UNIVERSITI PUTRA MALAYSIA

EVALUATION OF GROWTH AND SURVIVAL OF SNAKEHEAD (Channa striatus BLOCH.) IN CAPTIVE CONDITION

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DEDICATION

To my lovely mother, Rohana Wan Ibrahim and my beloved father, Mohd Pazai Mat Salim who always kept praying for me day and night to achieve my goal

To my brothers and sisters:
Mohd Rahul,
Mohd Agus Khairi,
Hani Hazwani,
Mohd Nazmi Izzat,
Mohd Akmal Dini,
Muhammad Illias,
Ainun Basyirah,
Ahmad Rusyidi.

and

To all my friends who supported me all those past years

Abstract of thesis was presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

EVALUATION OF GROWTH AND SURVIVAL OF SNAKEHEAD (*Channa striatus* BLOCH.) IN CAPTIVE CONDITION

By

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February, 2014

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Growth and survival of endangered snakehead *Channa striatus* were investigated at different diets, feeding frequencies and stocking densities under captive rearing condition. The first experiment was carried out on *C. striatus* fry using selected fresh diets like as bloodworm, trash fish and *Acetes* shrimp. The fry fed with trash fish showed significantly higher ($p < 0.05$) weight gain percentage (376.50 ± 20.74 %) than those fed with *Acetes* shrimp (233.05 ± 10.18 %) and bloodworm (199.08 ± 17.25 %). Fry fed with trash fish also showed the best SGR value (6.24 ± 0.17 % day^{-1}) followed by *Acetes* shrimp (4.81 ± 0.12 % day^{-1}) and then bloodworm (4.33 ± 0.22 % day^{-1}). The best FCR value (3.63 ± 0.27) was found in fish fed with trash fish compared to those fed with *Acetes* shrimp (7.41 ± 0.88) and bloodworm (11.48 ± 1.51). The second experiment was conducted to observe the variation of growth performance of *C. striatus* fry fed with commercial pellet and fresh trash fish. Three treatments were used in this experiment: trash fish (T1), commercial pellet (T2) and combination of trash fish and pellet (T3). The highest weight gain percentage (539.70 ± 33.67 %) was observed in T3, followed by T2 (475.77 ± 43.33 %) and T1 (189.46 ± 40.48 %). Significantly higher SGR was in T3 (5.30 ± 0.15 % day^{-1}), than in T2 (4.99 ±0.21 % day^{-1}) and T1 (3.01 ± 0.40 % day^{-1}) respectively. The highest survival was observed in T3 (96.11 ± 1.83 %), followed by T2 (95.00 ± 2.59 %) and T1 (80.56 ± 6.54 %) respectively. The feeding frequency experiment was carried out using pellet that contained 44% protein for 42 days. The fry were fed at 6 % of body weight daily at 2, 4, 6 and 8 times/day. The result showed significant ($p < 0.05$) differences in the weight gain (%) among the treatments where 2 times/day yield the highest value (316.23 ±36.94 %). SGR was also exhibited significant ($p < 0.05$) difference among the feeding frequency treatments and ranged from 2.64 to 3.37 % day^{-1}. The highest survival percentage was found in the fry fed 2 times/day (100.00 ± 0.00 %) while, the lowest was found in fry fed 8 times/ day (80.00 ± 0.00 %).

The final experiment was on the effect of different stocking density of *C. striatus* in captivity. There were three treatment of stocking density in this experiment which were 20 (T1), 30 (T2) and 40 (T3) individual/m^2. The final mean total length was significantly higher ($p < 0.05$) in T1 which was 17.70 ± 0.21 cm compared with T2 (16.55 ± 0.18 cm) and T3 (15.97 ± 0.21 cm). There was significant difference ($p < 0.05$) in weight gain percentage. The weight gain percentage in T1, T2 and T3 were 2262.990 ± 300.159, 2693.393 ± 298.070 and 1860.130 ± 77.614 % respectively. There were no significant different ($p > 0.05$) in SGR in T1 (1.55 ± 0.01 % day^{-1}) and T2 (1.57 ± 0.05 % day^{-1}) however both treatments were significantly difference with T3 (1.41 ± 0.01 % day^{-1}). There was no significant different ($p > 0.05$) in FCR in all treatments used. The estimated gross and net production was higher in T3 (1775.79 g/m^2), followed by T2 (1498.56 g/m^2) and T1 (1111.08 g/m^2). A similar trend was also found in net production among all the treatments. In conclusion, commercial pellet was the most suitable for *C. striatus* fry to promote better growth, weight gain and survival. Feeding frequency of 2 times/day was the optimum frequency for growth and survival of *C. striatus.* In term of growth performance, 20 individual/m^2 was the most suitable stocking density. In term of production, 40 individual/m^2 was the most suitable stocking density under a monoculture system in tank.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENILAIAN PERTUMBUHAN DAN KEMANDIRIAN HARUAN (*Channa striatus* BLOCH.) DALAM KEADAAN KURUNGAN

Oleh

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Pertumbuhan dan kemandirian hidup spesis terancam ikan haruan *Channa striatus* disiasat dalam pemakanan, kekerapan makan dan kepadatan stok yang berbeza di bawah keadaan ternakan terkurung. Eksperimen pertama telah dijalankan ke atas *C. striatus* menggunakan diet terpilih seperti cacing darah, ikan baja dan udang *Acetes*. Fri yang diberi makan dengan ikan baja menunjukkan perbezaan tinggi ($p < 0.05$) peratus pertambahan berat (376.50 ± 20.74 %) berbanding fri yang diberi makan udang *Acetes* (233.05± 10.18%) dan cacing darah (199.08 ± 17.25 %). Fri yang diberi makan ikan baja juga menunjukkan nilai SGR yang terbaik (6.24 ± 0.17 % hari^{-1}) diikuti oleh udang *Acetes* (4.81 ± 0.12 % hari^{-1}) dan kemudiannya cacing darah (4.33 ± 0.22 % hari^{-1}). Nilai FCR yang terbaik (3.63 ± 0.27) telah dijumpai pada ikan yang diberi makan dengan ikan baja berbanding dengan ikan yang diberi makan udang *Acetes* (7.41 ± 0.88) dan cacing darah (11.48 ± 1.51). Kajian kedua telah dijalankan untuk melihat perbezaan prestasi pertumbuhan fri ikan *C. striatus* yang diberi makan dengan pelet komersial dan ikan baja segar. Tiga rawatan telah digunakan di dalam kajian ini: ikan baja (T1), pelet komersial (T2) dan kombinasi ikan baja dan pelet komersial (T3). Peratus kenaikan berat tertinggi (539.70 ± 33.67 %) diperhatikan pada T3, diikuti oleh T2 (475.77 ± 43.33 %) dan T1 (189.46 ± 40.48 %). Perbezaan ketara tinggi SGR adalah pada T3 (5.30 ± 0.15 % hari^{-1}), berbanding T2 (4.99 ± 0.21 % hari^{-1}) dan T1 (3.01 ± 0.40 % hari^{-1}) masing-masing. Kajian kekerapan makan telah dijalankan menggunakan pelet yang mengandungi 44% protin selama 42 hari. Fri diberi makan 6 % daripada berat badan setiap hari pada 2, 4, 6 dan 8 kali/ hari. Keputusan menunjukkan perbezaan ($p < 0.05$) ketara dalam pertambahan berat (%) di kalangan rawatan yang di mana 2 kali/hari menghasilkan nilai tertinggi (316.23 ±36.94 %). SGR juga menunjukkan perbezaan ($P < 0.05$) ketara di antara rawatan kekerapan makan dan berjulat dari 2.64 hingga 3.37 % hari^{-1}. Peratus kemandirian yang tertinggi ditemui dalam fri yang diberi makan 2 kali/hari (100.00 ± 0.00 %) manakala, yang terendah ditemui dalam fri yang diberi makan 8 kali/hari (80.00 ± 0.00 %).

Kajian terakhir adalah kesan kepadatan stok *C. striatus* di dalam kurungan. Terdapat tiga kepadatan stok yang dikaji iaitu 20 (T1), 30 (T2) dan 40 (T3) individu/ m^2.

Jumlah panjang purata akhir adalah lebih tinggi dalam T1 iaitu 17.70 ± 0.21 cm berbanding T2 (16.55 ± 0.18 cm) dan T3 (15.97 ± 0.21 cm). Terdapat perbezaan ($p < 0.05$) ketara dalam peratusan pertambahan berat badan. Peratusan pertambahan berat badan dalam T1, T2 dan T3 adalah 2262.99 ± 300.16, 2693.39 ± 298.07 dan 1860.13 ± 77.61 % masing-masing. Tiada perbezaan ketara ($p > 0.05$) pada SGR dalam T1 (1.55 ± 0.01 % $hari^{-1}$) dan T2 (1.57 ± 0.05 % $hari^{-1}$) walau bagaimanapun kedua-dua rawatan mempunyai perbezaan yang ketara ($p < 0.05$) dengan T3 (1.41 ± 0.01 % $hari^{-1}$). Tiada perbezaan ketara ($p > 0.05$) dalam FCR dalam semua rawatan yang digunakan. Anggaran pengeluaran kasar terbaik adalah dalam T3, 1775.79 g/ m^2, diikuti oleh T2, 1498.56 g/ m^2 dan T1, 1111.08 g/ m^2. Gaya yang sama juga ditemui dalam pengeluaran bersih di dalam semua rawatan. Kesimpulannya, pelet komersial adalah makanan paling sesuai untuk fri *C. striatus* untuk menggalakkan pertumbuhan yang lebih baik, pertambahan berat badan dan kemandirian hidup. Kekerapan makan 2 kali/hari adalah kekerapan optimum untuk pertumbuhan dan kemandirian *C. striatus*. Dari istilah prestasi pertumbuhan, 20 individu/m^2 adalah kepadatan stok yang paling sesuai. Dari istilah pengeluaran, 40 individu/m^2 adalah kepadatan stok yang paling sesuai untuk sistem monokultur di dalam tangki.

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I certify that an examination committee has met on **14th February 2014** to conduct the final examination of **Afzan Muntaiana Bt Mohd Pazai** on her Master of Science thesis entitled **"Evaluation of Growth and Survival of Snakehead, *Channa striatus* (Bloch 1793) in Captive Condition"** in accordance with Universiti Pertanian Malaysia (Higher Degree) act 1980 and Universiti Pertanian Malaysia (Higher Degree) regulations 1981. The committee recommends that the candidate be awarded the relevant degree.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
Cu	Cuprum
cm	Centimeter
CRD	Completely randomize design
DO	Dissolved oxygen
DHA	Docosahexaenoic acid
FCR	Food conversion ratio
g	Gram
h	Hour
ha^{-1}	Hectare
H_2SO_4	Sulfuric acid
IUCN	International Union for Conservation of Nature
ind	Individual
kg	Kilogram
L	Liter
Min	Minute
Mg/L	Milligram per liter
ml	Milliliter
MTL	Mean total length
NaOH	Sodium hydroxide
pcs	Pieces
PER	Protein efficiency ratio
ppm	Part per million
PVC	Polyvinyl chloride
RAS	Recirculating Aquaculture System
SE	Standard error
SGR	Specific growth rate
Sp.	Species
T	Treatment
TL	Total length
TW	Total weight
UPM	Universiti Putra Malaysia
USA	United States of America
^0C	Degree Celsius
%	Percentage
<	Less than
>	More than

CHAPTER 1

GENERAL INTRODUCTION

Snakehead *Channa striatus* or locally known as "Haruan" in Malaysia is one of the native freshwater fish of tropical Africa and Asia (Ng and Lim, 1990). It belongs to family Channidae and also known as murrels or serpent-headed fish. It is carnivorous in nature and eats frogs, fishes, insects, tadpoles and earthworms (Rahman *et al*., 2012). The carnivorous behavior can be seen at early fry stage. Fry starts feeding on zooplankton and changes their feeding habit to eat small crustacean, insect and insect larvae at juvenile stage. It is an air-breathing fish that can survive in harsh environment with lower dissolved oxygen and high ammonia contents (Marimuthu and Haniffa, 2007). It can stay alive without water as long as its gills remain moist.

Since *C. striatus* is not a good swimmer it prefers stagnant, slow running and shallow water not more than 2 meters with dead log and aquatic plants so that it can easily hide and hunt for food (Mat Jais, 2007). However *C. striatus* can also be found in water with 12 meters of depth. The fish has unique habit of burrowing itself into the bottom mud of pond during drought and going deeper and deeper as the mud dries, only to come out when situation granted (Mat Jais, 1991; Rahman *et al.*, 2012). In Malaysia, *C. striatus* is a well known as remedy for wound healing and traditionally used among mid wives for decades. *Channa striatus* is consumed to hasten healing after giving birth and used as a supplement among caesarean mothers and to treat illnesses like diabetic, gangrene and cancer (Mat Jais *et al*., 1994; Mat Jais, 1997)

Channa striatus has form for about 13% of the marketable freshwater fishes in India (Chakrabarthy, 2006; Aliyu-Piako *et al*., 2009) and is cultured commercially mostly in Philippines, Thailand, Cambodia and Vietnam (Wee, 1982). However not all farmers are willing to culture snakehead due to its feeding behavior. The feed cost may be expensive compared to pellets since the price of trash fish has also increased due to market demands. (Jantrarotai and Jantrarotai, 1993). Nowadays, most commercial snakehead culture relies on capture of wild fry, and then trained them to accept formulated feed which consists of fish paste and rice bran or wheat flour (Diana *et al*., 1985).

Channa striatus is highly predaceous that they can swallow their prey whole (Diana *et al*., 1985). Therefore, proper knowledge of suitable culture methods should be known in order to successfully culture this species with high production and low cost. In Taiwan, Hong Kong, India and Bangladesh, snakehead species were successfully culture in earthen ponds (Wee, 1982; Rahman *et al*., 2012a). Diana *et al*. (1985) conducted monocultures of snakehead juveniles in ponds with stocking density ranging from 40 to 80m^{-2}. Typical survival was about 13-15% after 9-11 months. However, it was not certain whether the growth of snakehead was affected by stocking density. Other than that, there was no report available on successful culture of *C. striatus* in tanks.

The natural population of this species decreases rapidly due to habitat degradation and is now acknowledged as an endangered fish in Bangladesh (IUCN, Bangladesh 1998). Therefore, the present study on the evaluation of growth and survival of *C. striatus* in captive condition were carried out.

The objectives of this study were:

1. To evaluate the growth and survival of *C. striatus* fry based on different type of feeds (bloodworm, trash fish and *Acetes* shrimp).
2. To determine the growth performance of *C. striatus* fry fed with trash fish and commercial pellet.
3. To determine the effects of different feeding frequencies on growth performance and survival of *C. striatus* fry.
4. To determine the growth performance, survival and production of *C. striatus* in different stocking densities in tank.

REFERENCES

Abu Hassan, I., Hanafi, H., Che Musa, C. U. and Pathmasothy, S. 1988. *Status of shrimp and finfish feeds in Malaysia*. Report of the workshop on shrimp and finfish feed development: Johor Bharu.

Abu Hassan, I ., Hanafi, H., Che Musa, C. U. and Pathmasothy, S. 1989. Status of shrimp and finfish feeds in Malaysia. Report of a workshop on shrimp and finfish feed development, Johor Bahru, Malaysia, 25-29 Oktober 1988. ASEAN/ UNDP/ FAO Regional small scale Coastal Fisheries Development Project, Manilla, Philippines, pp.123-129

Ali, A.B. 1999. Aspect of the reproductive biology of female snakehead (*Channa striata*, Bloch) obtained from irrigated rice agroecosystem, Malaysia. *Hydrobio.* 411:71-77.

Aliyu-Paiko, M., Hashim, R. and Shu-Chien, A.C. 2010. Influence of dietary lipid/protein ratio on survival, growth, body indices and digestive lipase activity in Snakehead (*Channa striatus*, Bloch 1793)fry reared in re-circulating water System. *Aquacult. Nutrit.* 16: 466-474.

Aliyu-Paiko, M., Hashim, R. Chong, A.S.C., Yogarajah, L. and El-Sayed,A.F. 2010. Influence of different sources and levels of dietary protein and lipid on the growth, feed efficiency, muscle composition and fatty acid profile of Snakehead *Channa striatus* (Bloch, 1793) fingerling. *Aquacult. Res.* 41: 1265-1376.

Altaff, K., Raghunathan, M.B., Suresh, K.R. and Suriyanarayana, M.M. 2002. Harvest of zooplankton live food for ornamental fishes from natural ponds in north Chennai, Tamilnadu. *Ind. Hydro.* 5: 115-118.

Abol-Munafi, A.B., Tam, B.M., Ambak, M.A., and Ismail, P. 2004. Effect of different diets on growth and survival rates of snakehead (*Channa striata* Bloch, 1797) Larvae. *Korean J Biol Sci.* 8:313-317.

Arockiaraj, A.J.,Muruganandam, M., Marimuthu, K. and Haniffa, M.A. 1999. Utilization of carbohydrate as a dietary energy source by the striped murrel *Channa striatus* (Bloch) fingerlings. *Acta Zool. Taiwan.* 10(2): 103-111

Andrews, J.W. and Page, J.W. 1975. The effect of frequency of feeding on the culture of catfish, *Trans. Am. Fish. Soc.* 104: 317-321.

Baie, S.H. and Sheikh, K.A. 2000. The wound healing properties of *Channa striatus*-cetrimide cream- tensile strength measurement. *J. Ethnopharmacol* 71: 93-100.

Bascinar, N., Okumus, I., Bascinarr, N.S. and Saglam, H.E. 2001. The influence of daily feeding frequency on growth and feed consumption of rainbow trout

fingerlings (*Oncorhynchus mykiss*) reared at 18.5-22.5 ^{0}C. *Bamid.* 53: 80-83.

Boonyaratpalin, M., McCoy, E.W. and Chittapalapong, T. 1985. Snakehead culture and its socio-economics in Thailand. Annual Report, Fisheries and Aquaculture Department, Thailand, pp: 27

Bowman, W.C. and Rand, M.J. 1980. *Textbook of Pharmacology (2nd ed*.). Oxford: Blackwell.

Chakrabarty, N.M. 2006. Murrels and Murrel Culture, Narendra Publishing House, Delhi, pp: 12.

Choudhury, B.B.P., Das, D.R., Ibrahim, M. and Chakraborty, S.C. 2002. Relationship between feeding frequency and growth of one Indian Major carp *Labeo rohita* (Ham.) fingerlings fed on different formulated diets. *Pak. J. Biol. Sci.* 5 (10): 1120-1122.

Chappell, A.E. 1974. Linear programming cuts costs in production of animal feeds. *Operat. Resear. Quarter.* 25 (1): 19-26.

Chen, T.P. 1976. *Aquaculture Practice in Taiwan*. Fishing News (Books) Limited. Farnham: UK.

Chuchot and Chittamnan. 2004. Effect of feeding frequency on growth of juvenile snakehead fish (*Channa striatus*). *K. Mongkut's Agricult. J*. 22 (2): 48-54.

Chua, T.E. and Teng, S.K. 1978. Effect of feeding frequency on the growth of young estuary grouper, *Epinephelus tauvina* (Forskal) cultured in floating cages. *Aquacult.* 14: 31-47.

Chiu, Y., Sumagaysay, N.S. and Sastrillo, A.S. 1987. Effect of feeding frequency and feeding rate on the growth and feed efficiency of milkfish, *Chanos chanos* Forsskal, juveniles. *Asian Fish. Sci.* 1 (1): 27-31.

Choomthi, A., Soonthomvipat, P and Thongkhamchum, S. 2011. Cage Culture of Cobra Snakehead (*Chana Marulius* Hamilton, 1822) at Different stocking Density. Technical paper No. 11/2011. Inland Fisheries Research and Development Bureau, Department of Fisheries Ministry of Agriculture & Cooperatives.

Davidson, A., 1975. Fish and fish dishes of Laos. *Imprimerie Nationale Vientiane*, pp: 202.

Davies, O.A., Inko Tariah, M.B. and Amachree, D. 2006. Growth response and survival of *Heterobranchus longifilis* fingerlings fed at different feeding frequencies. *Afr. J. Biotechnol*. 5: 778-787.

De Silva, S.S. and Davy, F.B. 1992. Fish nutrition research for semi-intensive culture system in Asia. *Asian Fish. Sci.* 5: 129-144.

Degani, G.A. and Horowitz Levanon, D. 1985. Effect of protein level on impurities, diet, density, ammonia and DO level on growth of European eel, Anguila anguila (L). *Aquacult.* 46: 193-200.

Degani, G. A. 1991. The effect of diet, population density and temperature on growth of larvae and juvenile *Trichogaster trichopterus* (bloch and Schneider 1901). *J. Aqua. Trop.* 6:135-141.

Diana, J.S., Chang, W.Y.B.,Ottey, D.R. and Chuapoehuk, W. 1985. Productionsystems for commonly cultured freshwater fishes of Southeast Asia. In: *International Program Report No. 7*(ed. By Great Lake and Marine WaterCenter), pp. 75-79. University of Michigan, Ann Arbor, MI.

Dwyer, K.S., Brown, J.A., Parrish, C. and Lall, S.P. 2002. Feeding frequency affects food consumption, feeding pattern and growth of juvenile yellowtail flounder (*Limanda ferruginea*). *Aquacult.* 213: 279-292.

Froose, R. and Paula, D. 2009. *Channa striata* in Malaysia. Fish Base. World Wide Web electronic publication. pp:343

Gokcek, C.K. and Akyurt, Y. 2007. The effect of stocking density on yield, growth and feed efficiency of himri barbell *Barbus luteus* (Heckel, 1843) nursed in cages. *Israeli J. Aqua.* 59: 99-103.

Harpaz, S., Hakim, Y., Barki, A., Karplus, I., Slosman, T. and Eroldogan, O.T. 2005. Effects of different feeding levels during day and/or night on growth and brush-border enzyme activity in juvenile *Lates calcarifer* reared in freshwater re-circulating tanks. *Aquacult.* 248: 325-335.

Haniffa, M.A. and Arockiaraj, A.J. 1999. Dietary lipid requirement in the fingerlings of Channa striatus (Bloch). Natl. Symp. *On Sustainable Development of Fisheries towards 2020 AD*. pp 69

Haniffa, M.A., Merlin, T. and Mohamed, J.S.2000. Induce spawning of the striped murrel *Channa striatus* using pituitary extracts, human choronic gonadotropin and luteinzing hormone releasing hormone analogue and ovaprim. *Acta.Icht. Piscat*. 30: 53-60

Hashim, R. and Mat Saat, N.A. 1992. The utilization of seaweed meals as binding agents in pellet feeds for snakehead (*Channa striatus*) fry and their effects on growth. *Aquacult.* 108: 299-308.

Hecht, T. and Appelbaum, S. 1988. Observations on intraspecific aggressionand coeval sibling cannibalism by larva and juvenile *Clarias gariiepinus* (Clariidae: Pisces) under controlled conditions. *J. Zool*. 214: 21-44.

Hecht, T. and Pienaar, A.G. 1993. A review of cannibalism and its implications in fish larviculture. *J. World Aquacult. Soc.* 24: 246-261.

Hung, L.T., Tuan, N.A. and Lazard, J. 2001. Effect of frequency and time of feeding on growth and feed utilization in two Asian catfishes, *Pangasius bocourti* (Sauvage, 1880) and *P. hypophthalmus* (Sauvage, 1878). *J. Aquac. Trop.* 16(2): 171-184.

IUCN, Bangladesh, 1998. List of threatened animals of Bangladesh. Paper presented in the special workshop on Bangladesh Red Book of Threatened Animals, 22 February 1998, Dhaka, pp:13.

Invasive Species Program Snakeheads-The Newest Aquatic Invader. July 2002. U.S. Fish and Wildlife Service. Retrived 03 March 2012 from http://www.dnr.state.md.us/fisheries/ snakeheadfactsheetedited.pdf.

Jantrarotai, W. and Jantrarotai, P. 1993. On-Farm Feed Preparation and Feeding Strategies for Catfish and Snakehead. In: *Farm-Made Aquafeeds*, New, M.B., A.G.J. Tacon and I. Csaves (Eds.). FAO-RAPA/AADCP, Bangkok, Thailand, pp: 101-119.

Ji, S.C., Takaoka, O., Biswas, A.K., Seoka, M., Ozaki, K., Kohbara, J., Ukawa, M., Shimeno, S., Hosokawa, H., and Takii, K. 2008. Dietary utility of enzyme-treated meal for juvenile Pacific bluefin tuna *Thunnus orientalis*. *Fish. Sci.* 74 (1): 54-61.

Kaiser, H., Weyl, O. and Hecht, T. 1995. The effect of stocking density ongrowth, survival and agonistic behavior of African catfish. *Aquacult. Inter.* 3: 217-225.

Kaushik, S.J. and Meadale, F. 1994. Energy requirements, utilization and supply to salmoids. *Aqua.* 124: 81-94.

Khanna, S.S., 1978. *An introduction to fishes*. (Second Edition). Central Book Dept: Allahabad. pp. 428.

Kumar, S., Srivastava, A. and Chakrabarti, R. 2005.Study of digestive proteinases and proteinase inhibitors of *Daphnia carinata*. *Aquacult.* 243: 367-372

Kumar. D., Marimuthu, K., Haniffa, M.A. and Sethuramalingam, T.A. 2008. Effect of Different Live Feed on Growth and Survival of Striped Murrel *Channa striatus* larvae. E.U. *Journal of Fisheries & Aquatic Sciences* 25(2):105-110.

Khan, M.A. and Jafri, A.K. 1994. Replacement of fish meal with soybean meal diets formulated for fingerling carp *Labeo rohita* (Ham). *T. Third Fish. Forum* 663-666.

Kim, J., Masses, K.C., and Hardy, R.W. 1996. Adult artemia as food for first feeding Coho salmon (*Oncorhynchus kisuteh*). *Aquacult.* 144: 217-226.

Lee, S., Hwang, U. and Cho, S.H. 2000. Effects of feeding frequency and dietary moisture content on growth, body composition and gastric evacuation of juvenile Korean rockfish (*Sebastes schlegeli*). *Aquacult.* 187: 399-409.

Liu, E.G. and Liao, C. I. 1999. Effect of feeding regimen on the food consumption, growth and body composition in hybrid striped bass *Morone saxitilis* x *M. chrysops*. *Fish. Sci.* 64: 513-519.

Ling S.W., 1977. Snakehead, *ophiocephalus* spp culture. In: *S.W. Ling* (ed). Aquaculture in Southeast Asia: A historical overview: University of Washington Press, Seattle. pp 60–66.

Marimuthu, K. and Haniffa, M.A. 2007. Embryonic and larval development of the striped snakehead *Channa striatus*. *Taiwan.* 52 (1): 84-92.

Marimuthu, K., Haniffa, M.A., Arockiaraj, A.J. and Muruganandam, M. 2001. Spawning and parental behaviour in the induced bred murrels. *Ind. J. of Fish.* 48: 409-411.

Mat Jais, A.M. 1992. Haruan, *Channa striatus*, farming in backyard.Proceedings of the 3rd Asian Conference of Technology for Rural Development, August 12-14, 1992, Kuala Lumpur, Malaysia, pp: 230-232.

Mat Jais, A.M., McCulloh, R. and Croft, K. 1994. Fatty acid and amino acidcomposition in haruan as a potential role in wound healing. *Gen. Pharmacol.* 25: 947–950.

Mat Jais, A.M. 1997. Haruan *Channa striatus* as a component of health food. Proceedings of the Seminar of the Asean Food Technology, October 6-7,1997, Kuala Lumpur, pp: 39-43.

Mat Jais, A.M., Fung, R., Bosi, E., Platell, C., McCauley, R., and Croft, K. 1998. Preliminary evidence on the potential of Haruan (*Channa striatus*) for wound healing. *Mal. Appl. Biol.* 27: 50-51.

Mat Jais, A.M. 2007. Pharmacognosy and pharmacology of Haruan (*Channa striatus*), a medical fish with wound healing properties. *Bolet. Lat. Americ. y del Caribe de Plant. Med. y Aroma.* 6: 52-60.

Michelle, N.Y.T., Shanthi, G. and Loqman, M.Y. 2004. Effect of orally administered *Channa striatus* extract against experimentally-induced osteoarthritis in rabbits. *Int. J. Appl. Res. Vet. Med*. 2: 171-175.

Mathavan, S. 1976. Satiation time and predatory behavior of the nymph *Mesogomhus linetus*. *Hydrobiol* 50: 55-64.

Muntaziana, M.P.A., Amin, S.M.N., Kamarudin, M.S. and Rahim, A.A. 2013. Effect of selected diets on the growth and survival of snakehead fish (*Channa striatus*) fry. *J. Fish. and Aqua. Sci.* 8(2): 405-411.

Mollah, M.F.A., Mamun, M.S.A., Sarowar, M.N., and Roy, A. 2009. Effect of stocking density on the growth and breeding performance of broodfishand larval growth and survival of shoal, *Channa striatus* (Bloch). *J. Bangladesh Agric. Univ.***7**: 427-432.

Mohanty, S.S. and Samantaray, K. 1996. Effects of varying levels ofdietary protein on the growth performance and feed conversion efficiency of snakehead, *Channa striata* fry. *Aquacult. Nutr*. 2: 89–94

Mori, T., Bao, D.Q., Burke, V., Puddey, I.B. and Beilin, L.J. 1999. Docosahexanoic acid lowers ambulatory blood pressure and heart rate in humans. *Hyper.* 34(2):253-260.

Ng, P.K.L. and Lim, K.K.P. 1990. Snakeheads (Pisces: Channidae): natural history biology and economic importance. In *Essays in Zoology*. Papers Commemorating the 40th Anniversary of the Department of Zoology (ed,by L.M. Chou & K.L.P. Ng). pp. 127-152. National University of Singapore, Singapore.

Noeske-Hallin, T.A., Spieler, R.E., Parker, N.C. and Suttle, M.A. 1985. Feeding time differentially affects fattening and growth of channel catfish. *The J. Nutr.* 115: 1228-1232.

Parker, N.C. 1987. Feed conversion indices: controversy or convention? *Progress. Fish. Cult*. 49: 161-166.

Pathmasothy, S. and Lim, T.J. 1987. Comparative study of the growth rate and carcass composition of the striped catfish, Pangasius sutchi (Fowler) fed with chicken viscera and peleted feeds in static ponds. Department of Fisheries, Ministry of Agriculture, Malaysia. *Fish. Bull* 50: 11.

Qin, J.G. and Fast, A.W. 1996a. Effects of feed application rates on growth,survival and feed conversion of juvenile snakehead *Channa striatus*. *J. World Aquacult. Soc.* 27: 52-56

Qin, J.G. and Fast, A.W. 1996b. Size and feed dependent cannibalism with juvenile snakehead *Channa striatus*. *Aquacult.* 144: 313-320.

Qin, J.G. and Fast, A.W. 1997. Food selection and growth of young snakehead *Channa striatus*. *J. of Appl. Ichthyol.*13: 21-25.

Qin, J.G., Fast, A.W. and Kal, A.T. 1997. Tolerance of snakehead *Channa striatus* to ammonia at different pH. *J. World Aquacult. Soc.* 28: 87-90.

Qin.J.G, Fast, A.W., DeAnda, D.and Weidenbach, R.P.1997. Growth and survival of larval snakehead (*Channa striatus*) fed different diets.*Aquaculture*148.

Qin, J.G. and Fast A.W. 1998. Effects of temperature, size and density on culture performance of snakehead, *Channa striatus* (Bloch), fed formulated feed. *Aquacult. Resear.* 29: 299-303.

Qin, J.G. and Fast A.W. 2003. Intensive culture of snakehead (*Channa striatus*) during larval, juvenile and growth stages. *American Fish. Soc. Symp.* 38: 33-41.

Rahman, M.A., Arshad, A., & Amin, S.M.N. 2012.Growth and production performance of threatened snakehead fish, *Channa striatus* (Bloch), at different stocking densities in earthen ponds. *Aquacult. Resear.* 43: 297-302.

Rahman, M.A., Arshad, A., Amin, S.M.N., and Shamsudin, M.N. 2013. Growth and survival of fingerlings of a threatened snakehead, *Channa striatus* (Bloch) in earthen nursery ponds. *Asian J. Anim. Vet. Adv*. 8(2): 216-226.

Rahim, M.H.A., Rozila, A. and Mat Jais, A.M. 2009. The physical-chemical and morphological study of Haruan *Channa striatus* in Peninsular Malaysia. *Resear. J. of Bio. Sci.* 4 (9): 994-1009.

Riche, M., Haley, D.I., Oetker, M., Garbrecht, S. and Garling, D.L. 2004. Effect of feeding frequency on gastric evacuation and the return of appetite in tilapia *Oreochromis niloticus* (L.). *Aquacult.* 234: 657-673.

Ronyai, A. and Ruttkay,A.1990. Growth and food utilization of wels fry (*Silurus glanis*) fed with tubifex. *Aquacult. Hung. (Szarvas)* 6: 193-202.

Ruohonen, K. and Grove, D.J. 1996. Gastrointestinal responses of rainbow trout to dry pellet and low-fat herring diets. *J. of Fish Bio.* 49: 501-513.

Salama, A.J. 2008. Effect of different feeding frequency on the growth, survival and feed conversion ratio of the Asian sea bass *Lates calcarifer* juveniles reared under hypersaline seawater of the red sea. *Aquacult. Resear.* 39: 561-567.

Samantaray, K. and Mohanty, S.S. 1997. Interactions of dietary levelsof protein and energy on fingerling snakehead, *Channa striata*. *Aquacult.* 156: 241–249.

Sampath, K. 1984. Preliminary report on the effects of feeding frequency in *Channa striatus*. *Aquacult.* 40: 301-306

Sampath, K. and Pandian, T. J. 1984. Interaction of feeding frequency and density on food utilization in air-breathing murrel, *Channa striatus*. *Proc. Indian Acad. Sci. (Animal. Sci.*). 93: 445-453.

Sarowar, M.N., Jewel, M.Z.H., Sayeed, M.A. and Mollah, M.F.A. 2010. Impact of different diets on growth and survival of *Channa striatus* fry. *Int. J.Bio. Res.* 1(3): 08-12

Seenappa, D. and Devaraj, K.V. 1991. Effect of feeding levels on food utilization and growth of catla fry. Fish Nutrition Research in Asia. *Asian Fish. Soc. Spl. Publ* 5: 49-54.

Silva, C.R., Gomes, L.C. and Brandao, F.R. 2007. Effect of feeding rate and frequency on tambaqui (*Colossoma macropomum*) growth, production and feeding costs during the first growth phase in cage. *Aquacult.* 264: 135-139.

Shim, K.F. 1988. By-Product Utilization in Live Food Culture for Tropical Aquarium Fish. In: *Fish Nutrition Research in Asia*, De Silva, S.S. (Eds.), pp: 42-47. Heinemann Asia: Singapore.

Shiau, S.Y. 1997. Utilization of carbohydrate in warmwater fish-with particular reference to tilapia, *Oreochromis niloticus x O. aureus*. *Aquacult.* 151: 79-96.

Steffens, W. 1960. Ernahrung und wathstum des jungen zanders (*Lucioperca lucioperca*) in Teichen. Z. *Fur Fischerei*, 9: 161-272.

Sugden, L.G. 1973. Feeding ecology of pintail, gadwall, american wigeon and lesser scaup ducklings. *Can. Wildl. Serv. Rep*. 24: 44-44.

Teshima, S.I., Kanazawa, A. and Kawamura, G. 1984. Effect of serval factors of growth of milkfish, *Chanos chanos* (Forsskal) fingerlings reared with artificial diets in aquaria. *Aquacult.* 37: 39-50.

Wang, N.R., Hayward, S.N.R., Hayward, S. and Moltie, D.B. 1998. Effect of feeding frequency on food consumption, growth, size, variation, and feeding pattern of Age O hybrid sunfish. *Aquacult.* 165: 261-267.

War, M., Altaff, K., and Haniffa, M.A. 2011. Growth and Survival of Larval Snakehead Channa striatus (Bloch, 1793) Fed Different Live Feed Organisms. *Turkish J. of Fish. and Aqua. Sci.* 11: 523-528.

Wee, K.L. and Tacon, A.G.J. 1982. A preliminary study on the dietaryprotein requirement of juvenile snakehead. *Soc. Sci. Fish.* 48: 1463–1468.

Wee, K.L. 1982. The biology and culture of snakeheads. In: *Recent Advances in Aquaculture* (ed. by J.F. Muir and R.J. Roberts), pp. 180-211. West view Press: Boulder, CO, USA.

Wee, K.L. 1986. A preliminary study on the dietary proteinrequirement of juvenile snakehead. In: *Proc. Int. Conf. Dev. Managet. Trop. Living Aquat. Resources*, pp. 131–136. Serdang: Malaysia

Webster, C.D., Thompson, K.R., Morgan, M., Grisby, E.J. and Dasgupta, S. 2001. Feeding frequency affect growth, not fillet compositon of juvenile sunshine Bass Morone *Chrysops Morone Saxatilis* grown in cages. *J. world aquacult. Soc.* 323: 79-88.

Victor, R. and Akpocha, B.O. 1992. The biology of Snakehead *Channa obscura* (Gunther), in a Nigerian pond under monoculture. *Aquacult.* 101: 17–24.

Vidthayanon, C. 2002. Peat swamp fishes of Thailand. Office of Environmental Policy and Planning, Bangkok, Thailand, pp 136.

Wah Lam, S. and Shephared, K.L. 1988. Some effect of natural food level and high protein supplement on the growth of carp. *Aquacult.* 72: 131-138.

Yaakob, W.A.A. and Ali, A.B. 1992. Simple method for backyard production of snakehead (*Channa striata*, Bloch) fry. *Nag.* 15:2, 22-23.

Yang, Y., Diana, J.S. Shresta, M.K. and Lin, C.K. 2004. Culture of mixed-sex Nile Tilapia with predatory snakehead. In *R.Bolivar, G.Mair and K.Fitzsimmons editor*, pp 464-667. The 6th International Symposium of Tilapia in Aquaculture.

Yamamoto, M.N. and Tagawa, A.W. 2000. Hawaii's native and exotic freshwater animals. Mutual Publishing, Honolulu, Hawaii, pp 200.