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Fecundity and spawning frequency of *Rasbora tawarensis* (Pisces: Cyprinidae) an endemic species from Lake Laut Tawar, Aceh, Indonesia

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Abstract. This paper is contributing the additional importance information on the reproductive biology of *Rasbora tawarensis* in relation to provide comprehensive our understanding on the reproductive biology of this species. Monthly sampling was conducted from April 2008 to July 2009. The highest absolute fecundity was observed in December, but it was not significantly different ($p>0.05$) from January, May, July, August, October and November. The highest relative fecundity was observed in July but it was not different significantly ($p>0.05$) from January, May, June, August, September, November and December. The average absolute fecundity was 3715.4±893.6 eggs, while the average relative fecundity was 518±95.64 eggs.g^{-1} body weight. The spawning frequency of the female was 2 to 11 days and fish was frequent spawned during the reproductive seasons in March, September and December.
Key Words: reproduction, depik, threatened, IUCN red list, Takengon.

Introduction. Studies on reproductive behaviour of fish are important and a basic requirement for improvement and effective fishery resources management and conservation (Ali & Kadir 1996; Marshall et al 2003; Grandcourt et al 2009), in determining basic life-history information and for assessing the impacts of environmental variability on the dynamics of fish populations (Schlosser 1990). Life history parameters such as fecundity, spawning frequency and size at sexual maturity were varied between populations of a species, and temporally vary within population (Morgan 2008). Information on the spawning seasons and lenght-weight relationships of the *R. tawarensis* have been reported by Muchlisin et al (2010a; 2010b), however no data on the fecundity and spawning frequency were available. Therefore, this paper contributes importance information on the reproductive biology of *R. tawarensis* an endemic freshwater fish in Lake Laut Tawar.

Fecundity is of central interest in several aspects of fish biology, e.g. in recruitment-related studies in order to replace spawning stock biomass with total egg production, and in studies on life history evolution (Witthames & Marshall 2008). In addition, fecundity is also considered to be an essential factor to understand variations in population size, recruitment and population growth rate and hence is a life history trait very relevant to fisheries management (Kraus et al 2002; Lambert 2008; Alonso-Fernandez et al 2009). The fecundity varied among the species and individual, and has been known to be dependent on brood conditions such as size (length, weight and age), genetics, food availability and environmental factors. The objective of the present study was to evaluate the fecundity and spawning frequency of *R. tawarensis*.

Material and Method. Lake Laut Tawar (04°36'43"N 096°55'25"E) is situated in Aceh Tengah, Central Aceh, Nanggroe Aceh Darussalam Province Northern Sumatra, Indonesia. Details of sampling sites are described in Muchlisin et al (2010a; 2010b).

A total of 956 females *R. tawarensis* were sampled monthly from April 2008 to March 2009 and by using selective gillnet (mess size 5/9 inch, 1.5 m depth and 20 m

length). The gill nets were set up for eleven hours (18.00 PM to 05.00 AM) and every sampling trip was for two days. Collected fishes were counted, rinsed and anesthetized in a solution of Tricaine Methanesulfonate (MS 222), prepared by dissolving 4 g of MS 222 in 5 L tap water, then after preserved in 10% formalin a plastic bag. The fish samples were transported to the laboratory for further evaluation.

The absolute and relative fecundity were utilised in this study. Only sample of adult females in late or final oocyte maturation stage (FOM) were used for fecundity analysis (Murua & Saborido-Rey 2003), and at least 50% of matured females at FOM were randomly selected from monthly samples. Three sub-samples of ovaries weighing 0.1 g to 0.2 g were obtained from the anterior, posterior and the middle of gonad and soaked in solution comprising of 60 mL ethanol, 30 mL formaldehyde and 10 mL glacial acetic acid. The solution was used to wash the mucus to prevent the eggs from adhering together, to ease observation. The eggs were placed into a dish and counted under stereo light microscope (Nikon, YS-100). The mean from the three sub-samples were used to calculate absolute and relative fecundity using gravimetric method (Biswas 1993).

Spawning frequency is the number of days between spawning and it was determined by dividing 100 (representing the total population of fish) by the percentage of matured fish or fish with the late developing class of gonad. The percentage of female in the stage III (mature) and IV (ripe) were used to estimate spawning frequency. These are the only stages where the individual has the potential to spawn (Brown-Peterson et al 2001). Data were subjected to analysis of variance (ANOVA), followed by comparison of means using Duncan's multiple range test to determine significance of each data (Dytham 2003). The statistical analyses were performed using SPSS v14.

Results and Discussion. The individual absolute fecundity ranged from 2,354 (85.88 mm TL) to 6,277 (100.06 mm TL) (mean±S.D. = 3715.4±893.6 eggs), while the relative fecundity varied from 336 eggs.g^{-1} (94.91 mm TL) to 739 eggs.g^{-1} (93.31 mm TL) (mean±SD, 518±95.64 eggs.g^{-1} body weight). In addition, the monthly fecundity ranged from 2,744 to 4,327 eggs for absolute and 334 to 631 eggs.g^{-1} body weight for relative fecundity. The highest absolute fecundity was observed in December, but it was not significantly different ($p>0.05$) from January, May, July, August, October and November. The highest relative fecundity was observed in July but it was not different significantly ($p>0.05$) from January, May, June, August, September, November and December (Table 1) indicating that fecundity was relatively stable throughout the year. There was a positive relationship between absolute fecundity and body weight as well as body length of the *R. tawarensis* (Figure 1). Our results showed that the ovaries of the *R. tawarensis* contained multiple oocyte size classes of each stage of gonadal development (Figure 2). In general, oocyte size increased from stage I to stage IV (immature to ripe stages) and then decreased in stage V (spent), being at the maximum during the period of peak reproductive season and declining abruptly thereafter, when the fish become spent.

Monthly spawning frequency was estimated to occur every 2 to 11 days (Table 2). Analysis was only conducted on those months with greater than 5% final maturation stage to ensure accuracy as defined by Brown-Peterson et al (2001). In this case February and April were excluded from the analysis. The positive linear relationship between absolute fecundity and body weight as well as body length of the *R. tawarensis* is in agreement with the trend observed in the spotted snake head *Channa punctatus* collected from India (Marimuthu et al 2009), and *Tilapia mariae* from south-eastern Nigeria (Anene & Okorie 2008). Many studies have reported that fish fecundity increases with increasing brood size for both freshwater and marine fishes, for instance in rainbow trout (Bromage et al 1990), winter flounder, *Pseudopleuronectes americanus* (Buckley et al 1991), salmonids (Jonsson & Jonsson 1999), cardinal fish, *Apogon lineatus* (Kume et al 2000), African bonytongue (Adite et al 2006), mugilids *Liza argentea* and *Myxus elongates* (Kendall & Gray 2008), tucunare *Cichla kelberi* (Normando et al 2009) and Lawson & Jimoh (2010). Jonsson & Jonsson (1999) argued that increase of body size will increase the body cavity to accommodate more eggs and more energy available to produce many eggs. Therefore, in order to compare fecundities of fish of different size or

from different places, many researchers used the relative fecundity which is the number of eggs per unit weight (whether body or gonad weight).

Table 1

Absolute and relative fecundity by monthly sampling. Mean of fecundity in the same column followed by a different superscript are significant different ($p< 0.05$).

Months	Fecundity	
	Absolute	Relative
January	4083 ± 359^{cde}	504 ± 55^{bcd}
February	2744 ± 251^{a}	334 ± 30^{a}
March	2877 ± 1567^{ab}	349 ± 193^{a}
April	3183 ± 584^{abcd}	420 ± 84^{ab}
May	4260 ± 1191^{de}	591 ± 133^{cd}
June	2932 ± 329^{ab}	594 ± 81^{cd}
July	3668 ± 443^{abcde}	631 ± 109^{d}
August	3594 ± 1501^{abcde}	529 ± 114^{abcd}
September	3003 ± 549^{abc}	511 ± 63^{bcd}
October	4047 ± 1393^{cde}	478 ± 55^{bc}
November	3905 ± 212^{bcde}	522 ± 41^{bcd}
December	4327 ± 622^{e}	552 ± 65^{cd}

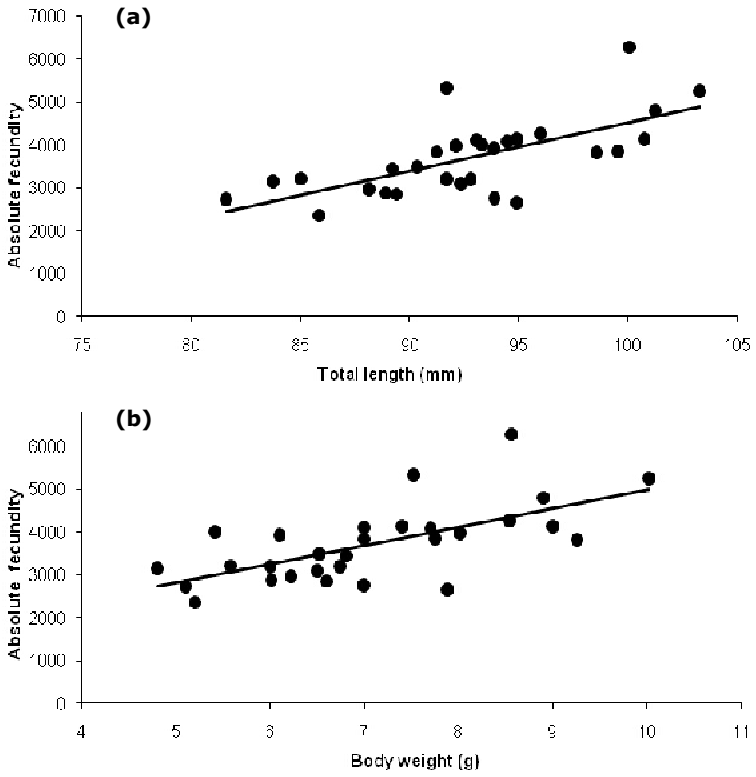

Figure 1. A plot of relationship between batch fecundity with (a) total body length (F= 112.49x – 6726.7, R= 0.45) and (a) body weight (F= 436.44x + 6284.5, R= 0.43).

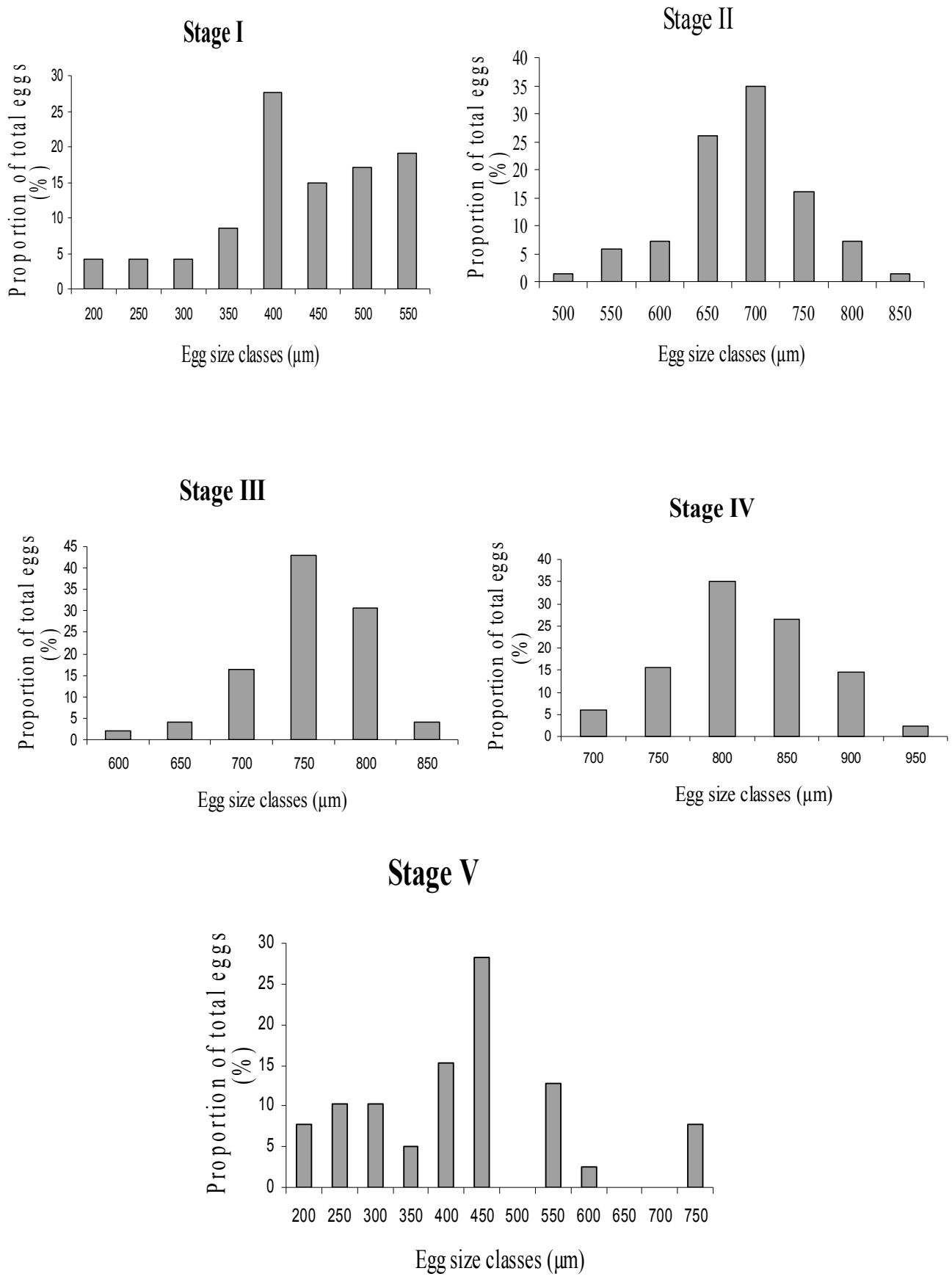

Figure 2. Proportion of total eggs and egg size distribution according to gonadal development stages.

Table 2

Proportion of mature female and spawning frequency by monthly sampling

Month	Number of fish examined	Number of mature female	Percentage of maturation (%)	Spawning frequency (day)
January	89	9	10.12	10
February	86	2	2.33	n/a
March	68	21	30.88	3
April	48	1	2.08	n/a
May	65	10	15.39	7
June	60	10	16.67	6
July	79	11	13.92	7
August	91	18	19.78	5
September	58	28	48.28	2
October	73	8	10.96	9
November	96	9	9.38	11
December	88	23	26.13	4

Herein, the gonad-free body weight was utilised to assess the relative fecundity of the *R. tawarensis* and the results showed that the relative fecundity of *R. tawarensis* varied from 336 to 739 eggs.g^{-1} body weight (mean±SD, 518±95.64) relatively similar to the Argentinean red porgy, *P. pagrus* (332 to 958 eggs.g^{-1}, Aristizabal et al 2009), but higher than many other species i.e. African bonytogue (2 to 6 eggs.g^{-1} body weight, Adite at al 2006), or pouting *Trisopterus luscus* (5 to 67 eggs.g^{-1}, Alonso-Fernandez et al 2008), tucunare *Cichla kelberi* (10.6 egg.g^{-1} body weight, Normando et al 2009), *Channa punctatus* (20 to 102 eggs.g^{-1} body weight, Marimuthu et al 2009) and angel fish, *Pterophyllum scalare* (77 to 86 eggs.g^{-1} body weight, Farahi et al 2010).

The spawning seasons of *R. tawarensis* were three times a years i.e. in March, September and December with peak in September (Muchlisin et al 2010a). This study revealed that spawning frequency of the *R. tawarensis* ranged between 2-11 days, this is positively correlated to the spawning season, where the spawning frequency was increased during the spawning season, for example every 7 days in July (out of spawning season) increases to every 2 days during the peak month of September. For comparison the spawning frequency of cobia was every 4-12 days (Brown-Peterson et al 2001), Spanish mackerel (*Scomberomorus commerson*, 2-3 days, McPherson 1993), red drum (2-4 days, Wilson & Neiland 1994), carangids (3 days, Clarke & Privitera 1995), yellow fin tuna (1-2 days, Schaefer 1996), blue fin tuna (daily spawner, Farley & Davis 1998), common snook (1-3 days, Taylor et al 1998), wahoo (2-6 days, Brown-Peterson et al 2000), and swordfish *Xiphias gladius* (every 3 days, Poisson & Fauvel 2009).

Conclusion. In general, the fecundity of *R. tawarensis* was relatively stable throughout. There was a positive linear relationship between absolute fecundity and body weight and total length. The fish was frequent spawned during the reproductive seasons in March, September and December.

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References

Adite A., Winemiller K. O., Fiogbe E. D., 2006 Population structure and reproduction of the African bonytogue *Heterotis niloticus* in the So River-floodplain system (West Africa): implication for management. Ecology of Freshwater Fishes **15**:30-39.

Ali A. B., Kadir B. K. A., 1996 The reproductive biology of the cyprinid, *Thynnichthys thynnoides* (Bleeker), in the Chenderoh Reservoir – a small tropical reservoir in Malaysia. Hydrobiologia **318**:139-151.

Alonso-Fernandez A., Dominguez-Petit R., Bao M., Rivas C., Saborido-Rey F., 2008 Spawning pattern and reproductive strategy of female pouting *Trisopterus luscus* (Gididae) on the Galician shelf of north-western Spain. Aquatic Living Resources **21**:383-393.

Alonso-Fernandez A., Vallejo A. C., Saborido-Ray F., Murua H., Trippel E. A., 2009 Fecundity estimation of Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) of Georges Bank: Application of the autodiametric method. Fisheries Research **99**:47-54.

Anene A., Okorie P. U., 2008 Some aspect of the reproductive biology of *Tilapia mariae* (Boulenger, 1901) in a small lake in south-eastern Nigeria. African Journal of Biotechnology **7**(14):2478-2482.

Aristizabal E., Suarez J., Vega A., Bargas R., 2009 Egg and larval quality assessment in Argentinean red progy (*Pagrus pagrus*). Aquaculture **287**:329-334.

Biswas S. P., 1993 Manual of methods in fish biology. South Asian Publisher Pvt Ltd, New Delhi, Indian. 157 p.

Bromage N., Hardiman P., Jones J., Springate J., Bye V., 1990 Fecundity, eggs size, and total egg volume differences in 12 stocks of rainbow trout. Aquaculture Fishery Management **21**:269-284.

Brown-Peterson N. J., Overdtreet R. M., Lotz J. M., Franks J. S., Burns K. M., 2001 Reproductive biology of cobia, *Rachycentron canadum*, from coastal waters of southern United States. Fisheries Bulletin **99**:15-28.

Brown-Peterson N. J., Fracks J. S., Burke A. M., 2000 Preliminary observation on the reproductive biology of wahoo, *Acanthocybium solandri*, from the northern Gulf of Mexico and Bimini, Bahamas. Proc Gulf Caribb Fish Inst **51**:414-427.

Buckley L. J., Smigielski A. S., Caldarone E. M., 1991 Winter flounder, *Pseudopleuronectes americanus* reproductive success.II. Effect of spawning time and female size on size, composition and viability of egg and larvae. Marine Ecology Progress Series **74**:125-135.

Clarke T. A., Privitera L. A., 1995 Reproductive biology of two Hawaiian pelagic carangid fishes, the bigeye scad, *Selar crumenophthalmus*, and the round scad, *Decapterus macarellus*. Bulletin of Marine Sciences **56**:33-47.

Dytham C., 2003 Choosing and using statistics. A biologist's guide (Second edition). Blackwell Publishing, 248 p.

Farahi A., Kasiri M., Talebi A., Sudagar M., 2010 Effect of different feed types on growth, spawning, hatching and larval survival in angel fish (*Pterophyllum scalare* Lictenstein, 1823). AACL Bioflux **3**(4):299-303.

Farley J. H., Davis T. L. O., 1998 Reproductive dynamics of southern bluefin tuna, *Thunnus maccoyii*. Fisheries Bulletin **96**:223-236.

Grandcourt E. M., Al-Abdessalaam T. Z., Francis F., Al-Shamsi A. T., Hartmann S. A., 2009 Reproductive biology and implications for management of the orange-spotted grouper *Epinephelus coioides* in the southern Arabian Gulf. Journal of Fish Biology **74**:820-841.

Jonsson N., Jonsson B., 1999 Trade-off between egg mass and egg number in brown trout. Journal of Fish Biology **55**:767-783.

Kendall B. W., Gray C. A., 2008 Reproductive biology of two co-occuring mugilids, Liza argentea and Myxus elongates in south-eastern Australia. Journal of Fish Biology **73**:963-979.

Kraus G., Tomkiewicz J., Koste F. W., 2002 Egg production of Baltic cod (*Gadus morhua*) in relation to variable sex ratio, maturity, and fecundity. Canadian Journal of Fisheries and Aquatic Sciences **59**(12):1908-1920.

Kume G., Yamaguchi A., Aoki I., Taniuchi T., 2000 Reproductive biology of the cardinalfish *Apogon lineatus* in Tokyo Bay, Japan. Fisheries Sciences **66**:947-954.

Lambert Y., 2008 Why should we closely monitor fecundity in marine fish population?. Journal of Northwest Atlantic Fisheries Sciences **41**:93-106.

Lawson E. W., Jimoh A. A.-A., 2010 Aspects of the biology of grey mullet, *Mugil cephalus,* in Lagos lagoon, Nigeria. AACL Bioflux **3**(3):181-194.

Marimuthu K., Hanifa M. A., Rahman M. A., 2009 Spawning performance of native threatened spotted snakehead fish, *Channa punctatus* (Actinopterygii: Perciformes), induced with ovatide. Acta Ichthyologica et Piscatoria **39**(1):1-5.
Marshall C. T., O'Brien L., Tomkiewiez J., Koster F. W., Kraus G., Marteinsdottir G., Morgan M. J., Saborido-Ray F., Blanchard J. L., Secor D. H., Wright P. J., Mukhina N. V., Bjornsson H., 2003 Developing alternative indices of reproductive potential for use in fisheries management, case studies for stocks spanning, an information gradient. Journal of Northwest Atlantic Fisheries Society **33**:161-190.
McPherson G. R., 1993 Reproductive biology of the narrow barred Spanish mackerel (*Scomberomorus commerson* Lacepede, 1800) in Queensland waters. Asian Fisheries Sciences **6**:169-182.
Morgan M. J., 2008 Integrating reproductive biology into scientific advice for fisheries management. Journal of Northwest Atlantic Fisheries Sciences **41**:37-51.
Muchlisin Z. A., Musman M., Siti Azizah M. N., 2010a Spawning season of Rasbora tawarensis (Pisces: Cyprinidae) in Lake Laut Tawar, Aceh Province, Indonesia. Reproductive Biology and Endocrinology **8**:49.
Muchlisin Z. A., Musman M., Siti Azizah M. N., 2010b Length-weight relationships and condition factors of two threatened fishes, *Rasbora tawarensis* and *Poropuntius tawarensis*, endemic to Lake Laut Tawar, AcehProvince, Indonesia. Journal of Applied Ichthyology **26**:949-953.
Murua H., Saborido-Ray F., 2003 Female reproductive strategies of marine fish species of the north Atlantic. Journal of Northwest Atlantic Fisheries Society **33**:23-31.
Normando F. T., Arantes F. P., Luzl R. K., Thome R. G., Rizzo E., Sato Y., Bazzoli N., 2009 Reproduction and fecundity of tucunare, *Cichla kelberi* (Perciformes: Cichlidae), an exotic species in Tres Marias Reservoir, South-eastern Brazil. Journal of Applied Ichthyology **25**:299-305.
Poisson F., Fauvel C., 2009 Reproductive dynamic of swordfish (*Xiphias gladius*) in the southwestern Indian Ocean (Reunion Island). Part 2: fecundity and spawning pattern. Aquatic Living Resources **22**:59-68.
Schaefer K. M., 1996 Spawning time, frequency and batch fecundity of yellowfin tuna, *Thunnus albacares*, near Clipperton Atoll in the eastern Pacific Ocean. Fisheries Bulletin **94**:66-76.
Schlosser I. J., 1990 Environmental variation, life-history attributes, and community structure in stream fishes: implications for environmental management and assessment. Environmental Management **15**:621–628.
Taylor R. G., Grier H. J., Whittington J. A., 1998 Spawning rhythms of common snook in Florida. Journal of Fish Biology **53**:502-520.
Wilson C. A., Nieland D. L., 1994 Reproductive biology of red drum, *Sciaenops ocellatus*, from the neritic waters of the northern Gulf of Mexico. Fisheries Bulletin **92**: 841-850.
Witthames P. R., Marshall C. T., 2008 The importance of reproductive dynamics in fish stock assessment. In: Payne, A., Cotter, J., Potter, T. (Eds.), Advances in Fisheries Science: 50 Years on From Beverton and Holt. Wiley-Blackwell, pp. 306–324.

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