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Impact of different feeds on growth, survival and feed conversion in stripped snakehead *Channa striatus* (Bloch 1793) larvae

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ABSTRACT

Growth, survival and feed conversion ratio of striped snakehead (*Channa striatus*) larvae fed on different feeds during nursery rearing were evaluated. Three different experiments were conducted using hatchlings, fry and fingerlings of *C. striatus* with three replicates per treatment. Growth performance of snakehead hatchlings was examined by feeding them with the following diets: Diet 1 - copepod, *Thermocyclops decipiens;* Diet 2 - cladoceran, *Ceriodaphnia cornuta* and Diet 3 - *T. decipiens* and *C. carnuta* in combination, for a period of four weeks. Weight gain in the fish fed with Diet 3 (*T. decipiens* + *C. carnuta*) was significantly higher ($p < 0.05$) than that of the fish fed Diet 2 (*C. carnuta*) and Diet 1 (*T. decipiens*). Feeding trial of 45 days duration conducted by feeding animal wastes (D1: chicken liver, D2: fish waste and D3 : combination of chicken liver and fish waste) to evaluate the growth and survival of *C. striatus* fry showed significantly high ($p<0.05$) survival rate in *C. striatus* fry fed diet D3 compared to those fed D1 and D2. Food conversion ratio (FCR) was lowest in the group fed D3 followed by those fed D1 whereas highest FCR was noticed in D2. Among the four types of formulated diets evaluated in fingerlings of *C. striatus,* the mean growth rate was significantly higher ($p<0.05$) in fish fed on chicken liver incoporated diet. Chicken liver diet showed the lowest FCR, where as highest FCR was recorded in control diet ($p<0.05$).

Keywords: *Channa striatus*, Fingerlings, Food conversion ratio, Formulated diet, Fry, Hatchlings, Striped snakehead

Introduction

Freshwater aquaculture is a rapidly expanding fish producing source and in order to develop aquaculture on a commercial basis, mass production of healthy and high quality seeds is warranted. Fingerling production is one of the many challenges faced in the commercial production of freshwater species. Optimum growth of aquatic animals largely depends on food quality (Haniffa and Venkatachalam, 1980; Josemon *et al*., 1994). Quality of food provided during the weaning period of larvae is a critical step in larviculture (Devresse *et al*., 1991).

Feeding requirements vary across species as well as at each developmental stage of the fish. In order to reduce excessive feeding expenses, numerous studies assessed the use of alternative, cheaper protein sources in fish feeds (Tacon *et al*., 1983; Guerrero, 1985; Lim and Dominy, 1989; 1990). Among freshwater fishes marketed in India, air breathing fishes form about 13% (Chakrabarty, 2006; Aliyu-Piako *et al*., 2010). The striped snakehead *Channa striatus* is an air breathing species native to Asia and Africa (Ng and Lim, 1990; Banerjee, 2007). It is cultured in Taiwan, Thailand, and Philippines at commercial level (Wee, 1980). Attempts made on larval nutrition of *C. striatus*, using formulated feeds in pelleted form instead of live feed have shown poor survival (Qin *et al.,* 1997; Kumar *et al.,* 2008). After complete absorption of yolk sac, murrel larvae require small sized live feed such as rotifers during first feeding (Ling, 1977). Chen (1990) found that snakehead larvae (9 mm) feed on rotifers, naupli and other organisms. Qin and Fast (1997) stated that *C. striatus* larvae start accepting formulated feed at 12 mm size (total length). Qin and Fast (1996) successfully weaned *C. striatus* larvae from live artemia to formulated feed. In India, murrel culture has not taken off much and due to nonavailability of seeds for stocking and also owing to lack of suitable techniques for feeding and culture. Commercial scale propagation of snakehead in hatcheries is yet to be standardised (Amornsakun *et al.,* 2011). Larviculture of murrels is a difficult task, since they are carnivorous, piscivorous and cannibalistic (War *et al*., 2011) and understanding of their feeding requirements is limited.

The present study attempted rearing of hatchlings, fry and fingerlings of the striped snakehead *C. striatus* using different live feeds/formulated feeds and assessed the growth performance and survival under laboratory conditions.

Materials and methods

Feeding experiments were conducted at the Centre for Aquaculture Research and Extension (CARE), St. Xavier's College, Tirunelveli, Tamil Nadu, India. Brood fishes were collected from the broodstock rearing pond at CARE. Mature males and females with an average weight of 810±250 g were selected following the method of Viveen *et al*. (1985). Fishes were induced to spawn by injecting luteinising hormone releasing hormone analogue (LH-RHa) at a dosage of 70 µg kg^{-1} body weight and breeding sets were introduced into the breeding tanks (1 m x 1 m x 1m). After spawning (22-24 h) fertilised eggs were collected and incubated in aquarium tanks (capacity 50 l) for hatching. Fertilised eggs hatched within 22-26 h and the yolk sac was absorbed completely after 3-4 days post-hatching (dph)

Feeding experiments on hatchlings

Experiments were conducted to study feed acceptability, growth rate and survival of 5 days old hatchlings of *C. striatus* for a duration of 28 days. Batches of 100 larvae of *C. striatus* of uniform size were introduced into the experimental tanks (90 cm x 45 cm) in triplicate. Fish larvae 6.03±0.1 mm (mean length) and 0.81±0.01 mg (mean wet weight) were randomly assigned to one of the following three diets: Diet 1 (copepod, *Thermocyclops decipiens*), Diet 2 (cladoceran, *Ceriodaphnia cornuta*) and Diet 3 (*T. decipiens* + *C. cornuta* in combination) and fed for a period of 28 days. *C. cornuta* and *T. decipiens* were cultured in the laboratory and fed to the larvae. Fishes were fed twice a day at 8.00 and 16.00 hrs at the rate of 500-600 individuals l^{-1} which is above satiation for the fish larvae (Qin and Fast, 1996). Fishes were sampled weekly for growth estimation and the data were subjected to statistical analysis.

Feeding experiments using fry

The fry of *C. striatus* (270 nos.) were randomly selected (average length and body weight, 4.38±0.04 cm and 0.5±0.02 g respectively). Thirty fry fishes were introduced into each tank of 80 l capacity containing 50 l water and triplicates were maintained for each diet using 9 aquaria. To examine the effect of feed on growth and survival of fry, three types of diets *viz*., chicken liver (D1), fish waste (D2) and mixed feed of chicken liver with fish waste (D3) were selected for feeding the fish for 45 days. Chicken liver and fish waste were collected daily from the local market, cleaned, cut into small slices and offered as food for the test fish. Feed was supplied at the rate of 5% of the body weight of the fishes twice a day. Feed waste and faecal matter were removed from the tanks and 50% water was changed daily before feeding.

Feeding experiments using fingerlings

Striped snakehead *C. striatus* fingerlings (240 nos.) of average length and weight 6.12±0.08 cm and 4.13 g, respectively were used. Feeding trials were conducted in tanks of 120 l capacity for 45 days. Fingerlings were stocked @ 20 nos. per tank and triplicates were maintained for each diet using 12 tanks.

Experimental diets were prepared separately using known quantities of ingredients (Table 1). Selected ingredients were powdered and sieved to get fine particles of uniform size. Ingredients were then weighed according to the formulation and hand kneaded by adding sufficient quantity of distilled water and finally made into dough. The dough was then cooked in a closed aluminium container for about 15 min and then cooled (Milton, 2011). The cooled dough was separated into four parts. One part was treated as control feed and the remaining three parts were mixed with chicken liver, anchovy meal and jawala meal respectively. The prepared feeds were stored in air tight containers and kept in refrigerator. Proximate composition of the diets is given in Table 2. The experiment was conducted for 45 days and the fishes were fed twice daily at the rate of 7% of the body weight at 08:00 and 18: 30 hrs.

In all the experiments, fishes were sampled once in 15 days for growth estimation. Five individuals from each tank were randomly collected, measured directly on a measuring board and weighed using an electronic balance (sensitivity 0.001 g). Unconsumed feed and fecal matter were siphoned out and 50% water was exchanged daily, with least disturbance to the fish. Water quality parameters *viz*., water temperature, dissolved oxygen (DO) and pH in the rearing water were monitored daily.

Data analysis

Increase in length, weight gain (WG), specific growth rate (SGR), mean growth rate (MGR), food conversion ratio (FCR) and survival rate were calculated employing the following equations:

Increase in length (cm)	= Final length – Initial length
Weight gain, WG (g)	= Final weight – Initial weight
Specific growth rate, SGR (% WG/d)	= $100 (\text{Ln } W_2 - \text{Ln}W_1)/t$
Mean growth rate, MGR (mg g^{-1} d^{-1})	= $1000 (W_2 - W_1)/0.5(W_1+W_2)\ t$
Food conversion ratio (FCR)	= dry feed fed (g)/Wet weight gain (g)
Survival (%)	= 100 x (Final number of fish/ Initial number of fish)

where, Ln= Natural log, W_1 = Initial weight, W_2 = Final weight, t = Culture period in days.

Table 1. Percentage composition of ingredients in experimental diets.

Ingredients (%)	Control	Chicken liver diet	Anchovy diet	Jawala diet
Soy flour	25	10	10	10
Tapioca flour	20	10	10	10
Wheat flour	20	10	10	10
Rice flour	20	10	10	10
Rice bran	10.5	7.5	7.5	7.5
Fish oil	2.5	2.5	2.5	2.5
Vitamin/Mineral mix	2	2	2	2
Anchovy meal	0	0	48	0
Jawala meal	0	0	0	48
Chicken liver	0	48	0	0

Vitamin-mineral premix (mg kg^{-1} diet): Riboflavin-80, Biotin–6, Vitamin A - 6000 (IU), Vitamin E - 2000, Nicotinic acid - 6000 IU, Pantothenic acid - 0.1, Menadione - 180, Thiamin hydrochloride – 0.6, Pyridoxine - 15, Inostol - 40, Astaxanthin - 400, Choline chloride - 60,Zinc (as sulphate) - 72, Iron (as sulphate) - 36, Manganese (as sulphate) - 12, Selenium (as selenate) - 0.2, Chromium (trivalent, as chloride) - 0.8, Iodine (as iodate) - 1.2, Copper (as sulphate) - 24, Cobalt (as chloride) - 0.6 and Molybdenum (as molybdate) - 0.2.

Table 2. Proximate analysis of the formulated diets (% drymatter basis) fed to *C. striatus* fingerlings

Parameters	Control	Chicken liver diet	Anchovy diet	Jawala diet
Crude protein	22.59	42.54	36.79	34.43
Crude carbohydrate	14.25	13.45	12.83	12.73
Crude fibre	2.89	2.14	2.53	2.18
Crude lipid	6.63	6.82	6.14	6.97
Crude ash	17.34	15.85	18.03	19.05

Values are means of two replications per diet

All statistical analyses were carried out using Statistica 6.0 and SPSS 10.0. Data were expressed as the mean±SE of triplicates. The means within each treatment and among treatments were compared using Turkey's test of multiple comparison with a 0.05 % significance level.

Results

Effect of live feed on C. striatus hatchlings

Growth performance of *C. striatus* hatchlings under varying treatments during the 28 day experimental period are presented in Fig. 1a and b. Among the 3 types of live feed diets, the highest increase in total length (30.46±0.01 mm) and weight gain (WG) (231.18±0.03 mg) was recorded in fishes fed with Diet 3 which was significantly different ($p<0.05$) from Diet 1 (26.66±0.14 mm and 171.23±0.01 mg) and Diet 2 (22.24±0.006 mm and 183.22±0.05 mg). The mean growth rate (MGR) of fish fed Diet 3 were however, not significantly different ($p\geq 0.05$) from those obtained in Diet 1 and Diet 2. Diet 3 showed significantly higher SGR (20.03±0.01% WG per day) than Diet 2(19.18±0.03 % WG per day). Growth rates (specific and mean) of fish in Diet 1 were 19.42±0.03% WG per day and 70.81±1.12 mg g^{-1} d^{-1} respectively. There was significant difference between the survival rate of fish fed different diets ($p< 0.05$, Fig. 1c)

Effect of feeding animal byproducts on C. striatus fry

Data on growth performance of *C. striatus* fry fed on the three different diets over a period of 45 days are summarised in Fig. 2a and b. WG (3.82±0.04 g) noticed in D3 was significantly higher ($p< 0.05$) than D1 (3.41±0.04 g) and D2 (3.22±0.02 g). SGR was highest (4.78±0.09% WG d^{-1}) in the fish fed with D3 followed by those fed with D1 (4.61±0.03% WG d^{-1}) and D2 (4.38±0.04% WG d^{-1}). MGR (mg g^{-1} d^{-1}) was significantly better in D3 (35.21±0.02) followed by D1 (34.52±0.02) and D2 (33.59±0.01) respectively. There was significant difference ($p<0.05$) in FCR for all treatments. Better survival rate (81.34±5.54%) was noticed in D3, which was found to be significantly different ($p<0.05$) from D1 and D2 (Fig. 2c). Values obtained for survival rate in D1 (76.33±4.72%) and D2 (76.12±2.62%) were, however, not significantly different.

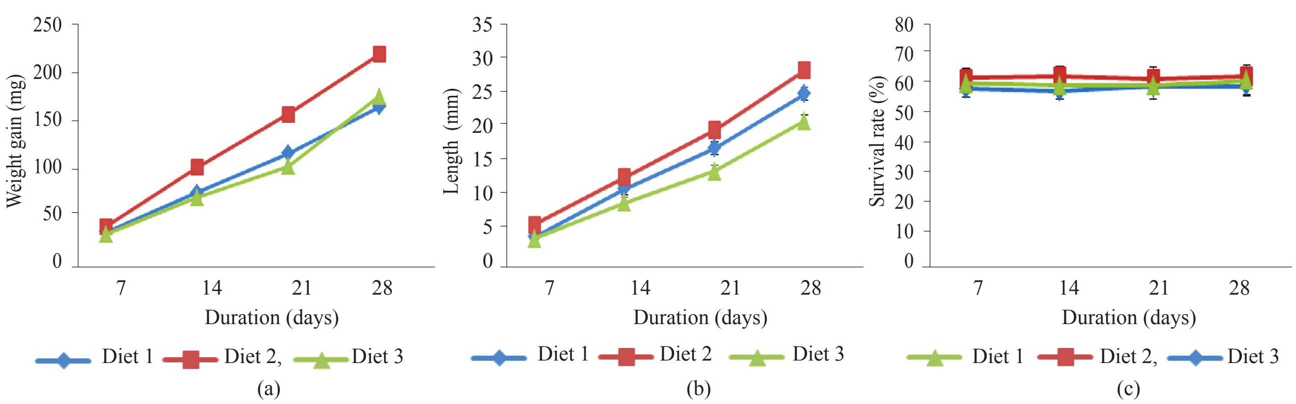

Fig. 1. Growth performance and survival of *C. striatus* hatchlings fed on different live feed organisms. (a): Weight gain, (b): Length increment, (c): Survival rate

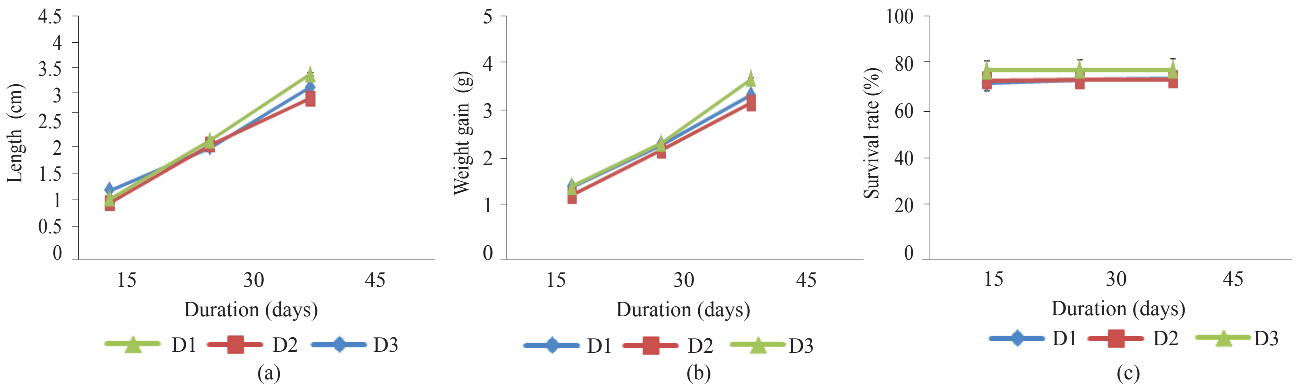

Fig. 2. Growth performance and survival of *C. striatus* fry fed on different diets. (a): Weight gain, (b): Length increment, (c): Survival rate

Effect of formulated diets on C. striatus fingerlings

Among the four formulated diets, the highest protein content was found in chicken liver diet (42.44%) followed by anchovy diet (36.79%), jawala diet (34.43%) and control diet (22.59%). All four formulated diets significantly affected growth performance and feed utilisation of *C. striatus* fingerlings (Fig. 3a and b). Among the four types of diets, MGR (mg g^{-1} day^{-1}) was significantly higher ($p<0.05$) in fish fed on chicken liver diet (25.40±1.05) followed by anchovy diet (24.24±1.41), Jawala diet (23.34±1.34) and control diet (22.65±1.57). Maximum SGR (% WG d^{-1}) was recorded in chicken liver diet (2.89±0.02) which was significantly different ($p<0.05$) from anchovy diet (2.72±0.02) and the minimum value was found in control diet fed fingerlings (2.50±0.04). Chicken liver diet showed the best (lowest) FCR of 1.09±0.12%, whereas the highest FCR (1.31±0.13%) was recorded in control diet and the difference was statistically significant ($p<0.05$). Survival rate (74.66±5.82%) was significantly different ($p<0.05$) in chicken liver diet than other treatments whereas the lowest value (52.33±4.72%) was recorded in control diet (Fig. 3c).

Dissolved oxygen content of water in the various treatments was relatively similar and ranged between 5.2-5.8 mg l^{-1}, pH was in the range 6.2 and 7.8, while water temperature ranged between 28^{0}C and 30^{0}C with a mean daily temperature of 28.05±0.55^{0}C.

Discussion

The important stage in the development of fish larvae is the changeover from endogenous to endo-exogenous to exclusively exogenous feeding (Santamaria *et al*., 2004). Availability of appropriate live feed during these stages is vital and it decides the survival rate of the larvae. It is also stated that formulated feeds are not preferred by larvae during endogenous feeding stage (Qin *et al.,* 1997).

Our data showed that the feeding rate has significant effect on all growth parameters in *C. striatus*. *C. striatus* larvae preferentially ingest the prey of smaller size in the initial days of the exogenous feeding. This may be because of the inability of the larvae of this species to ingest larger prey due to their small mouth size at the beginning of exogenous feeding. Results of the present investigation showed better growth and survival of *C. striatus* hatchlings when fed on mixed live feed (*T. decipiens* + *C. carnuta*) than those fed exclusively on *T. decipiens* and *C. carnuta*. It has been reported that *C. cornuta* is the

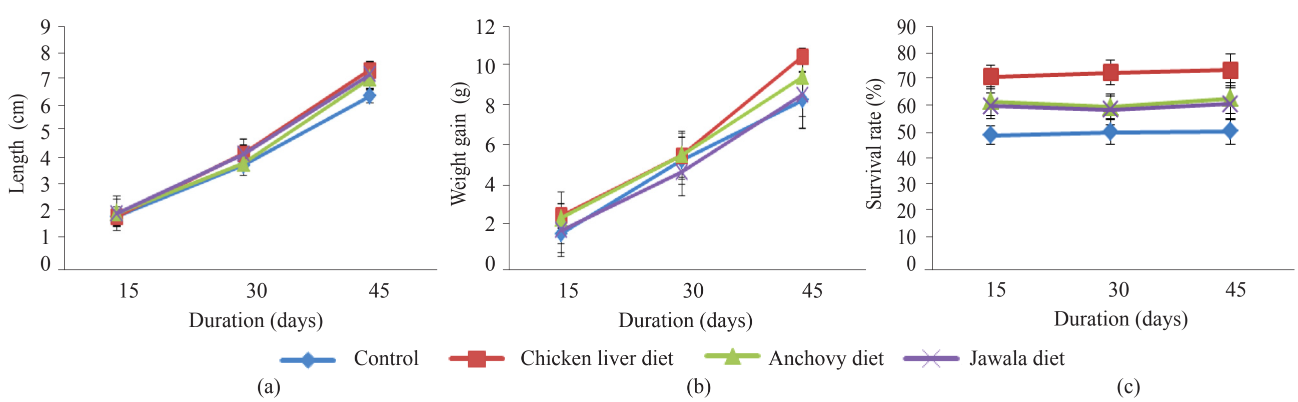

Fig. 3. Growth performance and survival of *C. striatus* fingerlings fed different diets. (a): Weight gain, (b): Length increment, (c): Survival rate

preferred live food organism for early fish larvae due to their smaller size and faster movement compared to other cladocerans (Suresh Kumar, 2000; Shrivastava *et al.*, 2006). Better performance of snakehead hatchlings in terms of growth and survival when fed with mixed live feed might be due to the suitability and varying size of these species. Zooplankton contain many digestive enzymes *viz*., proteases, carbohydrases and lipases which might assist the digestion process in the gut of fish larvae (Munilla-Moran *et al*., 1990) since morphological and functional stomach is absent at early stages. Combination of copepods and cladocerans might provide adequate level of required nutrients and digestive enzymes which explains higher survival rate obtained with combination diet, than with individual live feed.

Poultry byproducts have been effectively incorporated in fish feeds as a partial replacement for fish meal protein, which was determined by fish species and size as well as composition and processing techniques of poultry byproducts (Steffens, 1984). The highest WG, SGR, MGR, FCR and survival rate were observed in fry fed with a mixed diet D3 (chicken liver and fish waste) followed by D1 (chicken liver). These results agree with earlier study of Yang *et al*. (2004) who found that when poultry byproduct meal was replaced by 50% of the dietary fish meal, better growth and survival were observed in common carp. In the present study, better growth performance was observed with chicken liver than with fish waste diet. Therefore, chicken liver which is easily available in the market can be an alternative source of protein for commercial culture of murrels.

It is apparent that the rate of feeding is one of the main constraints for fish growth. Qin and Fast (1996) reported that feeding at 5% body weight may be near optimum using a dry and formulated feed for juvenile *C. striatus,* but our results showed increase in survival and growth, and decrease in FCR at feed applications at 7% of the body weight. Fish showed the best FCR and SGR when fed at 7% of the body weight per day on chicken liver incorporated diet ($p<0.05$), while there were no significant difference in FCR among the fish fed anchovy diet and jawala diet ($p>0.05$), but showed significant difference in terms of SGR ($p<0.05$). Similar results were recorded for juveniles of cobia (*Rachycentron canadum*), which when fed at 7% body weight showed greater SGR than 3% body weight (Sun *et al*., 2006). Other fish species like bagrid catfish juveniles (*Mystus nemurus*; Ng *et al*., 2000), channel catfish (*Ictalurus punctatus*; Robinson and Li, 1999) and European seabass (*Dicentrarchus labrax*; Eroldogan *et al*., 2004) also presented better growth when fed at higher feeding rates.

In our experiments, chicken liver meal supplemented diets containing 42.54% crude protein showed better results in terms of survival rate and increase in WG and SGR in *C. striatus* fingerlings. Rahman *et al*. (1982) found better growth of *Heteropneustes fossils* by feeding diet containing 40% protein. In aquaculture, a feed with FCR of 1:1 and 1:2 are considered as very efficient (Huet, 1972). In our trial, snakehead fed at 7% body weight had FCR of 1.09-1.25, which agrees with previous reports of Rouse and Kahn (1998), Jones and Ruscoe (2000), Thompson *et al*. (2004) and Webster *et al*. (2004). FCR's for rainbow trout *Oncorhynchus mykiss* and channel catfish *Ictalurus punctatus* in intensive culture commonly range from 1.2 to 2.0 (Huner and Dupree, 1984), but may sometimes be less than 1.0, or exceed 4.0 (Bardach *et al*., 1972).

In our results, striped snakehead hatchlings consumed live feed organisms and showed best results with Diet 3 (*T. decipiens* + *C. carnuta*). In the nursery culture of snakehead, cladocerans and copepods can be used as starter feed in indoor tank culture. The fry (average total weight 0.5±0.02 g) exhibited better results when fed with D3 (chicken liver + fish waste). Fingerlings of *C. striatus* exhibited best results using formulated chicken liver diet (42.54% crude protein). The results indicate that poultry byproduct (chicken liver) has great potential as an effective, low cost and readily available protein supplement in aquaculture of *C. striatus*.

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