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An Introduction of Light Traps for Sampling Freshwater Shrimp and Fish in the Barito River, South Kalimantan

Ahmadi
Marine and Fisheries Training Center, Ministry of Marine Affairs and Fisheries, Jakarta. JL. Medan Merdeka Timur No.16 Mina Bahari Building 3, 8th Floor Jakarta Pusat 10110, Indonesia

ABSTRACT

A set of light traps were used to sample freshwater shrimp and fish from Barito River in Banjarmasin, South Kalimantan. Each of five collapsible traps (same size and shape) and of four different traps (box-shape, wire-stage, bamboo-stage and minnow nets) was assigned with one of LED lamps or incandescent lamps. A total of 231 shrimps and 34 fishes were collected during the 6-night sampling periods of March 2009. The shrimp catch was dominated by the *Macrobrachium* sp. (99.6%) with size ranges varied from 24-85 mm total length. The fish catch composed of *Oxyeoleotris urophthalmus* (38.2%), *Glossogobius giuris* (20.6%), *Oxyeoleotris marmorata* (17.6%), *Flounder pleuronectes* (8.8%), *Puntioplites bulu* (5.9%), *Mastacembelus erythrotaenia* (5.9%) and *Osteochilus melanopleura* (2.9%) with size ranges varied from 60-310 mm total length. It can be concluded that color or relative intensity of light had strong effects on number of catch collected, where LED traps appear to be more effective than incandescent ones. The Minnow nets collected significantly number of catch compared to other three traps regardless white LED lamps and ordinary incandescent ones. The effect of size and shape of the traps that influenced number of catches was further discussed in this study.

Key words: LED/Incandescent lamps, light traps, *Macrobrachium* sp., Barito River, South Kalimantan

INTRODUCTION

In Indonesia, traditional fisherman using Prayang trap equipped with a kerosene lamp or the fixed Bagan trap with petromaks lamp to lures Black tiger shrimp *Penaeus monodon* into the traps from the shrimp ponds (Kawamura *et al.*, 1983). In general, the light traps have become increasingly popular for sampling fish and squid (Thorrold, 1992), larval and juvenile fishes (Hernandez and Shaw, 2003; Lindquist and Shaw, 2005; Marchetti *et al.*, 2004), marine crustacean (Holmes and O'Connor, 1988; Meekan *et al.*, 2001) or freshwater shrimp and fish (Collier *et al.*, 1997; Aswadirani, 2003; Mukhlasin, 2004; Ahmadi *et al.*, 2008). The light traps are also very useful when towed nets are ineffective or prohibited (Brogan, 1994; Hernandez and Shaw, 2003). Light traps used here, typically using battery-powered incandescent bulbs, chemical light stick, blacklight fluorescent (UV) or electrical lamps, while the use of LED lamps has not much been performed under field condition. As for the difference in light sources, each lamp has its unique optics and intensity output even same electrical power use.

At present, many types of traditional fishing gears are operated in the Barito River, including the use of harmful fishing methods (e.g., poisoning, electrofishing) that threaten the useful aquatic animal's life in the river. In the past, about 350 species was found in Barito River but now it possibly exist only about 150 species. This is mainly attributable to the destructive fishing and water pollution, among others. Several types of local fish are considered currently extinct and endangered fish such as the Arowana, jelawat, kalui, kelabau, belidah, baung and sanggam. Therefore, fishing technology development that environmentally friendly and efficient, should be promoted. The use of light would be a potential fishing method for harvesting freshwater shrimp and fish from the Barito River. In line with this, from time to time the automated light traps were developed from the conventional devices.

There was no scientifically published information on the use of light traps in Barito River, so far. It is claimed to be the first sampling method used for collecting shrimp and fish in this river. However, before light traps can be used quantitatively, several potential biases have to be considered. What species will be sampled by the light traps? How effective light traps used in high turbidity of the river? Are individual species collected in different numbers using specific colors/relative intensities of light? Do size and shape of the light trap affect number of catch? We performed this study to address these questions by extracting the sampling data collected from the Barito River.

MATERIALS AND METHODS

Study area: South Kalimantan is one of the 4 provinces in Kalimantan (formerly called Borneo) with capital city of Banjarmasin. It lies between W114°19'13" and E11°33'30" and between N1°21'49" and S44°10'14". It is bordered with East Kalimantan at the north, with Makassar Strait at the east, with Java Sea at the south and with West Kalimantan and Central Kalimantan at the west. Total area is 37.000 km^2, 57% or about 21.000 km^2 is forest and mountains range with altitude of 1.000 to 1.500 m above sea level. It closes to the equator line with the temperature ranged from 17-36.2°C, humidity rate of 81-90%, sunshine of 40-90%, with the average rainfall of 236 mm and rain days about 157 days/year. South Kalimantan is also often called Province of a thousand-river where the Barito River is the largest and the longest river in Indonesia with more than 6.000 km long. One of its tributary rivers is the Martapura River which in turn has two tributary rivers of its own, namely Riam Kanan and Riam Kiwa where the dams were constructed permanently. Barito River also connects with the Negara River which branches out into lesser rivers. It carries high sediment contains causing the water to be turbid and brownish in appearance (rather bluish at the area close to the ocean) but slightly better compare to Mahakam River in East Kalimantan. The river allows for transportation, drinking water sources, recreational activity and fisheries.

Shrimp and fish were sampled with light traps from the Barito Riverbank during 6-night periods of March 2009. The sampling area was located at Basirih Village about 10 km from Banjarmasin City (Fig. 1), ranged from S03° 19.012' to S03° 20.665' and from E114° 34.098' to E114° 36.296' determined by the GPS 60 (Garmin Co. Ltd., Taiwan). The experimental environments consisted of highly turbid, slow flowing and rarely vegetated habitat with water depths varied from 2-4 m. Visibility of the water was only about 50 cm from surface measured with the Secchidisk with total suspended solid (TTS) reaching 182-567 mg L^{-1}. The surface water temperature was recorded daily and ranged from 28.5 to 29°C throughout the trials. The trapping experiments were set up as follows:

Experiment 1: Five modified collapsible traps were constructed with the same dimensions and materials (iron rod frame 800×600×280 mm, covered with poly-ethylene netting and with two open slackness nylon monofilaments 23 mm mesh size at each end). Each of the five traps was assigned

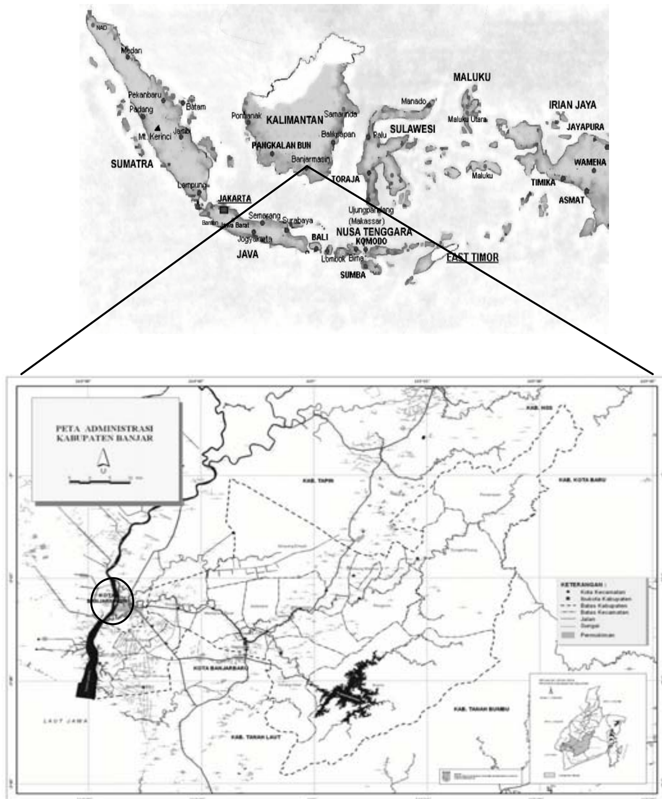

Fig. 1: The sampling area of Barito river in Banjarmasin, south Kalimantan

with one color of LED lamps (Torpedo flasher, Yuli Co.Ltd. China) or with incandescent lamps (YL/YS-1, Yuli Co.Ltd. China). Each color (blue, green, yellow, red and extra white) was tested and repeated three times with the same treatments. The objective of this experiment was to evaluate the effect of different color/intensity of lamps on number of catches.

Experiment 2: Four traps of different sizes and shapes were comprising: (1) box-shape trap: PVC rod frame 890×670×220 mm with black 150 mm hexagonal mesh wire (16 gauge PVC-coated wires). Ten entry funnels located on each side of the trap with a 500 mm inside ring entrance; (2) bamboo-stage trap: 420 mm high by 300 mm wide with an aperture of 15 mm apart and 25 mm wide opening; (3) wire-stage traps: 450 mm high by 400 mm wide, with 12 mm square mesh wire and 30 mm wide opening and (4) minnow nets: 600 mm long by 300 mm wide, covered with 12 mm polyethylene netting and 70 mm inside ring entrance. Each of the four traps was associated with single white LEDs or ordinary incandescent of squid fishing lamps (Yo-zuri Co.Ltd. Japan) following the same procedure. The objective of this experiment was to examine whether size and construction of the light traps affect number of catches.

The light traps were randomly laid on the bottom of the river and illumination began 1 h before sunset and picked up the next morning. On each sampling date, each trap was separated from the other traps approximately 5 m to minimize any significant light contamination between traps. Each trap of the groups was repeatedly used for three night operations (a total of 54 trials). The soaking-time for the traps varied from 14-16 h. After collection, the catches were identified for species and sex and measured for carapace length, total length and weight.

For the statistical analysis, the Mann-Whitney test was used to see which catch differed between two lamps or between individual sexes of the same species. The Kruskal-Wallis test was applied to see if there were significant differences in the total catch between the five traps in the Experiment 1 or between the four traps in the Experiment 2. The Multiple Comparison test was performed to see which catch differed significantly among the traps (Conover, 1980).

RESULTS

A total of 231 shrimps and 34 fish were caught across all treatments during the 6-night sampling periods (Table 1). There was a large variability in numbers between shrimp and fish collected. The shrimp catch was dominated by the longarms shrimp *Macrobrachium* sp. (99.6%) with size ranges of 24-85 mm total length (Fig. 2) and the lowest number was the giant freshwater shrimp *M. rossenbergii* (0.4%). Size-frequencies of the *Macrobrachium* sp. collected indicating that the light traps sampled juveniles and adults exclusively. A total of 85 males and 145 females including 55 egg-bearing females (38-74 mm TL) were collected in this study. The fish catch composed of *Oxyeoleotris urophthalmus* (38.2%), *Glossogobius giuris* (20.6%), *Oxyeoleotris marmorata* (17.6%), *Flounder pleuronectes* (8.8%), *Puntioplites bulu* (5.9%), *Mastacembelus erythrotaenia* (5.9%) and *Osteochilus melanopleura* (2.9%) with size ranges varied from 60-310 mm total length.

In the experiment 1, the LED lamps or colored incandescent lamps were associated with the same collapsible traps. Color or relative intensity of light had strong effects on numbers of shrimp and fish collected. The LED traps collected *Macrobrachium* sp. were significantly higher than that of colored incandescent ones (Mann-Whitney test, $p<0.05$) (Table 2). There was no difference in the total number of *Macrobrachium* sp. among LED traps used (Kruskal-Wallis test, $p>0.05$). It was identified that male has chelae 1.5 times longer than its total length and 1.3 times longer than female of the same size. The male's chelae collected in the light traps varied from 17-129 mm long. However, no significant different in the sizes between males and females collected (Mann-Whitney test, $p>0.05$) (Table 3). For colored incandescent lamps, yellow appeared to be the strongest attractor for *Macrobrachium* sp. among the colors (Multiple Comparison test, $p<0.05$). Then green was significantly different from blue, red and white (Multiple Comparison test, $p<0.05$). It was found that the number of female was significantly higher than that of male (Mann-Whitney test, $p<0.05$) regardless typical lamps used (Table 3). Male to female sex ratio of *Macrobrachium* sp.

Fig. 2: Pictures of *Macrobrachium* sp. collected from Barito River, Banjarmasin

Table 1: Total number, size range of Carapace Length (CL), Total Length (TL) and weight of shrimp and fish captured from the Barito River using various light traps over 6-night sampling periods

Local common name	English name	Scientific name	No. of catch	CL (mm)	TL (mm)	Weight (g)
Shrimp						
Udang Galah	Giant freshwater shrimp	*Macrobrachium rosenbergii*	1	38	75	2
Udang Sapit	Longarms shrimp	*Macrobrachium* sp.	230	10-38	24-85	0.4-9
Total			231			
Fish						
Blunguran mayang	Tank Goby	*Glossogobius giuris*	13	-	128-165	25-37
Belunguran hitam	-	*Oxyeoleotris urophthalmus*	7	-	110-135	15-32
Betutu/Bakut	Marble Goby	*Oxyeoleotris marmorata*	6	-	70-165	4-61
Sebelah	Flatfish	*Flounder pleuronectes*	3	-	60-135	4-32
Tilan	Spotted fire eel	*Mastacembelus erythrotaenia*	2	-	290-310	71-101
Puyau	-	*Puntioplites bulu*	2	-	60-80	2-5
Kelabau	-	*Osteochilus melanopleura*	1	-	235	177
Total			34			

Table 2: Total numbers of catch collected in the collapsible traps using LEDs and incandescent lamps in the experiment 1

	LED lamp					Incandescent lamp				
Species name	B	G	Y	R	W	B	G	Y	R	W
Macrobrachium rosenbergii	-	-	-	-	-	-	-	1	-	-
Macrobrachium sp.	31	31	22	26	28	5	13	22	6	4
Glossogobius giuris	2	-	4	2	1	1	1	1	-	1
Oxyeoleotris marmorata	-	-	1	1	-	-	-	-	-	1
Flounder pleuronectes	-	-	-	-	-	-	-	-	-	1
Mastacembelus erythrotaenia	-	-	-	1	-	-	-	-	1	-
Osteochilus melanopleura	-	-	-	-	-	1	-	-	-	-
Puntioplites bulu	-	-	-	1	-	-	-	-	-	-
Total	33	31	25	31	29	7	14	24	7	7

B: Blue, G: Green, Y: Yellow, R: Red, W: White

Table 3: Size ranges and numbers of individual sexes of *Macrobrachium* sp. caught by the collapsible traps with different colors of lamps in the experiment 1

	Size range (mm TL)		No. of catch	
Typical Lamp	Male	Female	Male	Female
LEDs				
Blue	52-73	44-68	6	26 (9)
Green	38-83	40-71	10	16 (9)
Yellow	33-80	38-52	9	13 (2)
Red	58-76	32-62	8	18 (10)
White	36-70	38-69	4	24 (11)
Total			37	97 (41)
Incandescent				
Blue	28	43	2	3
Green	64-83	33-70	3	10 (2)
Yellow	28-70	28-71	9	13 (3)
Red	57-69	24-58	3	3 (1)
White	28-62	44-52	2	2 (1)
Total			19	31 (7)

The bracketed numbers indicate the egg-bearing females

Table 4: Total numbers of catch collected in the box-shape, wire-stage, bamboo-stage and minnow net traps by mean of white LED and ordinary incandescent lamps in the experiment 2

	White LED lamp				Ordinary incandescent lamp			
Species name	A	B	C	D	A	B	C	D
Macrobrachium sp.	1	5	-	11	6	6	-	14
Oxyeoleotris urophthalmus	-	-	-	3	1	-	-	3
Oxyeoleotris marmorata	1	-	1	-	1	-	-	-
Flounder pleuronectes	-	-	-	-	-	-	-	2
Puntioplites bulu	-	-	-	-	-	-	-	1
Total	2	5	1	14	8	6	-	20

A: Box-shape trap, B: Wire-stage trap, C: Bamboo-stage trap, D: Minnow nets

Table 5: Size ranges and numbers of individual sexes of *Macrobrachium* sp. that collected in four different traps using white LED and ordinary incandescent lamps in the experiment 2

	White LED lamp				Ordinary incandescent lamp			
	Size range (mm TL)		No.of catch		Size range (mm TL)		No.of catch	
Typical traps	Male	Female	Male	Female	Male	Female	Male	Female
Box-shape	85	-	1	-	62-83	30-67	4	2(1)
Wire-Stage trap	75-85	-	4	-	40-80	47	5	1
Bamboo-Stage trap	-	-	-	-	-	-	-	-
Minnow nets	57-73	53-59	3	8(4)	45-81	45-61	12	2(1)
Total			8	8(4)			21	5(2)

The bracketed numbers indicate the egg-bearing females

was 1.0:2.6 for LED lamps and 1.0:1.6 for colored incandescent lamps. Both types of lamps were generally attractive enough to allure shrimp and fish into the traps in the river.

In the Experiment 2, performance of box-shape trap, wire-stage trap, bamboo-stage trap and minnow nets were investigated by mean of white LED and ordinary incandescent lamps. There were significant differences in the total catch between the four traps (Kruskal-Wallis test, $p<0.05$) and the Minnow nets collected significantly number of catch compared to other three traps (Multiple Comparison test, $p<0.05$) (Table 4). There was no significant difference between the collecting rates of the box-shape and wire-stage traps (Mann-Whitney test, $p>0.05$) but both traps caught more catch than bamboo-stage trap). More males than females were found in ordinary incandescent traps (Mann-Whitney test, $p<0.05$) (Table 5). The size and design of the light traps that affected number of catch were also evaluated in this study.

DISCUSSION

The present study clearly demonstrates that light traps can be used for harvesting shrimp and fish from the Barito Rivers without any bait. Data on phototactic response revealed that all colors or relative intensity of lights utilized in this study had strong effects on number of catches collected where LED traps appear to be more effective than incandescent ones. Although individual species collected in different numbers using specific colors or intensities of light, but insufficient support for a taxonomic color bias in the LED traps (Table 2). Most species seemed to respond similarly to the LED traps, except *Macrobrachium* sp. which to be found more attractive to the yellow incandescent trap. The efficacy of yellow light may be due to its wavebands not being attenuated under water as rapidly as blue or red wavebands (Wetzel, 2001). Yellow light also emits a greater intensity of light over a longer time than other colors tested which may have increased the effectiveness of yellow trap.

Macrobrachium sp. displayed stronger phototactic behaviour than *M. rosenbergii* (de Man, 1879) of the same genus in the river. From the results of phototactic data analysis, *Macrobrachium* sp. could be determined as a multichromatic species because it shows photopositive for all colors. Female dominated in catch during the whole sampling period (total sex ratio of male to female was 1.0:1.7). About 40% of total female collected in the light traps was egg-bearing females ranged from 38-71 mm total length (Table 3). Females are usually inactive during the breeding season, while females carrying the eggs still reacted positively to the light traps. It was also clear from our work with the American crayfish *Procambarus clarkii* (Ahmadi *et al.*, 2008). However, this result contrary to the observations of many studies (Richards *et al.*, 1996; Holdich, 2002; Faller *et al.*, 2006) which reported that egg-bearing females are less active than males. They become more active after releasing the young and preparing for mating.

Macrobrachium sp. in this river does not seem to have been scientifically described yet (proposed name *Macrobrachium baritoense*). It morphologically resembles with *M. australiense* (Holthuis, 1950) from Australia River (Dimmock *et al.*, 2004). To differentiate between two species, cheliped traits were considered as they show a high level of developmental variation (Short, 2000). It was clear from our findings that the male's chelae of *Macrobrachium* sp. (112 mm) has twice longer than that of *M. australiense* (51 mm) of the same size (72 mm) reported by Short (2000). The size range of *Macrobrachium* sp. (28-83 mm) collected from this study was also similar to *M. hainanense* (Parisi, 1919) in Chinase streams (Mantel and Dudgeon, 2004), *M. nippponense* (de Haan, 1849) in Japanese aquacultures (New, 2005) and *M. lamarrei* (H. Milne-Edward, 1937) in Nepal freshwater ponds and rivers (Sharma and Subba, 2005). However, it was considerably smaller than others *Macrobrachium* species in the same genus such as *M. ohione* (Smith, 1874) in the Upper Mississippi River (Conaway and Hrabik, 1997), *M. amazonicum* (Heller, 1862) in Amazon River (Bialetzki *et al.*, 1997), *M. rosenbergii* (de Man, 1879) in Thailand River (Sripatrprasite and Lin, 2003), *M. heterochirus* (Wiegmann, 1836) and *M. carcinus* (Linnaeus, 1758) in Mexico River (Mejia-Ortizi *et al.*, 2004). This study also suggests investigating the spawning season, distribution, growth and production of *Macrobrachium* sp. in the Barito River.

The results also showed that traps of different sizes and shapes but containing the same amount of attractant had effect on the numbers caught. The minnow nets collected almost 50% of total catch compared to other three traps regardless LED lamps and incandescent ones (Table 4). The least effective was a traditional bamboo-stage trap where shrimp/fish that went inside can easily find its way out again through bamboo-aperture itself (approx. 15 mm wide apart). This implies that to expect more catch by light traps, the trap designs should be modified. Sheaves (1995) asserted that the trap size can affect catch rates by influencing the density of animals in the trap. Beside the above problem, we found another reason why much less catches were sampled from Experiment 2, this because of the optical characteristic of squid fishing lamp that might be more suitably used in clear water (e.g., sea, coastal) rather than in turbid water.

Another criticism is clear from this study that the catch is not always found to be negatively correlated with turbidity which results may differ from other works (Meekan *et al.*, 2000; Lindquist and Shaw, 2005) in term of species target, size and design of traps, light sources and environmental condition. It is commonly understood that efficiency of light traps in clear water was greater than that of turbid water. The light attenuation is gradually declining with increasing of turbidity that would reduce the effective sampling radius of the traps (Lindquist and Shaw, 2005). It is interesting to conduct trapping experiments under highly turbid environment, since visibility of the water was only about 50 cm observed from surface with the help of the Secchidisk. Such condition may cause short sighting distance for the animals to access the light during nighttime. However, we have proved scientifically that light traps used in this study were able to entice shrimp and fish entered the traps even using 0.06 W LED with 3-volt dry-cell battery.

From this finding, we intend to enlarge our future phototactic study in Barito River to examine the light traps with specific designs associated with various colors or light intensities at different turbidity levels or under richly vegetated habitat. This indicating more detailed data will be needed to analyze the factors leading to this variation. Installation of underwater instruments (e.g., video-camera and digital light-meter) would also be helpful to investigate interaction between the animals and light traps as well as security risk.

We could not standardize catches to the Catch Per Unit of Effort (CPUE) for all treatments because the length of time that the lights were operational was variable and dependent on the type of light devices and variance in battery life. For future applications, the use of LEDs is considered more advantage than incandescent bulbs, because they are more energy efficient, more colors available and more durable. Creating a waterproof electrical light source at reasonable cost is the main challenge for designing light traps.

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REFERENCES

Ahmadi, G. Kawamura. and M.V. Archdale, 2008. Mechanism of phototaxis in American crayfish *Procambarus clarkii* (Girard, 1852) following different methods of trapping. J. Fish. Aquat. Sci., 3: 340-352.

Aswadirani, M., 2003. The Effect of Power of the Lamps Toward the Catch on the Lift Net in the Sungai Sipai River. Faculty of Fisheries, Lambung Mangkurat University, South Kalimantan, Pages: 37.

Bialetzki, A., K. Nakatani, G. Baumgartner and G. Bond-Buckup, 1997. Occurrence of *Macrobrachium amazonicum* (Heller) (Decapoda, Palaemonidae) in Leopoldo's inlet (Ressaco do Leopoldo), upper Parana river, Porto Rico, Parana, Brazil. Rev. Bras. Zool., 14: 379-390.

Brogan, M.W., 1994. Two methods of sampling fish larvae over reefs: A comparison from the Gulf of California. Mar. Biol., 118: 33-44.

Collier, K.J., B.J. Smith and B.R. Baillie, 1997. Summer light-trap catches of adult Trichoptera in hill-country catchments of contrasting land use, Waikato, New Zealand. N.Z. J. Mar. Freshwater Res., 37: 623-634.

Conaway, L.K. and R.A. Hrabik, 1997. The ohio shrimp, *Macrobrachium ohione,* in the Upper Mississippi River. Trans. Missouri Acad. Sci., 31: 44-46.

Conover, W.J., 1980. Practical Nonparametric Statistics. 2nd Edn. Texas Technique University, New York, USA., Pages: 493.

Dimmock, A., I. Williamson and P.B. Mather, 2004. The influence of environment on the morphology of *Macrobrachium australiense* (Decapoda: Palaemonidae). Aqua. Int., 12: 435-456.

Faller, M., I. Maguire and G. Klobucar, 2006. Annual activity of the noble crayfish (*Astacus asutacus*) in the Orljava River (Croatia). Bull. Fr. Peche Piscic., 383: 23-40.

Hernandez, Jr. F.J. and R.F. Shaw, 2003. Comparison of plankton net and light-trap methodologies for sampling larval and juvenile fishes at offshore petroleum platforms and a coastal jetty off Louisiana. Am. Fish. Soc. Symp., 36: 15-38.

Holdich, D.M., 2002. Biology of Freshwater Crayfish. 1st Edn. Blackwell Science, Oxford, ISBN: 063205431X, Pages: 702.

Holmes, J.M.C. and J.P. O'Connor, 1988. A portable light-trap for collecting marine crustaceans. J. Mar. Biol. Assoc. UK., 68: 235-238.

Kawamura, G., D.R. Monintja and K. Mangunsukarto, 1983. Fishing gear and methods in java, madura and Bali islands, Indonesia Rep. Kagoshima Univ. Sci. Surv. Indonesia, 1981: 9-40.

Lindquist, D.C. and R.F. Shaw, 2005. Effect of current speed and turbidity on stationary light-trap catches of larval and juvenile fishes. Fish. Bull., 103: 438-444.

Mantel, S.K. and D. Dudgeon, 2004. Growth and production of a tropical predatory shrimp, *Macrobrachium hainanense* (Palaemonidae), in two Hong Kong streams. Freshwater Biol., 49: 1320-1336.

Marchetti, M.P., E. Esteban, M. Limm and R. Kurth, 2004. Evaluating aspects of larval light trap bias and specificity in the Northern Sacramento river system: Do size and color matter?. Am. Fish. Soc. Symp., 39: 269-279.

Meekan, M.G., P.J. Doherty and L.J. White, 2000. Recapture experiments show the low sampling efficiency of light traps Bull. Mar. Sci., 67: 875-885.

Meekan, S.M., A. Wilson, A. Halford and Retzel, 2001. A comparison of catches of fishes and invertebrates by two light trap designs, in tropical NW Australia. Mar. Biol., 139: 373-381.

Mejia-Ortizi, L.M., F. Alvarez, R. Roman and J.A. Viccon-Pale, 2004. Fecundity and distribution of freshwater prawns of the genus macrobrachium in the Huitzilapan River, Veracruz, Mexico. Crustaceana, 74: 69-77.

Mukhlasin, R., 2004. The Use of Electrical Lamps with Different Powers Toward the Catch on The Stage Trap. Faculty of Fisheries, Lambung Mangkurat University, South Kalimantan, Pages: 36.

New, M.B., 2005. Freshwater prawn farming: Global status, recent research and a glance at the future. Aquacult. Res., 36: 210-230.

Richards, C., F.J. Kutka, M.E. McDonald, G.W. Merrick and P.W. Devore, 1996. Life history and temperature effect on catch of northern orconectid crayfish. Hydrobiologia, 319: 111-118.

Sharma, A. and B.R. Subba, 2005. General biology of freshwater prawn, *Macrobrachium lamarrei* (H. Milne-Edwards) of Biratnagar, Nepal. Our Nat., 3: 31-41.

Sheaves, M.J., 1995. Effect of design modifications and soak time vanations on Antillean-Z fish trap performance in a tropical estuary. Bull. Marine Sci., 56: 475-489.

Short, J.W., 2000. Systematics and biogeography of Australian Macrobrachium (Crustacea: Decapoda: Palaemonidae)-with descriptions of other new freshwater Decapoda. Doctor of Philosophy Thesis, University of Queensland, Australia.

Sripatrprasite P. and C.K. Lin, 2003. Stocking and recapture of freshwater prawn (*Macrobrachium rosenbergii* De Man) in a run of river type dam (Pak Mun Dam) in Thailand. Asian Fish. Sci., 16: 167-174.

Thorrold, S.R., 1992. Evaluating the performance of light traps for sampling small fish and squid in open waters of the central Great Barrier Reef lagoon. Mar. Ecol. Prog. Ser., 89: 277-285.

Wetzel, R.G., 2001. Limnology: Lake and River Ecosystems. 3rd Edn., Academic Press, San Diego, USA., Pages: 1006.