate linear relationship between soil salinity and mangrove species (correlations, $P < 0.05$).

Conclusion

The results of the study indicate Irakkandy lagoon consists of low biological diversity of mangroves compared to Negombo, Chilaw and Puttalam lagoons but is extremely valuable as a living mangrove forest due to its extent.

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Analyze the Histamine level in various positions of the Histamine developed Tuna fish

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Introduction

Sea food processing industry is a high income generating field in Sri Lanka and it brings high foreign exchange to the country. Big eye tuna (*Thunnus obesus*) and yellow fin tuna (*Thunnus albacares*) are the major tuna types which are exported by Sri Lanka to the international market. (FAO, 2014). However the presence of Histamine is the problematic factor in Tuna fish processing industry which leads the industry to many health issues and income losses.

Histamine is a chemical compound created from histidine and enteric bacteria are capable of transforming histidine to histamine by the enzyme decarboxylase. Once histamine is formed, it cannot be not destroyed by freezing, cooking, smoking, curing or canning. Histamine level of more than 5mg/100g is classified as unsafe by U.S. Food and Drug Administration. (Ebrahimet *al.*, 2012). Histamine level varies position of the tuna fish body. Hence this research was carried out to identify and analyze the Histamine level in various positions of the Histamine developed tuna fish.

Methodology

Survey was done to select the positions of taking samples from tuna fish. 15 fresh fish processing companies were selected and questionnaire was given. Three positions were selected based on the questionnaire filled by the fish processing companies. Three positions of the tuna fish were selected, beneath the pectoral fin of the fish, near the belly area and the tail end respectively and thirty tuna fish were subjected to Histamine test individually. ELISA method and histamine vertox test kit were used to analyze the histamine levels in the tuna fish. Sample preparation, sample extraction, sample dilution and Histamine testing are the major steps done in ELISA method. Collected data were analyzed by using Minitab 17 software. Highest mean values and variance values were taken from those positions. Non parametric Mann-Whitney test was done to find out the significant different among positions.

Results and Discussion

Highest mean values and variance values were taken from those positions.

High Histamine was recorded in the belly area due to the most of the bacteria which responsible for converting Histidine to Histamine, lived in the gut of tuna fish. Through poor post-harvest techniques, low hygiene practices, bad catching method, bad killing methods and bad handling methods could expose the gut material to the fish muscles and so enteric bacteria easily release the Histidine decarboxylase enzyme to Histidine free specific amino acid and then forming Histamine (Koohdaret *al.*, 2010). This reaction cannot be stopped and can only be controlled. Usually low histamine levels could be observed from gilled and gutted fish because gilled and gutted fish had

low probability to contaminate by histamine forming enteric bacteria (Ebrahimet al., 2012). Very low Histamine level was recorded in the tail area because effect of enteric bacteria which lived in the tail was very low because of that ability to bacterial contamination also very low and histamine also very low.

Table1. Comparison of mean, median, variance and standard deviation of histamine levels of tuna fish body

Position of the fish body	Mean	Median	Standard deviation
Beneath the pectoral fin	22.97 ppm	19.70 ppm	19.15
Near the belly area	25.74 ppm	18.30 ppm	26.44
Tail end	9.20 ppm	05.80 ppm	10.82

High Histamine was recorded in the belly area due to the most of the bacteria which responsible for converting Histidine to Histamine, lived in the gut of tuna fish. Through poor post-harvest techniques, low hygiene practices, bad catching method, bad killing methods and bad handling methods could expose the gut material to the fish muscles and so enteric bacteria easily release the Histidine decarboxylase enzyme to Histidine free specific amino acid and then forming Histamine (Koohdaret al., 2010). This reaction cannot be stopped and can only be controlled. Usually low histamine levels could be observed from gilled and gutted fish because gilled and gutted fish had low probability to contaminate by histamine forming enteric bacteria (Ebrahimet al., 2012). Very low Histamine level was recorded in the tail area because effect of enteric bacteria which lived in the tail was very low because of that ability to bacterial contamination also very low and histamine also very low.

Though belly area of the fish had high probability for forming Histamine in Tuna fish, most of the sea food companies preferred to take sample from beneath the pectoral fin. After taking sample from belly area small hole could be seen. It could reduce the good appearance of the products and more meat had to be removed to take the good quality of the products. Therefore sea food companies rather preferred beneath the pectoral fin of Tuna. Samples had to be taken out from deepest areas of those positions. It could increase the effectiveness of the test.

Conclusion

Highest Histamine value was recorded near the belly area of the tuna fish therefore best position for taking sample for Histamine test was near the belly area. Next Highest Histamine value was recorded beneath the pectoral fin and next best position for taking sample for Histamine test was beneath the pectoral fin.

Acknowledgement

I wish to thank Dr. S.C. Jayamanne, the head of the department and course coordinator of Aquatic Resources Technology Degree Programme. Internal supervisors, Mr. N.P.P Liyanage. Lecture, Aquatic Resources Technology Degree Programme. External supervisor, A.Perera, Jay sea foods processing (pvt) Ltd, Kepumgoda, Pamunugama.

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A Geographic Information System (GIS) approach in identification of the potential reservoirs for Giant Freshwater prawn (*Macrobrachium rosenbergii*) culture: A case study in Moneragala district, Sri Lanka

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Introduction

Culture Based Fishery (CBF) is a better approach to overcome poverty and malnutrition in Moneragala District since the district is enriched with large number of village reservoirs and minor perennial reservoirs. Introducing a valuable, high demanding and protein rich species such as Giant Fresh Water Prawn (*Macrobrachium rosenbergii*) through CBF is the best way to get the maximum utilization of these natural resources. Current practice of stock enhancement of *Macrobrachium rosenbergii* in reservoirs has resulted a heavy loss of stock and low returns. Therefore it needs a careful selection of potential reservoirs prior to stocking of post larvae.

As a tool in decision making, Geographic Information System (GIS) is still a new concept for CBF in Sri Lanka for aquaculture planning. The main intent of this study was to highlight the role of GIS in identifying potential reservoirs for stock enhancement of *Macrobrachium rosenbergii* under inland CBF in Moneragala District, Sri Lanka by developing a map.

Methodology

Nineteen minor perennial reservoirs distributed over nine divisional secretariat divisions in Moneragala District were visited during the dry season as the sample. Climate (Rainfall, Temperature), Bio-physical (Elevation) and Water quality (pH, Temperature, Hardness, Alkalinity, Dissolved Oxygen, transparency) and Socio-economic factors (proximity to roads and village, land use, poverty and population) were identified as influential factors for *Macrobrachium rosenbergii* culture based fishery. Data were collected from field surveys and responsible government institutes. Water quality parameters were tested on site and the university laboratory. In order to generate thematic layers for above each factors Interpolation techniques were applied for climate, elevation and water quality data; Population and poverty were considered in respective to DS divisions; multiple ring buffers were created for the proximity factors. Each factor was classified according to four suitability scales; very suitable, suitable, moderately suitable and unsuitable. Land use types in the district land use map were classified according to their suitability. Factors were ranked according to their relative influence on *Macrobrachium rosenbergii* fishery and weights were assigned according to their relative influence using the method of "Rank Sum". Finally, all thematic layers were integrated in ArcGIS 10.1 (Esri, 2012) environment to generate the potential map.

Results

According to the resulted map (Figure 1) unsuitable areas occupy about half of the extent of the district. If potential reservoirs for *Macrobrachium rosenbergii* culture were indicated in respective to DS divisions, Badalkumbura, Moneragala, Wellawaya, Medagama and Sevanagala divisions were resulted as highest potential areas. Thanamalwila, Bibile, Madulla, Buttala and Siyambalanduwa divisions were resulted as Suitable areas and Latter part of Madulla was indicated as Moderately suitable area. The district can gain more benefits by stocking *M. rosenbergii* in reservoirs that fall in most suitable areas. Since the water quality parameters were given the highest weight final result has high influence by water quality factor. Results are basically applicable to the dry season which is the period that water quality data were collected.

According to the field observations dry season is not favorable for CBF. Application of CBF at present is not in a satisfactory level with compared to the existing number of reservoirs. Potential areas resulting from multi-criteria evaluation (MCE) are mostly associated around the reservoirs where the optimum water quality for *M. rosenbergii* culture exists. Results could be advanced by tallying the obtained results with catch data of Giant Prawn as some reservoirs are already practicing prawn culture, but lacking of accurate catch data was a limitation for the research. Suitability of the reservoirs included in the sample could be concluded as follows (Table 1).

Table 3: Suitability of Selected Reservoirs

DS Division	Reservoir	Surface Area (ha)	Potential
Sevanagala	HabaraluWewa	80	Most Suitable
Thanamalwila	MahaWewa	80	Suitable
	DemodaraWewa	100	Suitable
Kataragama	HambegamuwaWewa	210	Suitable
	GestupanaWewa	80	Suitable
	MilegamaWewa	80	Suitable
Siyambalanduwa	SugalaDewi	50	Unsuitable
	DoserWewa	50	Suitable
	HeekaduAra	50	Suitable
	New HeekaduAra	30	Suitable
Moneragala	Kotiyagalawewa	120	Suitable
	MeepanaAra	10	Most Suitable
Bibile	Thambalawinna	15	Most Suitable
	MeegahaAra	120	Suitable
Badalkumbura	NagalaWewa	15	Most Suitable
	Katugahagalge	10	Most Suitable
Buttala	AmbakolaWewa	66	Suitable
	Yudaganawa	60	Suitable
Wellawaya	Handapanagala	226	Most Suitable

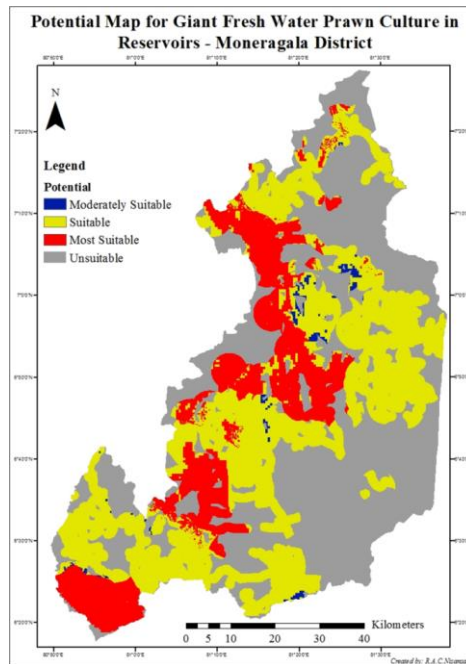


Figure 1: Potential Map for Giant Fresh Water Prawn (*M. rosenbergii*) culture in reservoirs – Moneragala district

Conclusion

Application of CBF at present is not in a satisfactory level with compared to the existing number of reservoirs. The district can gain more benefits by stocking *M. rosenbergii* under CBF in reservoirs falls in most suitable areas.

The result of study is very dependent on weighting, classifying suitability scores and ranking. Different weighting, rating, and classification methods could generate a variety of results.

Overall, the results of this study demonstrates that the GIS based approach is a useful tool for assessing potential reservoirs for culturing *M. rosenbergii* under culture based fishery especially in data-scarce conditions.

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Study of water quality changes and growth of cultured edible oysters (*Crassostrea madrasensis*), culture sites at Gagewadiya and Kandakuliya in Puttlam district

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Introduction

Global bivalve production from aquaculture has consistently increased over the years. Sri Lanka is a country which has vast natural resources and suitable environmental conditions for aquaculture. Therefore it has a great potential for develop and contribute to national fish and shellfish production. Although the bivalve industry is highly developed industry in East Asian region finfish and shellfish, specially mollusk and sea cucumbers cultures are at very initial stage in Sri Lanka (Samarasundera, 2010). Sustainable utilization of unexploited high demand finfish and shellfish species are a good alternative to develop the industry. Oysters are nutritious, still unexploited fishery resources in Sri Lanka. Which has good export demand worldwide. Although Sri Lanka have required resources naturally to uplift the industry in large scale, lack of information, limited supply of seeds and lack of trained personals are act as major constraints (FAO, 2006). The success of bivalve culture greatly depends on suitable environmental factors that ensure both optimal growth and quality as well as ensure food safety (FAO, 2006). Kandakuliya and Gagewadiya areas are blessed with natural oyster resources but which are not used commercial scale at present. Therefore the two locations have significant possibility to conduct oyster culture in large scale which providing self-employment opportunities for fisher communities. The study of water quality changes and growth of edible oysters (*Crassostrea madrasensis*) culture, sites at Gagewadiya and Kandakuliya in Puttlam district was carried out to investigate the possibility of establish these culture in commercial scale.

Methodology

The research project was conducted in two experimental sites (Gagewadiya and Kandakuliya), locates in Puttlam district, Sri Lanka. Field data were collected during October 2013 to July 2014 from pre-establish two experimental culture sites. There were four sampling points in each site separately K1, K2, K3, K4 in Kandakuliya and G1, G2, G3, G4 in Gagewadiya. Water quality data, growth data and phytoplankton data were collected each site separately. Water quality and phytoplankton data were collected twice a month, and growth data were collected once a month during the studied period. Temperature, pH, salinity, transparency were recorded as onsite measurements. Further analysis were conducted for nitrite, nitrate, phosphate and ammonia using DR-4000U spectrophotometer according to standard procedures of Parsons *et al.*, 1984. Unionized ammonia levels were calculated using total

ammonia levels. Phytoplankton samples were collected using phytoplankton net (50 µm mesh size). The samples were examined under light microscope and identified to genus level using identification keys (Newell and Newell, 1963; Rebert, 2003; Swadling, 2008; Verlencar and Somshekar, 2004). Length (distance between the end of umbo and the ventral shell margin) and width (length at the widest axis of the body) were taken as growth parameters. Twenty five *C. madrasensis* organisms were used to take measurements from each site separately, for the growth study.

Both primary and secondary data were used to analysis. Secondary data were taken from IDRC oyster research and culture programme. Minitab 16 statistical package was used to data analysis. All data were analyzed statistically using one way ANOVA (Turkey test) for all selected locations. Person product movement correlation coefficient analysis was done between water quality parameters and growth of oysters to find whether there were significant relationship between those variables.

Results and Discussion

According to the water quality study there were no significant difference ($P \geq 0.05$) in nitrite, nitrate, phosphate, unionized ammonia, temperature, pH, depth and transparency at Kandakuliya and Gagewadiya except salinity during the studied period. All water quality parameters were in acceptable range for oyster culture. Gagewadiya (2-29 ppt) showed lower salinity and wide salinity variation than Kandakuliya (25 -43 ppt), as this site receives fresh water from “kalaoya”. Rapid decline of salinity which make unfavorable for cultured oysters were observed in November 2013 and April 2014 at Gagewadiya. It was 2 ppt and 4 ppt respectively. This lower salinity was resulted from increased fresh water discharge from “kalaoya” catchment area. According to Sasikumar *et al.* (2007) *Crassostrea madarasensis* species can tolerate salinity changes from 0-40 ppt. However if these unfavorable salinities were exist longer period oyster spats can be transferred to other sites with optimum salinity. Finally it will help to increase the growth rate of *C. madrasensis* in that site.

According to growth study, there was no significant difference ($P \leq 0.05$) in growth rates (length and width) of *Crassostrea madarasensis* at Kandakuliya and Gagewadiya. Since the water quality parameters in both sites were nearly equal to each other, growth in both sites were similar. Even though there were no significant difference ($P \leq 0.05$) in growth, organisms in Gagewadiya site shown slightly higher growth than Kandakuliya. This is because of favorable aquatic environment for oysters in Gagewadiya than Kandakuliya. That creates by nutrition rich fresh water comes from “kalaoya”. Finally it cause to higher growth rate of the oysters in Gagewadiya than Kandakuliya.

Correlation analysis revealed that, there was no significant relationship ($P \geq 0.05$) between growth of *C. madrasensis* with nitrite, phosphate, unionized ammonia, pH and salinity levels. Nitrate, temperature and transparency have significant relationship ($P \leq 0.05$) with growth (length and width) of *C. madrasensis*. Nitrate cause to growth of phytoplankton in the surrounding water, which is primary food source for oysters. Therefore it directly affect to the growth of oysters. No harmful algal species were recorded during the studied period.

Conclusion

Salinity levels in both Gagewadiya and Kandakuliya were in tolerable level for *C. madrasensis* during the studied period. The absence of toxic algae (dianoflagellates) at both sites and suitable ranges of temperature, pH, transparency, nitrite, nitrate, phosphate, and unionized ammonia levels suggest that Kandakuliya and Gagewadiya areas are suitable for commercial oyster culture practices. According to growth study, *C. madrasensis* growth in Gagewadiya site shows slightly higher growth rate than Kandakuliya site. Therefore Gagewadiya site can be recommended as best site among those two sites.

Acknowledgment

We would like to express our heartfelt gratitude to all the people in IARAD and ESD divisions in National Aquatic Resources Research and Development Agency, who gave their tremendous help to successfully completion of this research work. Further we like to extend our sincere gratitude to International Development Research Center (IDRC) for providing grants to conduct the research work.

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