Asian Fisheries Science **21**(2008):21-33
https://doi.org/10.33997/j.afs.2008.21.1.003

Asian Fisheries Society, Manila, Philippines

A Survey on African Catfish (*Clarias gariepinus*) Feeding and Production in Laos

O. PHONEKHAMPHENG[1], L.T. HUNG[2] and J.E. LINDBERG[3*]

[1]Department of Livestock and Fisheries
Faculty of Agriculture, National University of Laos
Vientiane, Lao PDR

[2]Faculty of Fisheries, Nong Lam University
Ho Chi Minh City, Vietnam

[3]Department of Animal Nutrition and Management
Swedish University of Agricultural Sciences
P.O. Box 7024, SE-750 07 Uppsala, Sweden

Abstract

A formal survey was carried out to collect information concerning African catfish (*Clarias gariepinus*) production systems practiced at small, medium and large farms in three districts, selected as representatives for a rain-fed, wetland and irrigated areas. In addition, feedstuffs used were collected for chemical analysis.

Catfish pond areas per farm ranged from 100-3,200 m^2 in the rain-fed, 160-2,800 m^2 in the wetland and 120-5,000 m^2 in the irrigated areas. Catfish yield per six months and ha pond area was in the range 1.7 to 3.0 ton fresh weight with no major difference between areas. However, including all data the fish yield (t ha^{-1} 6 $months^{-1}$) was correlated (R^2 = 0.53; P<0.0001) to the fish pond area (m^2). A total of thirteen feedstuffs, including both conventional and unconventional, were identified as being frequently used for catfish feeding. The use of feedstuffs varied between different agro-ecological areas and between farms of different size within each area. There were large differences in the overall diet content of major nutrients. However, in general, the diets were low in crude protein (150-220 g kg^{-1} DM) and had to low protein to energy ratio.

In conclusion, the results from the present study indicates that there appears to be a considerable potential to improve the production of catfish in Laos by introducing better feeding strategies and improving management practices.

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* Corresponding author. Tel.: +46 18 67 2102; Fax.: +46 18 67 2995
E-mail address: jan-eric.lindberg@huv.slu.se

Introduction

Small-scale aquaculture is an important source of income for rural households in Laos, and fish and other aquatic products also contribute to the food security of the population. It has been estimated that fish consumption is about 84 % of total food consumed from animal sources. Half of the total consumption of aquatic products is coming from fish and the other half from other aquatic animals and amphibians (LARReC 2000).

In Laos, the majority of fish producers are smallholders, most of whom are located in rural areas. However, the knowledge-base on fish production is limited and there is a need to transfer and develop suitable technologies to function profitably in a rural context.

The African catfish (*Clarias gariepinus*) has been identified as one of the fish species with the greatest potential to contribute to fish production in Laos, in particular because the technologies available can be transferred to function profitably even in a rural context (DLF 1999).

The future development of small-scale aquaculture systems depends on available feed resources, as feeding constitutes a significant portion of the operation cost (Edwards 1997). Fish meal, the conventional dietary protein source in fish feeds, is often scarce and expensive in any market, and as it accounts for a major part of the total protein in fish feeds, the feed cost is often high. An increased use of local resources will reduce the feeding costs (Edwards and Allan 2004).

Thongsay et al. (2002) reported from a survey on potential feed resources in Vientiane province that there are many kinds of by-products available from cereal crop production and waste from the local alcohol distillation that can be used as animal feed. In addition, it should be possible to use more unconventional feedstuffs such as termites, earthworms, frogs and snails to support the development of catfish farming in Laos.

This survey was performed to provide baseline data on available natural feed resources that are used for catfish feeding and to evaluate the nutritional properties of current diets for catfish production.

Materials and Methods

Study sites

The study was conducted in three of ten districts in Vientiane municipality, namely Naxaythong (N), Sikhotabong (S) and Xaythany (X), which are located about 40 km to the north, 12 km to the north and 20 km to the south of Vientiane City, respectively. The area has an altitude of around 150 m above sea level. The survey was carried out between January and May 2005. The three districts were selected because of their different of agro-ecological characteristics. Naxaythong district is representative for a rain-fed area, while Sikhotabong is representative for wetland areas with a high potential for agricultural production and Xaythany district is an irrigated area. The climate in the area can be divided into two main seasons: wet and dry. The wet season lasts from May to October and the dry season from November to April. Annual rainfall averages about 1600 mm and the peak rainfall occurs in the period July to August. The average minimum and maximum temperatures are about 16 and 32^{o}C, respectively.

Survey

The survey methodology initially involved the selection of the research site with three categories of farms selected according to size, namely: small, medium and large. The criteria for classification of farm size was based on pond area and were a maximum of 500 m^2 for small-sized farms, 500 to 2,000 m^2 for medium-sized farms and more than 2,000 m^2 for large-sized farms. In total 27 catfish farms were chosen as being representative of the three different agro-ecological zones (9 in each zone) and comprising 3 farms of each size. Rapid rural appraisal methods (Melville 1993) were designed to collect essential information relating to the availability of catfish feed resources and the utilisation of agricultural by-products. This included farmer interviews using structured questionnaires, information discussions and observation of farmers' agricultural production.

Data collection, analysis and calculations

In connection with farm visits, samples of feedstuffs used by the farmers were collected from each farm in each district. This was performed over a period of two weeks per district. Data for each farm were collected with respect to catfish yield, number of workers employed and available feed resources.

Collected feed samples were dried and ground to pass through a 1 mm screen and stored in desiccators pending further analysis. The samples were analyzed for dry matter (DM), ash, crude protein (CP), crude fat (EE) and crude fiber (CF) according to standard methods of AOAC (1990). The content (g kg^{-1}) of nitrogen-free extracts (NFE) in DM was calculated as: 1000 – (ash + CP + EE + CF). The content (kJ kg^{-1} DM) of gross energy (GE) was calculated from the content of CP, EE and ash as described by Ewan (1989).

Based on information collected about ingredient use in catfish feed at each farm, the dietary content of CP, EE, CF, NFE, ash and GE was calculated to allow an evaluation of the nutrient supply.

Statistical analysis

Descriptive statistics was used to present general data while Minitab (2000) was used to calculate mean values and standard deviations (SD) on data from the proximate analysis of samples and for linear regression analysis.

Results

Farm characteristics

The pond size for small, medium and large fish farms ranged from 100 to 360 m^2, from 480 to 1,120 m^2 and from 1,800 to 5,000 m^2, respectively (Table 1). There were no major differences in pond size between the different agro-ecological zones, except for a larger pond size on large farms in irrigated areas.

There were 2 to 6 workers at each farm (Table 1) with a tendency for higher numbers on large farms. This results in a very marked difference in the number of workers per ha in farms of different size. The range was from 2 to 4 workers per farm for small farms, from 3 to 4 for medium farms and from 4 to 6 for large farms. There were no women workers on 8 of the 27 farms (30 %); in the remaining 19 farms, the proportion of women of the total work force ranged from 17 to 100 %.

The estimated catfish yield (per 6 months and ha pond area) in small, medium and large farms ranged (fresh weight) from 1.9 to 2.4 tons, 1.5 to 2.2 tons and 2.3 to 3.0 tons, respectively (Table 1). In rain-fed, wetland and irrigated areas the estimated catfish yield (per 6 months and ha pond area) ranged from 1.5 to 2.5 tons, 1.8 to 2.8 tons and 1.7 to 3.0 tons, respectively. Overall, the fish yield (t ha^{-1} 6 $months^{-1}$) was correlated (y = 0.0002 x + 1.99; R^2 = 0.55; P<0.0001) to the fish pond area (m^2) (Fig. 1).

Table 1. Descriptive data of the small, medium and large catfish farms surveyed at the three study sites

Location	Farm size*	Work force		Fish pond area (m^2)	Net fish yield ($t \cdot ha^{-1} \cdot 6\ months^{-1}$)
		Total (n)	Women (%)		
Nasaythong	S	4	25	100	2.1
Nasaythong	S	4	0	120	2.0
Nasaythong	S	4	0	360	2.3
Nasaythong	M	3	33	720	2.2
Nasaythong	M	3	0	640	1.9
Nasaythong	M	3	0	1,120	1.5
Nasaythong	L	6	33	3,200	2.5
Nasaythong	L	5	33	2,600	2.3
Nasaythong	L	6	25	2,400	2.5
Sikhotabong	S	3	33	160	2.2
Sikhotabong	S	3	33	350	2.2
Sikhotabong	S	2	0	200	1.9
Sikhotabong	M	3	33	480	2.2
Sikhotabong	M	3	33	860	2.1
Sikhotabong	M	4	25	740	1.8
Sikhotabong	L	6	0	2,800	2.8
Sikhotabong	L	4	33	2,200	2.5
Sikhotabong	L	4	0	1,800	2.4
Xaythani	S	3	33	170	2.4
Xaythani	S	3	33	120	2.1
Xaythani	S	4	25	260	2.0
Xaythani	M	4	33	600	1.7
Xaythani	M	3	20	540	2.0
Xaythani	M	4	17	960	2.2
Xaythani	L	6	33	5,000	3.0
Xaythani	L	4	50	4,160	2.8
Xaythani	L	5	25	4,700	2.5

*S = small; M = medium; L = large

Potential feedstuffs

The main feedstuffs used by the farmers were traditional feedstuffs such as maize, broken rice, cassava root meal, rice bran, soybean, soy waste, dried fish and fish meal (Table 2). In addition, some more unconventional feedstuffs such as leucaena meal, earth worms, termites and golden apple snails were used (Table 3).

The highest CP content was found in golden apple snail, fish meal and dried fish, followed by soy waste, soybean, termites and earth worms. Soybean, termites and dried fish were highest in EE and *Leucaena* was highest in CF. Highest ash content was found in fish meal, earth worms and golden apple snails.

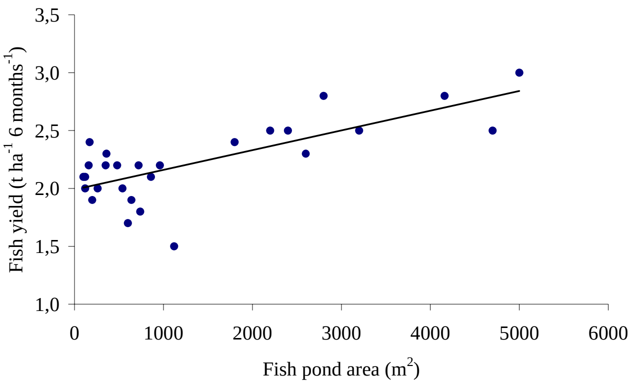

Fig. 1. The relationship ($y = 0.0002x + 1.99$; $R^2 = 0.55$; $P<0.0001$) between fish yield (t ha^{-1} 6 $months^{-1}$) and fish pond area (m^2) in catfish (*Clarias* gariepinus) farms in three districts in Vientiane municipality.

Table 2. Analyzed chemical composition (g kg^{-1} DM) of carbohydrate-rich feedstuffs used in diets for catfish in three districts in Laos.

Feed stuff	L	Crude protein		Crude fat		Crude fiber		NFE		Ash	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Fine rice bran	N	117	12	92	38	140	75	565	87	86	10
	S	117	9	85	27	126	25	582	49	91	19
	X	107	17	85	25	142	65	572	74	93	10
Rice bran	N	72	11	66	19	176	42	594	56	91	16
	S	98	19	109	30	185	32	507	44	101	22
	X	73	7	60	34	184	53	575	57	108	38
Maize	N	74	13	41	4	22	7	853	21	10	4
	S	81	15	39	8	26	7	844	26	10	4
	X	67	16	45	13	28	7	848	21	11	2
Broken rice	N	63	14	17	4	8	6	864	48	48	24
	S	68	6	17	5	8	3	871	47	37	20
	X	67	8	18	6	7	3	880	28	29	19
Cassava root meal	N	27	6	20	9	32	5	904	13	16	3
	S	24	5	22	11	31	4	907	15	15	4
	X	27	7	24	10	31	7	901	15	17	6
Leucaena meal	N	145	38	38	6	312	56	413	52	92	24
	S	160	48	33	12	258	95	483	91	65	15
	X	156	34	46	22	284	62	451	97	63	12

Legend: L=location; N=Naxaythong; S=Sikhotabong; X=Xaythani; FE=nitrogen free extract; SD=standard deviation

Table 3. Analyzed chemical composition (g kg^{-1} DM) of protein-rich feedstuffs used in diets for catfish in three districts in Laos

Feedstuff	L	Crude protein		Crude fat		Crude fiber		NFE		Ash	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Soybean	N	373	38	132	28	81	26	367	44	47	14
	S	379	48	123	30	92	36	355	77	50	7
	X	374	64	127	41	97	31	355	49	47	11
Soya waste	N	394	52	7	10	67	21	454	40	67	21
	S	410	20	16	9	69	12	450	32	55	20
	X	405	47	27	10	68	12	446	60	54	10
Earth worms	N	375	68	52	7	4	7	339	55	230	65
	S	345	68	40	9	6	10	377	89	232	30
	X	389	40	41	10	5	6	336	59	229	56
Termites	N	388	53	110	7	75	33	313	81	113	40
	S	397	33	106	9	59	5	337	64	101	27
	X	419	40	108	10	77	31	288	64	108	36
Golden apple snail	N	496	29	51	8	21	18	239	24	192	21
	S	489	22	44	15	17	18	254	58	196	53
	X	504	26	35	17	25	22	257	44	171	11
Dried fish	N	446	44	108	58	5	5	375	81	66	21
	S	478	10	104	8	7	6	315	15	96	8
	X	442	25	96	5	6	2	366	32	89	8
Fish meal	N	483	42	17	43	5	4	248	53	221	48
	S	488	24	64	16	8	4	230	39	210	17
	X	476	43	70	23	26	3	226	55	202	27

Legend: L=location; N=Naxaythong; S=Sikhotabong; X=Xaythani; FE=nitrogen free extract; SD=standard deviation

Catfish feed characteristics

The use of ingredients varied considerably between different agro-ecological areas and between farms of different size within each area (Table 4). There were also considerable differences in the feed content of CP, EE, CF, NFE and ash. With one exception (Xaythani district), the range in CP was from approximately 160 to 220 g kg^{-1} DM. The EE content tended to be highest in the rain-fed area compared with the other agri-ecological areas. The feed content of CF was lowest for large farms in irrigated areas and highest for farms in wetland areas. The feed GE content ranged from 18.0 to 22.4 MJ and the CP:GE ratio ranged from 7.5 to 14.9 g MJ^{-1}.

Table 4. Feed ingredients (g kg^{-1} DM), chemical composition (g kg^{-1} DM), gross energy (GE) content (MJ kg^{-1} DM) and crude protein (CP) to GE (CP:GE) ratio (g MJ^{-1}) of catfish diets in three districts in Laos[1]

	Nasaythong			Sikhotabong			Xaythany		
	S	M	L	S	M	L	S	M	L
Ingredients									
Fine rice bran	-	-	264	-	413	-	-	-	162-235
Rice bran	485-486	294-669	351	33-48	411	455	435-668	335-673	-
Maize	-	209	148-250	59-202	116	146	-	98	68-97
Broken rice	248-250	119	99-245	111-197	255	-	258	29	193
Cassava root	-	-	120	50	55	-	-	199	102-210
Leuceana	-	-	-	-	69	109	-	-	50
Soybean meal	-	-	122	-	111	-	74	-	80-500
Soya waste	-	125	-	86-202	66	120	-	-	70
Earth worm	-	81	-	54	55	-	80-115	95	-
Termites	60	45	-	100	-	-	71-80	40	-
GAS[2]	115-117	127	153	-	-	171	-	97	-
Dried fish	88-90	78-127	147	120	160	-	121	95	-
Fish meal	-	-	102	-	212	-	-	299	73-165
Chemical composition[3]									
Crude protein	167-172	176-201	155-195	177-180	181-216	207	177-191	194-197	164-275
Crude fat	170-175	179-199	152-192	61-74	70-71	68	55-60	59-60	43-56
Crude fiber	95-114	99	56-80	90-100	86-87	127	89-130	80-129	43-63
NFE	561-583	241-499	599-665	553-607	531-577	504	485-581	367-490	490-504
Ash	91-95	31-47	66-83	62-97	94-99	67	99-107	85-110	70-101
GE	20.7-20.8	22.1-22.4	20.7-21.5	18.4-18.7	18.4-18.5	19.0	11.9-18.0	18.0-18.4	18.1-18.5
CP:GE	8.1-8.2	8.0-9.0	7.5-9.1	9.4-9.8	9.8-11.7	10.9	9.0-10.7	10.6-11	9.1-14.9

[1] Districts; Nasaythong, Sikhotabong and Xaythani. Fish farm size; S: small, M: medium, L: large
[2] GAS = golden apple snails; [3] NFE = nitrogen-free extract; GE = gross energy (MJ); CP:GE = crude protein : gross energy (g MJ^{-1})

Discussion

The main feedstuffs used by catfish farmers such as maize, broken rice, cassava root meal, rice bran, soybean, soy waste, dried fish and fish meal are also traditionally used in livestock production in Laos (Edwards and Allan 2004). Maize is grown throughout the tropics and is the principal cereal grain employed in the feeding of livestock and it has also been fed successfully to fish (FAO 1983). Cassava is a staple crop in the region (Vongsamphanh 2003) and during the past 10 years the use of cassava root meal products in livestock feeding has been reported to increase in the Vientiane district (Thongsay et al. 2002). Cassava root meal has successfully been used as an ingredient in catfish feed in Vietnam and Thailand (Preston 2001). Rice bran and broken rice are commonly used for catfish production in Laos (Oulaytham and Bounsong 2005) and are obtained from mills within the village. The use of rice bran in fish feed results in a good quality pellet that has high water stability (FAO 1983). There are some constraints to the use of soybeans in livestock feed since the overall production in Laos is low and the yields per ha are low. Therefore, an extensive use of soybean in catfish production will result in a need to import from neighboring countries.

There are concerns over the increasing gap between supply and demand for fish, thereby threatening national food security in many countries, due to the extensive use of dried fish and fish meal in fish feeds (Naylor et al. 2000; Delgado et al. 2003). There are a huge number of small-scale fisheries in the Asia Pacific region that generates large quantity of dried fish, often referred to as “trash fish”, much of which is consumed or utilized locally as part of household food security, artisan processing or used for small-scale rural aquaculture and livestock raising (Chandrapal 2005). It has been estimated that the amount of small fish (*Clupeichthys aesamensis;* Pa Keo) harvested from the Ngum reservoir in Laos, and used to produce dried fish, amounts to about 400-500 tons per year (MOAF 2004). This quantity is far from enough to cover the needs for livestock feed and results in large imports form other countries in the region. Thus, the use of dried fish and fish meal in catfish feeds will not be sustainable in the long-term perspective and has to be replaced by other suitable feed resources.

Except for *Leucaena* leaf meal, the other unconventional feedstuffs used at farm level for catfish production were of animal origin (i.e. earth worms, termites and golden apple snails). *Leucaena* is a fast-growing and drought-resistant tropical leguminous tree, which offers probably the widest assortment of uses as compared to other legumes (Alceste and Jory 2000). However, there is a lack of data on its usefulness as a feedstuff for fish in general and for catfish in particular.

Earthworms are one of the most complete food sources in nature, in terms of its nutrient content, but there are limitations for large scale production (Appelhof 1982). Although very popular with fishermen, they are not commonly raised on a commercial basis because they reproduce slowly and require special production and control procedures. Myles (2005) suggested that, the most suitable consumer of termites would be some kind of fresh water fish that normally consumes aquatic insects. Although commonly used by catfish farmers, large scale production of termites will be most likely for use in catfish feed. Interestingly, golden apple snails were the most commonly used feed resource of the unconventional feedstuffs of animal origin. The use of golden apple snails as a feed resource is an important factor to control damage in the rice fields (Douangbupha and Khamphoukeo 2002).

The content of crude protein, crude fat, crude fiber, nitrogen-free extracts and ash for the more common feedstuffs used in catfish feed was comparable to other published data (Lovell 1993; Somsueb 1993; NIAH 1995). In the more unconventional feedstuffs, the content of crude protein was high in those of animal origin. The levels were similar to those reported by Dynes (2003) for earth worms, by Oyarzun et al. (1996) for termites and by Keansombath (2003) for golden apple snails. The crude protein content was comparable to soybean for earth worms and termites, and to dried fish and fish meal for golden apple snails. This makes them interesting as replacement of more conventional feedstuffs to provide enough crude protein in the feed. Termites and dried fish had a high content of crude fat, comparable to soybeans, and contained considerably more crude fat than earth worms and golden apple snails. Earth worms and golden apple snails were both high in ash content, and similar to the values for fish meal, which could be positive for the mineral supply but will have a negative impact on the energy values for these feedstuffs.

The nutrient profiles of the feeds used for catfish production varied considerably, mainly between the different agro-ecological areas. This was most obvious for the content of crude fat which ranged from approximately 40 to 200 g kg^{-1} DM, with the highest values for the rain-fed area. However, the level of crude protein was comparable in all areas and ranged from approximately 150 to 220 g crude protein kg^{-1} DM, with one extreme value at 275 g kg^{-1} DM on one large farm in the irrigated area. A survey on the feeding on catfish farms in Vietnam gave values in the range 160-350 g crude protein kg^{-1} DM (Edwards and Allan 2004) and in Thailand the corresponding values were 280-320 g crude protein kg^{-1} DM (Unprasert 1988). Experience from other warm water fish species (FAO 1983), indicates that the feed crude protein content should be in the range 240-300 g kg^{-1} DM to support a high growth rate. Studies on *Clarias gariepinus* have shown that the crude protein level in the feed should be 300-350 g kg^{-1} DM to give a high growth rate (FAO 1983). The crude protein requirements of *Clarias gariepinus* have been estimated to be around 400 g kg^{-1} DM (Machiels and Henken 1985; Degani et al. 1989). The protein:energy (P:E) ratio for the complete diets was in the range 8 to 12 g crude protein MJ^{-1} gross energy for all but one (approx. 15 g MJ^{-1} GE). This should correspond to 11 to 17 g crude protein MJ^{-1} digestible energy, assuming an average energy digestibility of 70 % in catfish diets with dietary crude fiber content in the range 60 to 130 g kg^{-1} DM (Ali 2001). The optimum P:E ratios for growing *Clarias gariepinus* have been reported to be in the range 25 to 30 g crude protein MJ^{-1} digestible energy (Machiels and Henken 1985; Uys 1989). Consequently, the feeding applied on the catfish farms of all sizes in this survey was far from optimal both in terms of dietary crude protein content and dietary P:E ratios.

The net yield of catfish from pond culture in small, medium and large farms was in the range 1.5 to 3.0 tons ha^{-1} half $year^{-1}$. That is fairly low compared to other countries in the tropics (Rahman and Varga 1992; Yi et al. 2003) and indicates a substantial potential for improvements. It appears likely that the poor nutrient content of the feeds, crude protein in particular, would be the major factor that could account for the low yield of catfish in Laos. According to De Graff and Janssen (1996) it should be possible to produce 6.5-9 tons ha^{-1} $year^{-1}$ of catfish with proper feeding and management. Interestingly, in the current study fish yield was related to fish pond area (Fig. 1) which may indicate that feeding and management was improved with farm size.

Conclusion

The feedstuffs potentially available for catfish production in Laos have the necessary nutritional properties to be used in feed formulation to produce fish feed. However, the diets used in the agro-ecological areas under study were insufficient in protein content and had to low protein to energy ratio. The catfish yield from ponds in all areas under study was far below the levels that should be possible to reach with proper management and feeding. Thus, there appears to be a considerable potential to improve the production of catfish cultivated in ponds in Laos by introducing better feeding and management practices.

Acknowledgment

The authors are grateful to the Swedish International Development Authority (Sida/SAREC) for funding this study and the faculty of Agriculture, National University of Lao for allowing the first author to carry out this survey. Thanks are also due to the Feed Analysis Laboratory of the Department of Livestock and Fisheries of the Ministry of Agriculture and Forestry.

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Received 3 December 2006; Accepted 20 March 2007