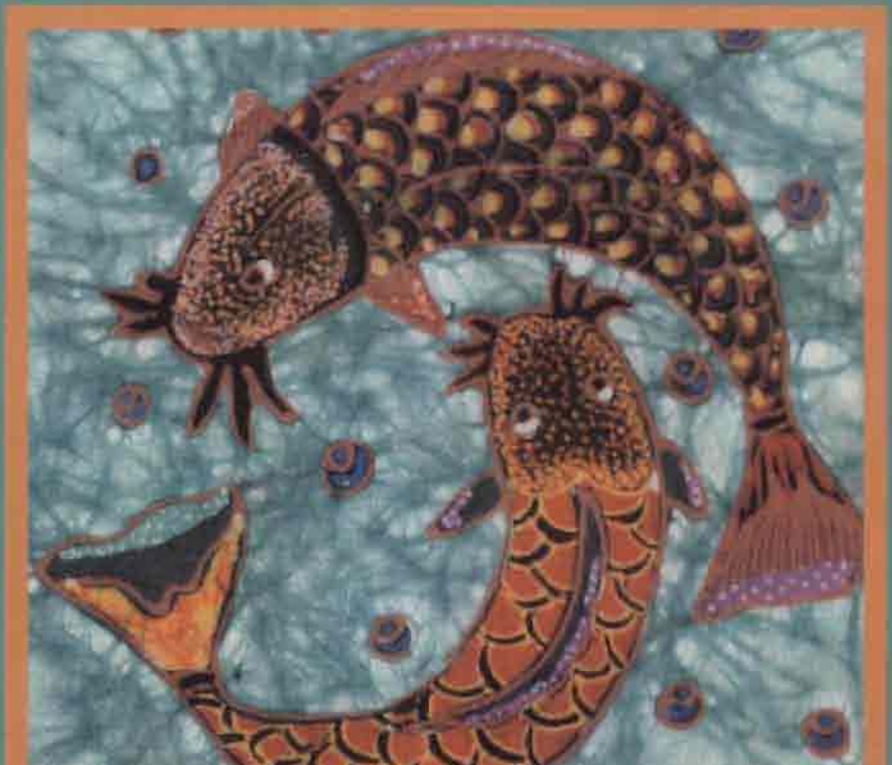
THE BIOLOGICAL DIVERSITY AND AQUACULTURE OF CLARIID AND PANGASIID CATFISHES IN SOUTH-EAST ASIA



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EFFECTS OF FREQUENCY AND PERIOD OF FEEDING ON GROWTH AND FEED UTILISATION IN TWO ASIAN CATFISHES, *PANGASIUS BOCOURTI* (SAUVAGE, 1880) AND *PANGASIUS HYPOPHTHALMUS* (SAUVAGE, 1878)

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Abstract

Feeding to satiation in *P. bocourti*, resulted in higher growth with increased meal frequency. However, growth performance of two-meal or three-meal feeding was not significantly different at all. Moreover, feeding three meals a day led fish to consume a relatively higher amount of feed than fish administered two meals a day. When compared feed intake of the feeding at 12:00 to those of the feeding at 17:00, *P. bocourti* tends to take more food at 17:00 feeding, even though both feedings had the same interval between meals. It is obvious that besides feeding frequency, feeding time is an important factor affecting increased feed intake in *P. bocourti* when they were subjected to feed to satiation.

When fed an equal fixed ration, *P. bocourti* and *P. hypophthalmus* had growth performance and feed efficiency which did not alter so much with increased meal frequency. However, one-meal feeding in the morning resulted in a lower growth and reduced feed utilisation than multiple feeding treatments. The reduced growth and lower feed utilisation here were apparently caused by feeding period rather than by frequency effect, since one-meal feeding during the night gave the same growth and feed efficiency as other feeding regimes in the night-time. Therefore, feeding in early morning resulted in lower feed intake and reduced assimilation efficiency as well. Moreover, feeding period during the night exhibits a higher growth and better feed efficiency than diurnal feeding in both species. Increased meal frequency and nocturnal feeding of an equal fixed ration usually resulted in a relatively higher fat deposition in both species with a higher adipose-somatic and hepato-somatic index.

When combined data of feeding during the day and during the night, it showed that continuous feeding in *P. bocourti* and *P. hypophthalmus* led to a significantly lower growth performance and reduced feed efficiency than fractionated feeding. In addition, when fed a continuous regime, *P. bocourti* had a significantly higher coefficient of variation of final weight than other fractionated feedings.

INTRODUCTION

Pangasius bocourti and *Pangasius hypophthalmus* are two indigenous fish species living in the Mekong River (Roberts & Vidthayanon, 1991). The culture of *P. bocourti* in floating cages has been a production with an annual figure of 13 000 tons (Cacot, 1994). The culture of latter species in earthen ponds has been a long traditional activity with an estimated figure of several tens thousand tons.

When supplied sufficiently feed in quality as well as in quantity, fish has growth rate depending upon two main factors: voluntary feed intake and feed assimilation efficiency (Brett, 1979; Diana *et al.*, 1988). Feeding frequency is one of important factor affecting both voluntary feed intake and assimilation efficiency (Brett, 1971). There are many previous studies on frequency in which fish was fed to satiation; thus, difference in fish growth and feed efficiency reflects an influence of frequency on feed intake rather than on feed assimilation efficiency.

Besides frequency, feeding period also has a great influence on growth and feed utilisation in fishes (Brett, 1979), especially in catfish which is usually said to have a mainly nocturnally trophic activity. Many studies confirmed a better growth performance in catfish fed during the night: *Heterobranchus longifilis* (Kerdchuen & Legendre, 1991), *Silurus glanis* (Authouard *et al*., 1987), *Clarias gariepinus* (Hogendoorn, 1981), *Ictalurus punctatus* and *Ictalurus melas* (Boet, 1981). Nevertheless, it appears that the influence of light/dark alternation on trophic activity of some catfish may be masked under restricted conditions of temperature or dissolved oxygen (Boujard & Luquet, 1996)

Therefore, the objective of the study is to evaluate effects of frequency and period of feeding on growth and feed utilisation when *Pangasius bocourti* and *Pangasius hypophthalmus* are allowed to feed to satiation or an equal fixed ration.

MATERIALS AND METHOD

Experiment fish and culture facilities

Experimental fish were obtained from broodfish cultured in earthen ponds. They were induced spawning with a human gonadotropin hormone injection. Fingerlings originated from one female, were acclimatised in one week for *P. bocourti* and two weeks for *P. hypophthalmus* since this species is more sensitive to confined condition. *P. bocourti* fingerlings of 7.3-7.5 g (first experiment) and of 4.8-5.0 g (second experiment) were cultured at a stocking density of 25 fish per 50 L aquarium in a recycling water system. *P. hypophthalmus* fingerlings of 4.8-5.0 g were reared in outdoor concrete tanks (1 x 1 x 0.6 m) at a stocking density of 25 fish per tank. Water in tank was pumped from a storage earthen pond (600 m^2). The pond contains microphyte, tilapia and silver carp. The lightning condition is natural with a 13D/11N photoperiod.

Water in aquarium were aerated and exchanged at a flow rate of 4-5 $L.min^{-1}$. Dissolved oxygen and pH were monitored twice a week, ranged from 4.3 to 5.5 $mg.L^{-1}$ and from 7 to 7.5, respectively. Ammonia and nitrite, monitored once a week, varied from 0.3 to 0.8 $mg.L^{-1}$ and from 0.01-0.04 $mg.L^{-1}$, respectively. Water temperature in aquarium ranged from 28°C to 30°C.

Water in concrete tanks were exchanged at a flow rate of 10–12 $L.min^{-1}$. Dissolved oxygen in tanks, measured early in the morning, ranged from 3.0-3.5 $mg.l^{-1}$, pH from 7.0 to 7.3. Ammonia and nitrite varied from 0.2 to 0.4 $mg.L^{-1}$ and from 0.02 to 0.04 $mg.L^{-1}$, respectively. Water temperature in tanks ranged from 28°C to 33°C.

Feed and feeding

Fish were fed with pelleted feed which were produced with the following formula:

Fish meal	70%
Soybean meal	20%
Rice starch	8%
Soybean oil	1%
Vitamin and mineral premix	1%

The feed has a proximate composition as follows:

Moisture	3.10%
Protein	37.17%
Lipid	5.41%
Mineral	23.50%
Cellulose	8.96%

There are three experiments in the present study. The first experiment was a satiation feeding trial for *P. bocourti*. Feed was distributed by hand one, two or three meals a day piece by piece until fish stopped feeding. Consumed feed was daily registered. There are three replicates of each treatment for the experiment.

Feeding procedure:

One meal feeding	7:00		
Two meal feeding	7:00	17:00	
Three meal feeding	7:00	12:00	17:00

In the second experiment (for *P. bocourti*) and third experiment (for *P. hypophthalmus*), fish were fed an daily equal fixed ration of 5-6% biomass (5% for the first week and 6% for the following). Feeding adjustment took place every two weeks. The feeding level was sufficient that fish fed one meal a day and consume completely distributed feed. Both second and third experiment had 8 treatments, including 1, 2, 3 meals or continuous feeding which were distributed during the day or during the night. There are two replicates of tanks or aquarium for each treatment.

Sampling and data analysis

Each experiment lasted six weeks. Fish were weighed in batch every two weeks to adjust feeding for the second and third experiment. Initial and final weight were taken individually at a precision of 0.01g. At the end of the experiment, ten fish in each tank or aquarium were sacrificed to measure liver and abdominal fat in order to determine hepato-somatic index: HSI = (liver weight/total weight) x 100 and adipo-somatic index: ASI = (abdominal fat/total weight) x 100.

Treatment	Meal number	Feeding period	Feeding time		
1D	1 meal	Daytime	7:00		
2D	2 meals		7:00		17:00
3D	3 meals		7:00	12:00	17:00
CTD	Continuous		7:00	to	17:00
1N	1 meal	Night time	19:00		
2N	2 meals		19:00		05:00
3N	3 meals		19:00	24:00	05:00
CTN	Continuous		19:00	to	05:00

Feeding procedure for the second experiment (*P. bocourti*) and the third experiment (*P. hypophthalmus*). Continuous feeding were done with an automatic feeder.

Ten other fish were subjected to chemical carcass analysis.

Data were analysed using the SPSS software for statistical analysis. Final mean weights, specific growth rates (SGRs), coefficient of variance of final mean weigh (CV%); HSI and ASI were subjected to GLM analysis (General Linear Model) and Duncan's multiple range test to determine the significant difference at 0.05 level.

RESULT

Frequency and period of feeding in **Pangasius bocourti**

Growth performance and feed efficiency

The first experiment, in which *P. bocourti* is allowed to consume feed to satiation, demonstrated that fish fed three meals a day, had a highest specific growth rate of 3.63%.d^{-1} when compared to one meal feeding (2.61%.d^{-1}) or two-meal feeding (3.39%.d^{1}). However, the SGR in three meal frequency was not significantly different from those in fish fed two meals a day (Table 1). Therefore, feeding to satiation resulted in higher growth with increased meal frequency. Concerning to a total daily feed intake, Figure 1 demonstrated that feeding one meal a day resulted in lower feed intake than fish administrated two or three meals a day.

Moreover, feeding three meals a day led fish to consume a relatively higher amount of feed than fish administered two meals a day. When compared feed intake of the feeding at 12:00 to those of the feeding at 17:00, *P. bocourti* tends to take more food at 17:00 feeding, even though both feedings had the same interval between meals. It is obvious that besides feeding frequency, feeding time is an important factor affecting increased feed intake in *P. bocourti* when they were subjected to feed to satiation. Increased frequency of feeding to satiation also raised food conversion ratio (FCR) but the FCRs in two or three meal feeding was not significantly different. They were 2.12 and 2.19, respectively. The coefficient of variance of final weight (CV%) was not significantly different among 1, 2 or 3 meal frequencies.

The second experiment in which *P. bocourti* received an equal fixed ration, demonstrated that fish growth and its feed efficiency did not alter so much with increased meal frequency. One meal

Growth and feed efficiency	One Feeding	Two feedings	Three Feedings
Initial weight (g)	7,52 ± 0.15 ^{a}	7,50 ± 0.23 ^{a}	7,35 ± 0.06 ^{a}
Final weight (g)	22.57 ± 1.84 ^{a}	31.19 ± 3.29 ^{b}	34.60 ± 0.77 ^{b}
CV (%)	16.59 ± 2.26 ^{a}	15.50 ± 0.15 ^{a}	13.43 ± 1.65 ^{a}
SGR (%.day^{-1})	2.61 ± 0.18 ^{a}	3.39 ± 0.21 ^{b}	3.63 ± 0.12 ^{b}
Hepato-somatic index (%)	2.42 ± 0.34 ^{a}	3.09 ± 0.44 ^{ab}	3.66 ± 0.36 ^{b}
Adipo-somatic index (%)	2.01 ± 0.22 ^{a}	2.46 ± 0.44 ^{ab}	3.61 ± 0.46 ^{b}
Feed intake per fish (g)	25.58 ± 0.25 ^{a}	49.58 ± 2.28 ^{b}	57.90 ± 2.00 ^{c}
FCR: food conversion ratio	1.71 ± 0.18 ^{a}	2.12 ± 0.35 ^{b}	2.19 ± 0.11 ^{b}

Mean ± SD; CV(%): coefficient of variance of final weight; SGR: specific growth rate. Figures in the same row followed by similar superscripts letter, are not significantly different (p>0.05).

Table 1: Growth performance and feed efficiency in *P. bocourti* fed to satiation in function to increased meal frequency. Fish were fed 1, 2 or 3 meals a day at 7:00, 12:00 or 17:00. Fish intake was calculated per individual in a period of 42 days.

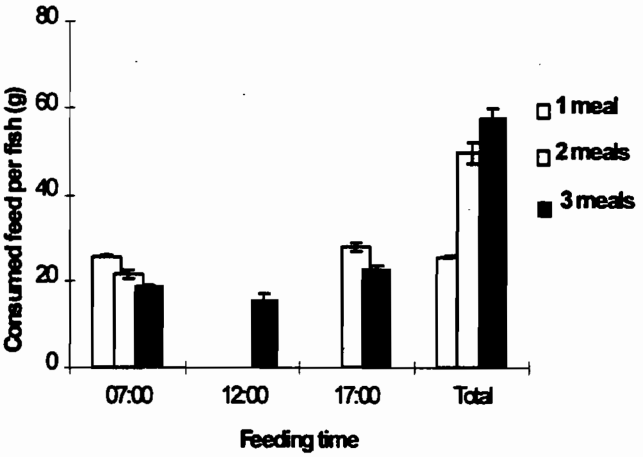

Figure 1: Amount of ingested feed by each fish (*P. bocourti*) in a period of 42 days in response to feeding time. Fish were fed to satiation with 1 meal, 2 meals or 3 meals a day either at 7:00, 12:00 or 17:00.

feeding in the day resulted in a lower growth and reduced feed utilisation than multiple feeding treatments. The SGR was only $3.39\%.d^{-1}$, lowest when compared to other treatments (3.6-4.0%. day^{-1}) and the FCR was 1.56, highest when compared to others. The reduced growth and lower feed utilisation here were apparently caused by feeding period rather than by frequency effect. Since one meal feeding during the night gave the same growth and feed efficiency as other feeding regimes. The SGR of $4.00\%.d^{-1}$ in one feeding at 19:00 was similar to figures of nocturnal feedings, ranging from 3.66 to $4.02\%.d^{-1}$ (Table 2).

In contrary to fractionated feeding, continuous feeding during the day or the night in the second experiment usually gave a tendency of lower growth and reduced feed efficiency in comparison to fractionated meal feeding. When combined data of feeding during the day and during the night, it showed that continuous feeding led to a significantly lower growth performance and reduced feed efficiency than fractionated feeding (Table 2). In addition, when fed a continuous regime, *P. bocourti* had a significantly higher coefficient of variation of final weight (CV%) than other fractionated feedings. The CV% varied from 32.07% in the day to 22.52% in the night, compared to CV% of other feeding treatments ranging in 11.19% to 15.05%. Concerning to feeding period, the second experiment demonstrated that nocturnal feeding in *P. bocourti* gave evidently higher growth rates. SGRs were $3.68\text{-}4.02\%.d^{-1}$ in night time feeding, when compared to $3.39\text{-}3.62\%.d^{-1}$ in daytime feeding. Food conversion ratio were 1.21-1.37 in night-time, when compared to 1.39–1.56 in daytime regardless of either continuous or fractionated feeding.

Fat deposition in abdominal cavity

When allowed to feed to satiation in *P. bocourti*, increased feeding frequency obviously led to an increase in adipose-somatic index (ASI) and hepato-somatic index (HSI). The differences were statistically significant in one-meal feeding compared to two or three meal feeding and there were not significantly different between two and three meal feeding (Table 1). Meanwhile an equal fixed ration in *P. bocourti* particularly resulted in a

	Daytime				Night time			
	1 meal	2 meals	3 meals	Continuous	1 meal	2 meals	3 meals	Continuous
Initial weight (g)	5.76^{a}	5.76^{a}	5.71^{a}	5.79^{a}	5.72^{a}	5.53^{a}	5.65^{a}	5.71^{a}
Final weight (g) *, &	23.93^{a}	26.24^{bc}	26.11^{bc}	24.43^{ab}	30.60^{d}	29.89^{d}	29.90^{d}	26.74^{c}
CV (%) &, μ	14.93^{ab}	15.05^{ab}	12.66^{a}	32.07^{c}	14.22^{ab}	14.53^{ab}	11.97^{a}	22.52^{b}
SGR (%.day^{-1}) *, &	3.39^{a}	3.61^{a}	3.62^{a}	3.43^{a}	4.00^{c}	4.02^{c}	3.97^{bc}	3.68^{ab}
FCR *, μ	1.56^{c}	1.39^{abc}	1.39^{abc}	1.45^{bc}	1.22^{a}	1.21^{a}	1.25^{ab}	1.37^{bc}
HIS (%) *, &	3.25^{a}	3.42^{a}	3.44^{a}	3.54^{a}	4.28^{c}	3.83^{abc}	3.54^{abc}	4.19^{bc}
ASI (%) &, μ	2.18^{a}	2.14^{a}	2.22^{a}	2.55^{ab}	2.38^{a}	2.25^{a}	2.26^{a}	2.80^{b}

CV: coefficient of variance of final weight. SGR: specific growth rate. FCR: food conversion ratio. HSI: hepato-somatic index. ASI: adipo-somatic index. Figures followed by same superscript letters, are not significantly different at 5% statistical level ($P>0.05$).

* : a significant difference between night time to daytime feeding.

& : a significant difference among feeding frequency.

μ : a significant interaction between frequency and period of feeding.

Table 2: Growth performance, feed efficiency and fat accumulation in *P. bocourti* in response to frequency and period of feeding. Fish were fed an equal fixed ration of 1, 2, 3 meals a day or a continuous feeding. Feeding time were 7:00, 12:00, 17:00 for daytime feeding or 19:00, 24:00, 05:00 for night time feeding.

relatively higher fat deposition with increased meal frequency than a single feeding, but the difference in ASI and HSI among treatments was not statistically significant (P>0.05). However, continuous feeding gave a significantly higher ASI and a trend of higher in HSI than those in fractionated feeding (Table 2). In addition, nocturnal feeding of an equal fixed ration in *P. bocourti*, resulted in a significantly higher HSI and a tendency of higher ASI than those fed in the daytime (Table 2).

Frequency and period of feeding in Pangasius hypophthalmus

Growth performances and feed efficiency

The third experiment in which *P. hypophthalmus* fed an equal fixed ration led to the similar result as in *P. bocourti*. Increased feeding frequency did not improve fish growth and feed efficiency. However, one meal feeding in daytime resulted in a lowest fish growth and a reduced feed assimilation. The SGR were only 2.65%.d^{-1} compared to SGRs of other treatments (3.12-3.52%.d^{-1}) and the FCR was 1.82 higher than others treatments (1.34-1.50). The reduced growth and lower feed utilisation here were apparently caused by feeding period rather than by frequency effect. Nocturnal feeding in *P. hypophthalmus* resulted in a higher fish growth and a better feed efficiency than diurnal feeding. The SGRs during the night were in a range of 3.27-3.52%.d^{-1}, compared to 2.65-3.37%.day^{-1}.in the daytime. The FCRs in the night were in a range of 1.34-1.41, lower than figures of 1.38-1.82 in daytime (Table 3). Continuous feeding in *P. hypophthalmus* even had a tendency of inferior growth and a reduced feed efficiency when compared to fractionated feeding. However, The CV% in the continuous feeding was not significantly different from those of fractionated feeding. That was different from the case in *P. bocourti* (Figure 2). Moreover, one meal feeding in *P. hypophthalmus* led to a relatively higher CV% than other treatments. The CV% in one meal feeding during the day or the night were 19.57% and 23.24% respectively, relatively higher than others (11.74%-17.96%).

In summary, when an equal feed ration occurred in *P. bocourti* and *P. hypophthalmus* feeding frequency does not have important influence on fish growth and feed efficiency, except for one feeding in the morning. Conversely, feeding period during the night exhibits a higher growth and better feed efficiency than diurnal feeding in both species. Feeding in early morning resulted in lower feed intake and reduced assimilation efficiency as well.

Fat deposition in abdominal cavity

Increased feeding frequency in *P. hypophthalmus* did not alter so much the HSI and ASI. These figures were not significantly different at 0.05 level (Table 3). However, continuous feeding resulted in a tendency of higher fat deposition in abdominal cavity (Figure 3). On

Treatments	Daytime feeding				Night time feeding			
	1 meal	2 meals	3 meals	Continuous	1meal	2 meals	3 meals	Continuous
Initial weight	$4,81^{a}$	$4,83^{a}$	$4,78^{a}$	$4,84^{a}$	$4,91^{a}$	$4,81^{a}$	$4,79^{a}$	$4,82^{a}$
Final weight *, &	$14,56^{a}$	$19,44^{c}$	$19,73^{cd}$	$17,92^{b}$	$20,26^{cd}$	$20,99^{d}$	$19,52^{cd}$	$18,96^{bc}$
SGR *, &	$2,65^{a}$	$3,34^{cd}$	$3,37^{cd}$	$3,12^{b}$	$3,37^{cd}$	$3,52^{d}$	$3,44^{cd}$	$3,27^{bc}$
CV (%) &, μ	$19,57^{ab}$	$14,45^{ab}$	$11,73^{a}$	$12,93^{a}$	$23,04^{b}$	$15,82^{ab}$	$13,56^{a}$	$17,96^{b}$
FCR *,&	$1,82^{c}$	1.40^{ab}	$1,38^{ab}$	$1,50^{b}$	$1,40^{ab}$	$1,34^{a}$	$1,37^{a}$	$1,41^{b}$
HSI &	$2,75^{b}$	$2,69^{b}$	$2,48^{a}$	$2,87^{bc}$	$3,04^{c}$	$2,71^{b}$	$2,72^{b}$	$2,86^{bc}$
ASI *, &, μ	$0,42^{ab}$	$0,44^{abc}$	$0,41^{a}$	$0,55^{bcd}$	$0,61^{d}$	$0,56^{cd}$	$0,4\ 6^{cd}$	$0,59^{d}$

CV: coefficient of variance of final weight. SGR: specific growth rate. FCR: food conversion ratio. HSI: hepato-somatic index. ASI: adipo-somatic index. Figures, followed by same superscript letters, were not significantly different at 5% statistical level (P>0.05).

*: a significant difference between night time to daytime feeding.

&: a significant difference among feeding frequency.

μ: a significant interaction between frequency and period of feeding.

Table 3: Growth performance, feed efficiency and fat accumulation in *P. hypophthalmus* in response to frequency and period of feeding. Fish were fed an equal fixed ration of 1, 2, 3 meals a day or a continuous feeding. Feeding time were 7:00, 12:00, 17:00 for daytime feeding or 19:00, 24:00, 05:00 for night-time feeding.

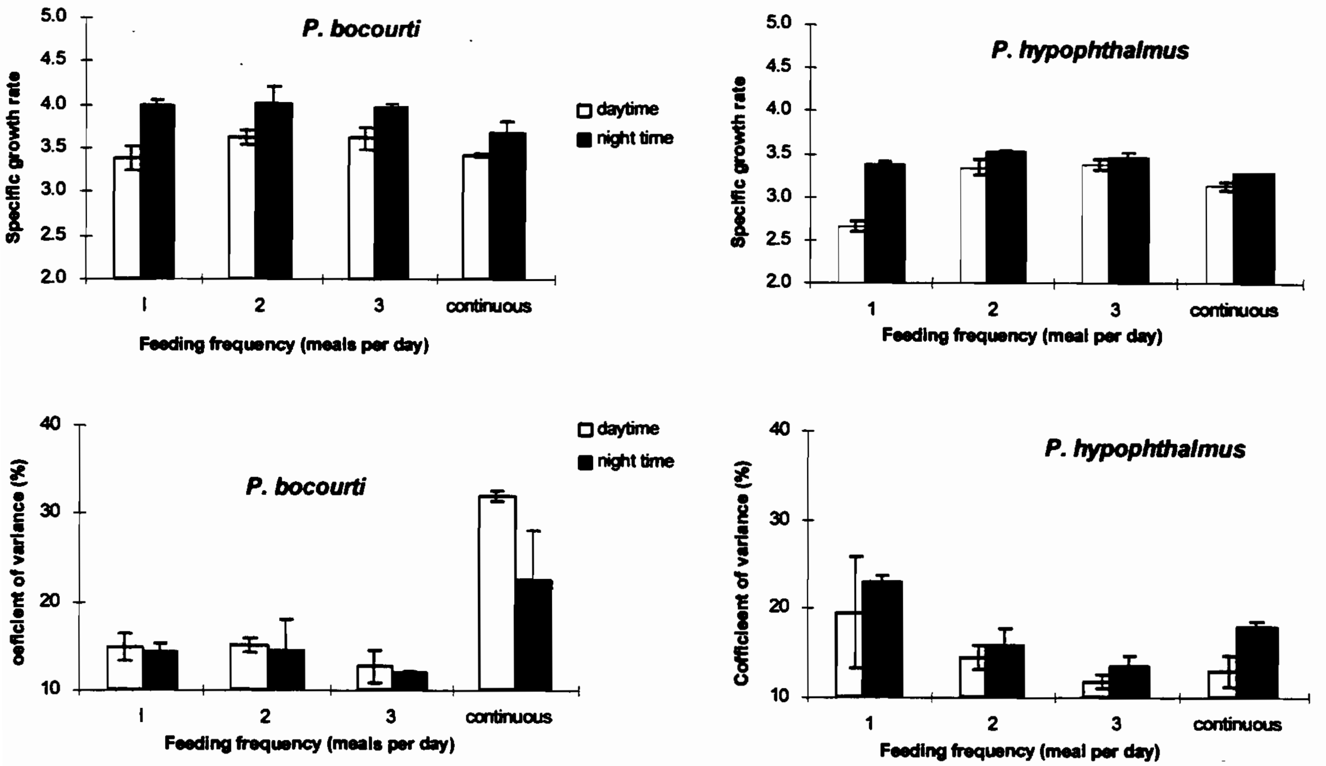

Figure 2: Effects of feeding frequency and period of feeding on the growth (SGR) and the coefficient of variance (CV%) of final weight in *P. bocourti* and *P. hypophthalmus*. Fish are fed an fixed equal ration at the feeding frequency 1, 2, 3 meals or a continued feeding in daytime or in the night-time.

the other hand, period of feeding had more clear effect on fat deposition in *P. hypophthalmus*. The HSI and ASI in the nocturnal feeding were relatively higher than those in diurnal feeding (Table 3).

DISCUSSION

When fed to satiation, *P. bocourti* consumed an amount of food that was raised by increasing feeding frequency. Increased feed intake with higher feeding frequency was reported in fishes (Adrews & Page, 1975; Grayton & Beamish, 1977; Lovell, 1979; Hogendoorn, 1981; Marian *et al.*, 1981; Sampath, 1982). However, the amount of feed consumed by increasing frequency reaches to a maximal feed intake due to the stomach content limitation. *P. bocourti* fed to satiation of two meal frequency, nearly reached to a maximal feed intake. Even thought three meal feeding had a relatively higher feed intake but the growth was not significantly different from those of two feedings. Increasing feed intake in three feeding was to one part possibly due a higher feed loss. Fish are fed by hand distribution to satiation, so feed distribution only stopped when observed a little bit of uneaten feed. Another part, the feed efficiency in high meal frequency tends to be reduced. It was reported that increased feeding frequency results in either a reduction of individual meal size or defecation of material before being fully digested, thus a lower feed assimilation occurred due to higher deamination cost and apparent specific dynamic action (Buurma & Dina, 1994).

Fish growth and feed utilisation in *P. bocourti* and *P. hypophthalmus* fed an equal fixed ration, do not rise with increased meal frequency. That is in accordance with studies in *Heterobranchus longifilis* (Kerdchuen & Legendre, 1991), *Salmo gairdneri* (Grayton & Beamish, 1977). However, some other studies have reverse results like in *Clarias gariepinus* (Hogendoorn, 1981), *Clarias fuscus* (Buurma & Diana, 1994), *Heteropneustes fossilis* (Marian *et al.*, 1981) and *Cyprinus carpio* (Huisman, 1974). Buurma and Diana (1994) demonstrated that *Clarias fuscus* fed three meals a day resulted in significantly higher growth than fish fed single feeding but fish fed two or three meals were not significantly different. It seems that lower growth in one meal feeding of their study was caused by feeding period rather than by changes in feeding frequency. The same

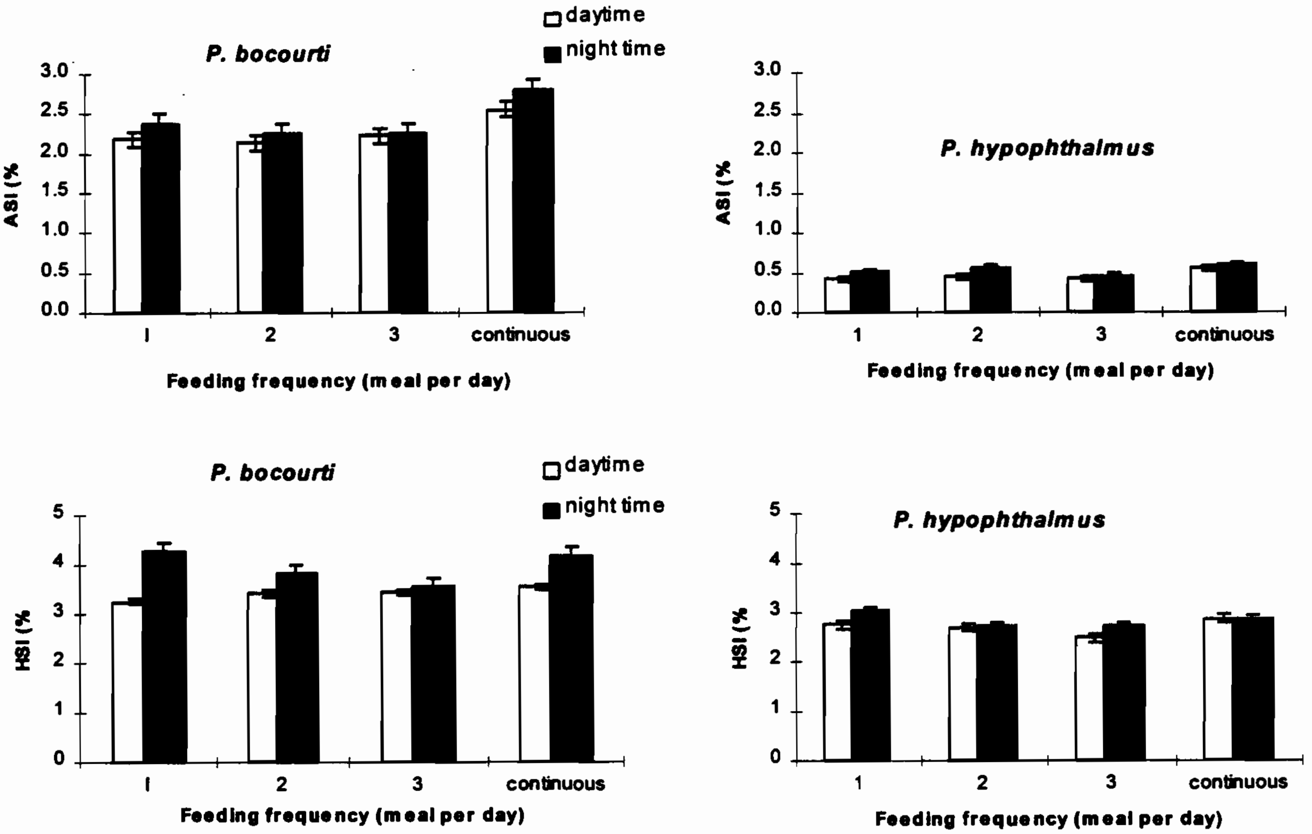

Figure 3: Effects of feeding frequency and period of feeding on adipose-somatic index (ASI) and hepato-somatic index (HSI) in *P. bocourti* and *P. hypophthalmus*.

phenomenon was observed in *P. bocourti* and especially in *P. hypophthalmus* in the present study. One meal feeding during the day (7:00) gave a lower growth but one meal during the night did not significantly differ from two or three meal feeding. It is usually impossible to determine whether the better growth observed in catfish with increased meal frequency is due to an augmentation in voluntary feed intake or to changes in nutrient retention efficiency (Boujard & Luquet, 1995). Mortality did not occur in our experiment and distributed feed was completely consumed as well, so fish were supposed to have an equal feed intake. When supplied an equal feed intake, *P. bocourti* and *P. hypophthalmus* did not alter fish growth and feed efficiency with increased meal frequency. Thus, it is possible to say that increased meal frequency of an equal ration does not have any effect on assimilation efficiency in both species. On the contrary, when fed to satiation fish tends to have faster growth with increased meal frequency. The higher growth in increased meal frequency is clearly due to increased feed consumption.

When fed a continuous feeding with an equal feed intake, *P. bocourti* and *P. hypophthalmus* do not ameliorate their growth performances and feed efficiency. The same result was observed in many fish species in which fish growth increased parallel to higher meal frequency and it rapidly get stable at a level of several limited meals per day. That corresponds to one daily meal in *Channa striatus* (Sampath, 1984), two meals a day in trout (Luquet *et al.*, 1981) and *Ictalurus punctatus* (Andrews & Page, 1975), one to two meals in *Heteropneustes fossilis* (Marian *et al.*, 1981). On the other hand, Kerdchuen and Legendre (1991) found that *Heterobranchus longifilis* had higher growth with continuous feeding and a same result was likewise found in *Clarias gariepinus* (Hogendoorn, 1981). Fractionating a daily distributed feed into many tiny meals in continuous feeding, therefore has divergent results on fish growth and feed efficiency of different fish species. The difference is possibly related to its feeding behaviour, especially to the presence of a distinct stomach of digestion physiology. When used a demand-feeder, Boujard and Leatherland (1992) found the aggregation of food demand in *Oncorhychus mykiss*. They explained that it is probably related to the presence of a district stomach, playing a predominantly storage role with little or no mixing or digestive function. For fish having periodic access to food sources, the storage capacity is essential. Conversely, in browsing fish such as *Oreochromis aureus* (Hargreaves *et al.*, 1988) and *Carassius auratus* (Rozin & Mayer, 1961) the absence of a marked gut storage site is associated with a continuous feeding. It is strange to know that *Heterobranchus longifilis* and *Clarias gariepinus* have a marked stomach but these fish expose a higher fish growth in continuous feeding. More studies thus should be needed to explain the phenomenon. In our results, *P. bocourti* fed a continuous feeding exhibited a higher heterogeneity of fish size at the end of the experiment in comparison to fractionated feeding. The phenomenon was not observed in *P. hypophthalmus*. There is a hypothesis for such an observation. *P. bocourti* is a highly greedy species. The fish rapidly rushes to get feed in short period and therefore stronger and faster fish receive more feed distributed bit by bit in a continuous feeding. Conversely, *P. hypophthalmus* ingests slowly feed, more fish thus receives a small amount of feed distributed little by little in continuous feeding.

Increased meal frequency is usually applied in aquaculture to obtain highest growth with an acceptably lower feed efficiency. *P. bocourti* and *P. hypophthalmus* do not improve their feed assimilation efficiency with increased feeding frequency. However, one meal feeding is not enough to have an optimal growth since its stomach fullness is limited. *P. bocourti* fed to satiation, consumed only 5-6% body weight with one meal feeding but two or three feedings induced fish to ingest 12-15% of their biomass. In practice, aquaculturist thus can do the feeding at a two meal frequency to get much benefit from higher feed intake.

Results of the present study likewise demonstrated that nocturnal feeding resulted in higher growth and better feed efficiency than diurnal feeding in *P. bocourti* and *P. hypophthalmus*. Our result is in concordance with other species of Siluriformes (Kerdchuen & Legendre, 1991; Authouard *et al.*, 1987; Hogendoorn, 1981; Boet, 1981). Boujard and Luquet (1996) likewise marked several restricted condition which may effect feeding behaviour in fishes that possibly changes nocturnal feeding activity. Randolph and Clemens (1976) reported that *Ictalurus punctatus* in limited condition of temperature or dissolved oxygen depends much on two limited factors rather than on night/day alternation. In the present study, *P. bocourti* were cultured in a recycling water system with a dissolved oxygen of higher than 4 $mg.l^{-1}$ and *P. hypophthalmus* is an air breathing species (Browman & Kramer, 1985). Water temperature ranged in 28–30°C (*P. bocourti*) and in 28–33°C (*P. hypophthalmus*). Therefore, there was not any restricted condition in feeding trial for both species. The higher feed efficiency when fed in night-time may be in relation to a circadian variation metabolism and its hormonal control (Spieler, 1979; Noeske & Spieler, 1983). Leatherland *et al.* (1974) demonstrated that growth hormone and plasma prolactin in *Oncorhynchus nerka* were higher during the night. A same observation was reported in *Ictalurus punctatus* with a higher plasma corticoid concentration in night-time (Goudie *et al.*, 1983; Davis *et al.*, 1984). Sheridan, *et al.* (1986) found that the corticoid takes place in lipogenesis in fishes and the hormone likely takes part in protein and lipid metabolism (Donaldson *et al.*, 1979).

In the present study, one meal feeding in the morning in *P. bocourti* and *P. hypophthalmus* seemed not to be suitable. These fish had inferior fish growth performances and reduced assimilation efficiency in comparison to others of one meal feedings either at 17:00, 19:00 or 5:00. In *P. bocourti*, voluntary intake in the morning was lower than other feedings as well. Kerdchuen and Legendre (1991) also observed the same result in *Heterobranchus longifilis* when fed at 8:00. It is obvious to conclude that besides feeding period, feeding time likely plays an important role in stimulating voluntary feed intake as well as assimilation efficiency in both species.

Frequent feeding generally improved fish growth due to increased feed intake. That leads to elevate lipid deposition and change body composition. The event was observed in channel catfish (Noeske-Hallin *et al.*, 1985), rainbow trout (Grayton & Beamish, 1977) and hybrid Tilapia (Tung & Shiau, 1991). Satiation feeding in *P. bocourti* apparently induced higher fat deposition through a higher hepato-somatic and adipo-somatic index. However, when fed an equal feed ration, there are likewise a relative tendency of increased fat deposition with increased frequency in both *P. bocourti* and *P. hypophthalmus* . As a result, when fed highly increased meal frequency in continuous feeding these fish resulted in more clearly higher fat accumulation than single feeding. Tung and Shiau (1991) observed hybrid Tilapia, *Oreochromis niloticus x O. aureus*, fed six times a day had higher fat body content compared to fish fed twice a day. They also observed the higher 6-phosphogluconate dehydronase in fish fed six times a day. Conversely, there are some other studies in which higher feeding frequency suppressed lipid deposition in *Epinephelus akaara* (Kayano *et al.*, 1993), *Plecoglossus altivelis* (Yao *et al.*, 1994) and *Heterobranchus longifilis* (Kerdchuen & Legendre, 1991).

Kerdchuen and Legendre (1991) even showed that *Heterobranchus longifilis* fed during the night exhibited a lower lipid deposition. However, both *P. bocourti* and *P. hypophthalmus* in the study showed a tendency of higher lipid deposition in abdominal cavity during nocturnal feeding.

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