

Indonesia's Exports of Frogs' Legs

Mirza D. Kusrini and Ross A. Alford

Indonesia is one of the world's largest exporters of frogs' legs for consumption as food. The majority of the frogs are caught in natural habitat on the island of Java - predominantly the Crab-eating Frog *Fejervarya cancrivora* (75%), and the Giant Javan Frog *Limnonectes macrodon* (19%). While the greater number of frogs taken is for local consumption, the available data show increasing numbers of frogs' legs have been exported from Indonesia over time - from around 28 t in 1969, rising to around 5600 t in 1992 and then declining to around 3800 t in 2002. A strong increase in exports after 1985 corresponded with the banning in that year of exports of edible frogs from India and Pakistan - formerly the principal exporters of frogs' legs. This paper examines the trade in Indonesia based on export data covering 34 years (1969 to 2002) and market surveys and interviews conducted in 2001 to 2003. Although some concern has been raised about the trade, this paper discusses the possibility that the current level of harvest has not depleted Indonesia's population of edible frogs. However, it is not possible at the moment to state that current harvest levels are not a problem as insufficient information is available on production for the substantial domestic market.



Figure 1. Map showing part of South-east Asia, including survey area.

INTRODUCTION

Frogs' legs are widely regarded as culinary delicacies in most regions of the world, including Europe, the USA, Asia and Australia (Jennings and Hayes, 1985; Patel, 1993; Martin, 2000; Schmuck, 2000a; Truong, 2000; Vredenburg *et al.*, 2000; Paltridge and Nano, 2001; Szilard and Csengele, 2001; Török, 2003). Indonesia is one of the primary exporters of frogs' legs (Niekisch, 1986; Martens, 1991; Schmuck, 2000b). Until now, little information has been available on the volume of Indonesia's exports of frogs' legs, data only being available for certain years (Barfield, 1986; Niekisch, 1986; Martens, 1991; Schmuck, 2000b). Gaps in our knowledge of the trade in edible Indonesian frogs make it difficult to evaluate the impact of this trade and its conservation implications. This paper reviews the trade of frogs' legs for export and domestic purposes based on data from Biro Pusat Statistik (Indonesian Statistical Bureau) and interviews with frog harvesters, middlemen and exporters.

METHODS

Species in trade

With the assistance of five field assistants, the authors surveyed local markets in three provinces

(Jakarta, West Java and East Java) to record the species and numbers of frogs sold. Market observations in West Java were mainly carried out in the Bogor and Sukabumi districts; activities in East Java were monitored in the Surabaya, Madiun, Mojokerto and Pasuruan districts (Figures 1 and 2). The locations were selected based on their accessibility and recorded high rates of frog exports. Most of the interviews were undertaken on an informal basis with local traders or middlemen and did not adhere to a standard questionnaire. Each market was observed once during 2001 to 2003.

In order to obtain information on the fluctuations of the harvest, workers were asked whether the harvest had been lower in recent years. This information is crucial because there have been no previous data on the population of edible frogs. Harvesters and middlemen were interviewed mostly in their harvest area, which is in West Java province (Bogor and Sukabumi) and East Java province (Madiun, Mojokerto and Pasuruan).

To assess the size of frog preferred by harvesters and traders, frogs caught by harvesters who had been followed by the study team were measured for their snout vent length (SVL) and mass. The number of harvesters and traders interviewed and observed varied among locations owing to various difficulties in contacting the local harvesters. In total 27 frog harvesters and 23 local people who sell the frogs at markets (some of whom also act



Figure 2. Map of Java showing survey areas.

as middlemen) were interviewed during 2001 to 2003. As there are no official statistics available on the number of frog harvesters and traders, it is not possible to estimate how representative this figure is of their total number.

According to the Ministry of Fisheries, there are some 22 exporters of frogs' legs in Java and Sumatra. The authors were only able to find three exporters who were willing to discuss their business. They were asked about the source of frogs, capture methods, species sold, countries of export and problems relating to export, and revenue. Two exporters were interviewed in Surabaya (East Java) during August 2003, and one exporter who lives in Cirebon (West Java) responded via electronic mail. In addition, in October 2001 one of the authors (Kusri) interviewed a researcher from Balai Budidaya Air Tawar (BBAT - Centre for Freshwater Aquaculture) in Sukabumi (West Java), the institution that was responsible for first introducing the North American Bullfrog *Rana catesbeiana* to Indonesia for the purpose of raising by culture. A bullfrog farmer in East Java was also interviewed during August 2003 to gain information on the problems associated with frog farms, and the extent of development of such farms.

In this paper, the names for non-CITES-listed species are given according to Iskandar (1998).

Export data

Trade statistics recorded by the Indonesian Government between 1960 and 2002 and reported in the *Foreign Trade Statistical Bulletin* by the Indonesian Statistical Bureau were examined. Based on these data, an overall history of the frogs' legs trade was assembled, including information on the major importers, the value of the trade, net weight exported each year, and the locations of major frog sources.

The first available data on exports of frogs' legs are from 1969 and were listed under fisheries products. Between 1969 and 1974 they were categorized simply as frog meat. Since 1975 frog meat has been registered under five categories: 1) meat and edible meat of frogs' legs, fresh or chilled; 2) meat and edible meat of frogs' legs frozen; 3) meat and edible meat of frogs (excluding legs) fresh or chilled; 4) meat and edible meat of frogs

(excluding legs) frozen; and 5) other meat of frogs (Biro Pusat Statistik, 1969-2002). The units recorded in trade are in kilogrammes. However, there is no mention of the species from which the meat or legs are taken. In this account, all forms of "edible frog meat" are included together. While there have been some records of frog meat categorized under "edible frog meats excluding leg" since 1991, the quantity is very small (0.34% of total) and for the purposes of this report have been included with the data relating to frogs' legs.

Harvest estimates for export purposes

Frogs captured by harvesters (N=736) were measured to obtain the correlation between body length (SVL, mm) and body mass (g). In order to estimate the actual take of frogs for export purposes, based on the ratio of wet mass to skinless leg mass for each species, the authors measured SVL, whole wet masses and skinless leg masses of *Limnonectes macrodon* (36 females and 27 males) and *Fejervarya cancrivora* (33 females and nine males) taken randomly from frog harvesters in West Java. The equation to estimate harvest is as follows: $Total\ number\ of\ frogs\ harvested = annual\ mean\ mass\ of\ exported\ frogs'\ legs\ (grammes) / mean\ weight\ of\ pair\ of\ legs^1$.

STATUS

Limnonectes macrodon is listed as Vulnerable in the IUCN Red List (2004) where it states that the species in Indonesia is now considered uncommon, but not yet rare, where previously it was more common.

RESULTS

Species in trade

Three species of native frogs were sold in local markets of Jakarta, West Java and East Java, as well as *Rana catesbeiana* which is raised on frog farms but does not occur in the wild. Of the native species, the larger species (Crab-eating Frog *Fejervarya cancrivora* and Giant Javan Frog *Limnonectes macrodon*) were the most commonly sold. Surveys in East Java only found *Fejervarya cancrivora* and Grass Frog *Fejervarya limnocharis* specimens being traded. However, East Java traders did say that they sometimes sold frogs caught in streams matching the description of *Limnonectes macrodon*.

There are two different end consumers: local consumers who prefer fresh frog meat, and processed and frozen frogs' legs for overseas markets. In local markets, frogs were mostly sold alive as the outward appearance of frogs is important. Specimens of *Rana catesbeiana*

¹While the trade derives from Sumatra for some periods, based on interviews with traders the authors are certain that the same species are being harvested. *Fejervarya cancrivora* is distributed widely in Indonesia. Although scientists believe that *Limnonectes macrodon* is only distributed in Java, taxonomically it was previously put as *L. blythii* or *L. kadarsani*, which are distributed widely in other parts of Indonesia (Iskandar, 1998). These frogs are very much alike in appearance and are the same size as *L. macrodon*. Veith et al. (2000) found that frogs listed as other species harvested from these two islands were actually *Fejervarya cancrivora*.

Species	Sex	No.	SVL (mm)		Std Dev	Mass (gram)		Std Dev
			Mean	Range		Mean	Range	
<i>Fejervarya cancrivora</i>	Female	367	75.10	40.00-162.00	16.89	48.55	2.94-152.40	26.48
	Juvenile	5	35.90	33.50-38.00	1.75	3.93	3.45-4.35	0.35
	Male	183	65.54	50.20-86.20	6.01	29.55	14.50-57.40	8.09
	Total	555	71.60	33.50-162.00	15.23	41.88	2.94-152.40	24.03
<i>Fejervarya limnocharis</i>	Female	16	43.69	30.00-78.00	16.22	10.34	1.87-32.00	12.9
	Male	27	46.24	32.57-70.20	13.75	10.87	2.60-41.00	10.04
	Total	43	45.29	30.00-78.00	14.58	10.67	1.87-41.00	11.04
<i>Limnonectes macrodon</i>		138	80.47	54.74-138.10	12.78	66.41	17.00-146.05	26.49

Table 1. Size and mass of frogs captured by harvesters in West and East Java, Indonesia.

No information on the sex of *L. macrodon* is available owing to the difficulty in distinguishing between the sexes.

were rarely seen in local markets, however a few live specimens were on sale in supermarkets in Jakarta. Interviews with local traders in all markets revealed that most local consumers dislike the taste of *R. catesbeiana* and prefer the native frog species.

Frogs' legs are usually supplied to the exporting companies already skinned, large specimens of *Fejervarya cancrivora*, *Limnonectes macrodon* and *Rana catesbeiana* being the most favoured. The manager of one exporting company stipulated that he should be supplied only with *Limnonectes macrodon* however he admitted that since supplies come in the form of skinless frogs' legs, as long as they are of acceptable size it is possible that they include other species such as *Fejervarya cancrivora*.

Frog size

A total of 736 frogs of three species (*Fejervarya cancrivora*, *F. limnocharis* and *Limnonectes macrodon*) captured by harvesters in West Java and East Java were measured. *Fejervarya cancrivora* made up 75.4% of specimens captured, while only a small percentage was *F. limnocharis* (5.8%) and the rest were *Limnonectes macrodon* (18.8%). Frogs captured were usually mature, except a small number of *Fejervarya cancrivora* specimens which were of sizes considered as juvenile (Table 1).

Traders either categorize frogs into large, medium or small, or use an alphabetized system: A, B and C. Large and medium-sized frogs are placed in Categories A and B, respectively, with 9 to 12 frogs/kg in Category A, or 13 to 25 frogs/kg in Category B, and more than 25 frogs/kg are categorized as C, or small. Frogs' legs that are exported are usually from large and medium-sized frogs (Category A or B) with export prices in 2003 at around USD3-4/kg of skinless frogs' legs or around Rp.25 200-33 600/kg (USD1=Rp.8400).

Levels of income and profit

Harvester income depends on the number or mass of frogs caught, the route taken and skills employed in harvesting. To minimize costs of transportation, harvesters rarely go far from the place where they sell the catch, preferring to walk whenever possible. Other than transportation, additional costs for each trip are for snacks,

coffee and cigarettes. The maximum cost of transportation and snacks (including coffee and cigarettes) that harvesters were willing to spend was Rp.1000/day during the high season. If it is assumed that transportation costs are nil and the price of frogs is constant at Rp.6000/kg (mixed), harvesters could make around Rp.5000-11 000/day (low season) and Rp.11 000-29 000/day (high season) (Table 2). A full-time harvester working for 25 days/month would receive a monthly income of Rp.245 000-635 000. This estimate is probably lower than actual earnings, because harvesters tend to capture bigger frogs (thus increasing their income) and prices fluctuate, and are higher in the low season because of lower supply. Based on interviews, the lowest income of

	Snacks	Min. Yield	Max. Yield	Min. Wages	Max. Wages
low season	1000	1	2	5000	11 000
high season	1000	2	5	11 000	29 000
5 days low season					
in a month	5000	5	10	25 000	55 000
20 days high season					
in a month	20 000	40	100	220 000	580 000
Monthly wages				245 000	635 000

Table 2. Harvester daily wages (Indonesian Rupiah).

Note: The price of frogs is based on the maximum price of mixed frogs (Rp.6000/kg). Wages per day is yield multiplied by price of frog minus food and assuming that transportation costs are nil. Monthly wages refer to wages during low season plus wages during high season.

Species	Condition	Category	Harvester	Consumer	Gross revenue
<i>L. macrodon</i>	each		750	3000	2250
	per kg		10 000	35 000	25 000
<i>F. cancrivora</i>	each	C	150	700	550
	per kg	C	5000	17 000	12 000
<i>F. limnocharis</i>	per kg (skinless)	C	6000	12 000	6000
	per kg	B	5500	20 000	14 500
	each	A	600	2000	1400
	per kg	A	5000	20 000	15 000
	per kg (skinless)	A	10 000	30 000	20,000
	per kg	Mixed	6000	8000	2000

Table 3. Comparative prices (in Indonesian Rupiah) of frogs sold from harvester to local consumer, based on the maximum price available for each stakeholder.

Stakeholder	Sold to	Location	Price of <i>F. cancrivora</i> and <i>F. limnocharis</i>				Price of <i>L. macrodon</i>		
			small	medium	large	mixed	small	large	mixed
Harvester	Middleman	Caringin (WJ)	150 each		600 each			750 each	
Harvester	Middleman	Cibatok (WJ)				6 000/kg		10 000/kg	
Harvester	Middleman	Kelapanunggal (WJ)			10 000/kg		14 000/kg		
Harvester	Middleman	Karangtengah (WJ)	5 000/kg	5 500/kg	6 000/kg				
Harvester	Middleman	Pasar Pelita (WJ)			13 000/kg				
Harvester	Middleman	Ciracap (WJ)				5 000/kg		6 000/kg	
Middleman	Consumer	Caringin (WJ)			750 each		1 250 each		
Middleman	Distributor	Cibatok (WJ)	7 000/kg					13 000/kg	
Middleman	Consumer	Karangtengah (WJ)	12 000/kg	20 000/kg				22 000/kg (B)	
			(B)	(J)				or 25 000/kg (J)	
Middleman	Consumer	Pasar Pelita (WJ)	15 000-17 000/kg					18 000-20 000/kg	
Middleman	Distributor	Ciracap (WJ)	8 000/kg		12 000/kg			18 000/kg	
					(A & B)				
Middleman	Trader	Glodok (J)	6 000-8 000/kg		12 000-15 000/kg		1 000 each	2 500 each	
Middleman	Trader	Senen (J)		20 000/kg* or 1 500 each	350 00/kg* or 2 000 each			20 000/kg	
Middleman	Trader	Senen (J)	7 000/kg		17 000/kg	8 000/kg		20 000/kg	
Middleman	Trader	Petak sembilan (J)			15 000/kg			20 000/kg	
Trader	Consumer	Glodok (J)	15 000/kg* or 500-700 each		25-30 000/kg* or 20 000/kg		1 500 each	3 000 each	
Trader	Consumer	Senen (J)	15 000-25 000/kg* or 12 000-20 000/kg		25 000/kg			3 500/kg	
Trader	Consumer	Petak sembilan (J)		1 000 each	25 000/kg or 2 000 each			30 000/kg or 3 000-4 500 each	

Table 4. Price of frogs (in Indonesian Rupiah) in Jakarta and West Java according to buyers, 2002 and 2003.

Note: *mean price for skinless legs, otherwise price for live frogs: (B)=Bogor, (J)=Jakarta (WJ)=West Java

Stakeholder	Sold to	Location (East Java)	<i>Fejervarya cancrivora</i> and <i>Fejervarya limnocharis</i>			
			small	medium	large	mixed/skinless
Harvester	Middleman	Madiun				13 000/kg
Harvester	Middleman	Madiun			9 000/kg	
Harvester	Middleman	Madiun/Magetan			10 000/kg	
Harvester	Middleman	Mojokerto				8 000/kg (high season) 12 000/kg (low season) live
Harvester	Middleman	Pasuruan	6 000/kg		10 000/kg	
Harvester	Middleman	Sidoarjo			10 000/kg (live)	
Middleman	Consumer	Madiun				10 000/kg
Middleman	Consumer	Madiun	10 000/kg	15 000/kg	25 000/kg	
Middleman	Consumer	Madiun	10 000/kg		25 000/kg	
Middleman	Distributor/Exp	Madiun	7 000/kg	15 000/kg	20 000/kg	
Middleman	Consumer	Madiun/Magetan	12 000/kg		22 500/kg	
Middleman	Consumer	Mojokerto			25 000/kg	
Middleman	Consumer	Pasuruan			15 000/kg (live)	
Middleman	Consumer	Pasuruan			25 000/kg	
Middleman	Consumer	Sidoarjo	1 500/each	2 500 each	3000 each	
Exporter	Consumer					25 200-33 600/kg (USD3-4, 1 USD=Rp. 8400)

Table 5. Price of skinless frogs' legs in East Java (in Rupiah) unless stated as other form, 2002 and 2003.

Period	Annual mean mass of frogs' legs (kg '000s)	Annual range number of frogs taken (individuals '000s)		Annual mean number of frogs taken (individuals '000s)	
		A	B	A	B
		1969-1978	1 402	10 176-52 019	12 794-38 607
1979-1988	2 878	20 884-106 756	26 256-79 232	75 462	43 144
1989-1998	4 302	31 214-159 561	39 243-118 423	113 056	64 484
1999-2002	3 831	27 796-142 088	34 946-105 455	100 676	57 423

Table 6. Annual mean volume of frogs' legs exported and predicted number of frogs taken for export.

A = SVL between 89-162 mm, mean 101.43 mm and B = SVL between 100-150 mm, mean 125 mm

a full time harvester was Rp.450 000/month whilst the highest was 900 000/month.

For middlemen, the gross revenue for each type of frog varied (see Tables 3-5). Middlemen and traders must also spend substantial amounts of money for fixed costs, such as equipment, carbide or batteries, transportation to carry frogs to traders or local markets, and the hiring of people to cut and skin frogs. Middlemen who had connections with exporters usually did not need to cover the costs of transportation since exporters usually come to the middleman. However, interviews revealed that only some middlemen distributed their frogs' legs to exporters. Exporters usually have higher quality control. Interviews with exporters revealed that at least 2-5% of frogs' legs coming from middlemen were usually rejected for various reasons such as the occurrence of bruises or parasite infection. One of the middlemen interviewed remarked that he had lost a substantial amount of money because more than 30% of the last batch of frogs' legs he sent were rejected. This caused him to leave the export market and concentrate on the local market, which he said was much more flexible. Other middlemen used a combination of approaches, catering for both local and export markets. Frogs that are too small for export are sold in local markets. The net revenue for middlemen and traders varies, ranging from Rp.100 000/day to Rp.600 000/day.

Frogs in local markets were sold either by number (when live) or by mass (either the whole frog or as skinless legs). Prices recorded for the years 2002 and 2003 varied according to species, size, location, stakeholders, and season (Tables 4 and 5). In East Java consumers paid Rp.1500 (small) to Rp.3000 (large) for each live frog, and Rp.6000-Rp.25000 per kg of skinned frogs' legs. Whereas in Jakarta, small frogs harvested from rice fields were sold for Rp.750 each and large frogs sold for up to Rp.25 000 per kg of whole live frogs. The price of *Limnonectes macrodon* was usually higher than that for rice field frogs. In West Java and Jakarta specimens of this species were usually sold live by number or by weight. The cheapest *L. macrodon* specimen sold to consumers was in Bogor (Rp.1250/frog) compared to Jakarta, where prices ranged from Rp.1500 (small) to Rp.3000 (large)/frog, or around Rp.25000/kg.

Profiles of exporters

Companies that export frogs' legs usually also export other fisheries products such as prawns and fish. Twenty-two companies, employing 3596 people, were listed by the government as exporting frogs' legs in 2000 (Ministry of Fisheries, 2000). Almost two thirds (14) of these companies were based in Java, which on average employed 188 people each; the rest were in Sumatra, where an average of 132 people were employed at each company. This number fluctuates from year to year. After trying for two years to track down some of the companies, the authors found that some of them had closed down and that others they encountered were not listed at all. Managers from two exporting companies that were not listed were inter-



THE CRAB-EATING FROG *FEJERVARYA CANCRIVORA* MADE UP THREE-QUARTERS OF THE SPECIMENS HARVESTED DURING THE STUDY PERIOD.

viewed - one company started in 1972 and the other in 1999. Both companies export other seafood products, mainly prawns and lobsters.

According to these sources, exported frogs mostly came from East Java (Kediri, Madiun, Nganjuk, Bojonegoro, Pasuruan, Jombang, Madura), but also from West Java (Tasikmalaya and Cirebon), central Java (Solo, Cilacap), and locations outside Java such as Lampung (southern end of Sumatra), Bali and south Kalimantan (Banjarmasin). The managers from the two aforementioned companies declared that they rely mostly on supply from adjacent areas, however they would sometimes obtain frogs from other islands, especially during periods of low supply. Most frogs are removed from natural habitat, and only a small number come from frog farms.

Exporting companies usually have cold storage, processing and packaging facilities. They operate at least six days a week and employ 30 to 50 full-time workers, or more if the demand is high. Frogs are processed in compliance with international quality standards (Ministry of Agriculture, 1993). An appointed laboratory usually tests the frogs for bacteria, parasites and other pathogens such as *salmonella* before they are cleared for export.

The estimated number of frogs harvested and exported from Indonesia

Data were examined for the years 1969 to 2002. Exports of frogs' legs from Indonesia fluctuated greatly but the trends show an increase in most years between 1969 (2800 t) and 1992 (5600 t), especially during the period 1985 and 1992 (Figure 3). Exports decreased after 1993, and showed a downward trend until 1999, after which there was a limited increase. The average annual volume increased two-to-three-fold between 1969 and 1978 and the post-1980 years (Table 6).

There was a significant difference in the ratio of wet mass to skinless leg mass between *Fejervarya cancrivora* and *Limnonectes macrodon* ($F_{(1,102)}=75.509$, $P < 0.001$; Table 7). However, since export data are not presented separately by species, the authors used the combined estimates of mean mass per pair of legs and mean total mass of frog per mass of legs to estimate numbers of frogs and total mass of frogs removed from the wild.

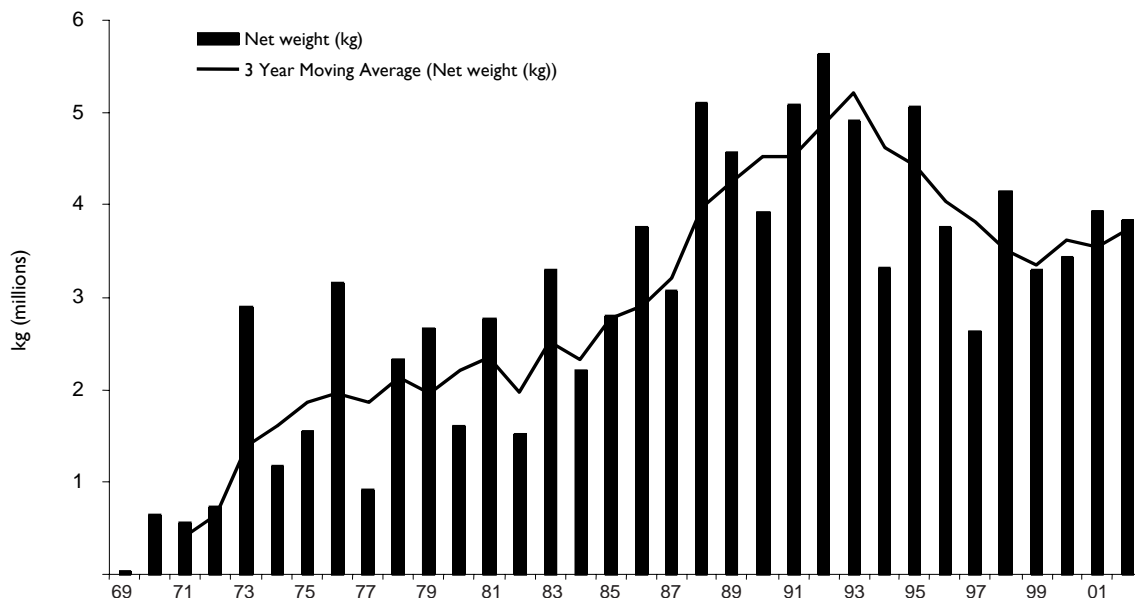


Figure 3. Frogs' legs exports from Indonesia, 1969 to 2002.

Source: Biro Pusat Statistik (BPS), 1969-2002.

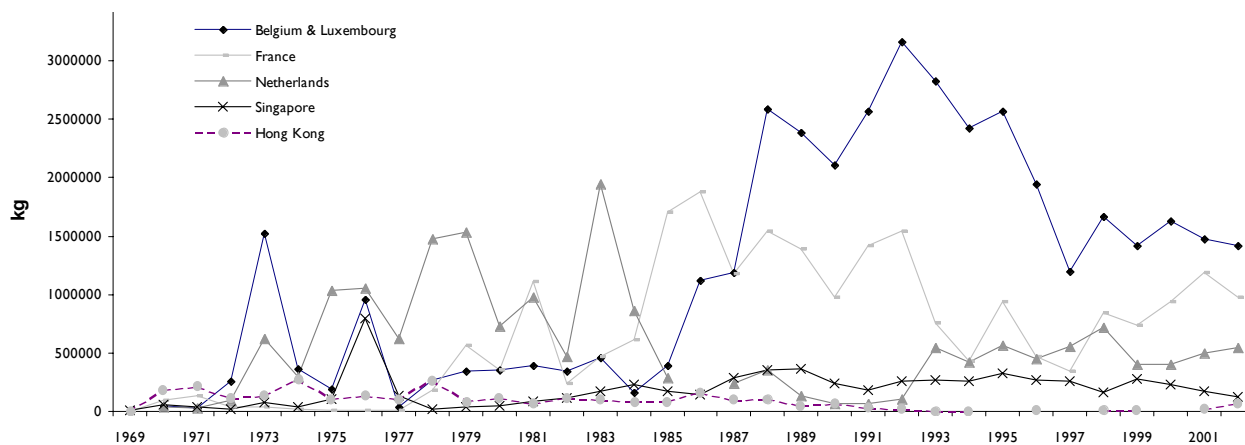


Figure 4. Destinations of exported frogs' legs, 1969-2001. Source: Biro Pusat Statistik (BPS), 1969-2000.

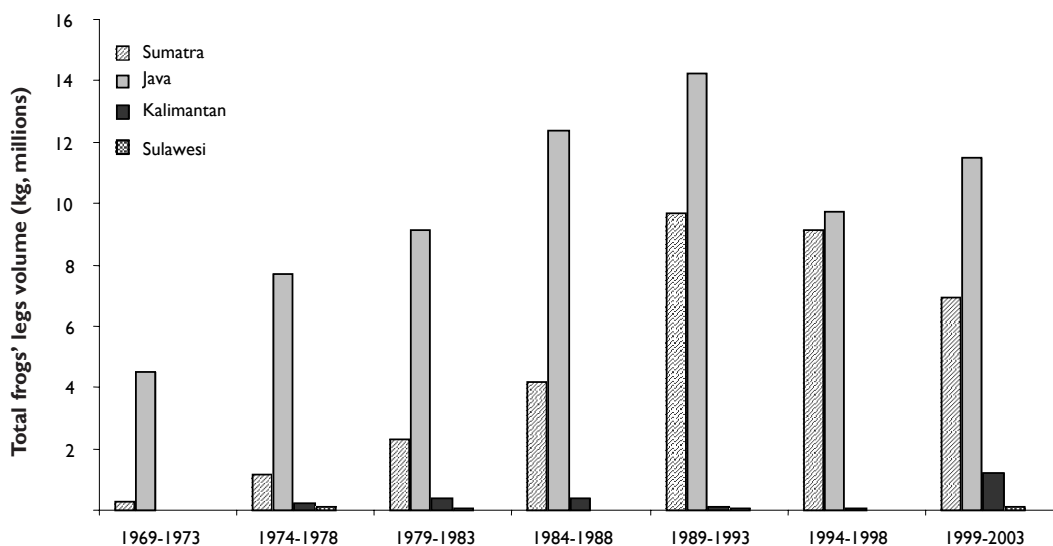


Figure 5. The volume of frogs' legs exported from Sumatra, Java, Kalimantan and Sulawesi, Indonesia.

Source: Biro Pusat Statistik (BPS), 1969-2000.

Species	Number	Mean	Std Deviation	Range
<i>Fejervarya cancrivora</i>	42	0.3208	0.03143	0.25 - 0.41
<i>Limnonectes macrodon</i>	63	0.4160	0.06751	0.21 - 0.65
Total	105	0.3772	0.07272	0.21 - 0.65

Table 7. The proportion of whole body mass accounted for by leg mass in *Fejervarya cancrivora* and *Limnonectes macrodon*.

On average a frog's legs account for 37.7% of its total weight (Table 7). The correlation between total weight and length was estimated based on regressions² taken from mature *Fejervarya cancrivora* and *Limnonectes macrodon* specimens captured by harvesters that the authors observed in West Java and East Java. The equation is: $\text{Log Weight} = 2.724 * \text{log SVL} - 3.456$ ($F_{(1,794)} = 5028.869$; $P < 0.001$). Estimates were made in two ways:

1) Using data from harvesters for frogs with body masses of at least 80 g, it was estimated that the SVL of exported edible frogs is between 89-162 mm with a mean of 101.43 mm. Since data were taken from harvesters who mostly cater for domestic consumption, the SVL assigned here might be biased to smaller frogs. Predicted total weight: range 71.41-365.36 g, mean = 100.87 g. Predicted weight of pair of legs (total weight x 37.7%): range 26.96-137.81 g, mean = 38.05 g.

2) Presuming that frogs taken for export might be larger, it was estimated that the SVL of edible frogs is 100-150 mm with a mean of 125 mm. Predicted total weight: range 98.17-296.26 g, mean = 180.29 g; Predicted weight of a pair of legs (total weight x 37.7%): range 36.32-109.62 g, mean = 50.56 g.

Based on the above equation, the estimate ranges widely. For instance, the mean number of frogs exported annually during 1989 to 1998 is estimated as being in the range of 31 to 160 million frogs a year, depending on the length of frogs used in the equations (Table 6). However, the actual number of frogs taken was probably higher than recorded. The skinning of frogs' legs destined for export markets is either carried out by the middleman or, more usually, by somebody employed by him, before the frogs' legs are sent to exporters; only specimens with no bruises or other imperfections are accepted by the exporters. Because frogs are usually captured using a net on a long pole, some are inevitably bruised. Frogs' legs rejected by exporters are not usually kept for domestic consumption either since the domestic market favours live frogs. The number of frogs' legs rejected by exporters varied from two to five per cent of the total number of frogs caught, although one middleman remarked that he had once rejected as

much as 30%. Upon further questioning, it became apparent that the high incidence of rejection was likely to be attributed to this middleman's lack of experience in exporting frogs.

Destinations of exported frogs' legs

In total, some 36 jurisdictions imported frogs' legs from Indonesia from 1969 to 2002. Ten of these were in Asia (China, East Timor, Hong Kong, Japan, Malaysia, Pakistan, Singapore, South Korea, Taiwan and Viet Nam); two in the Middle East (Bahrain and Egypt); 14 were in Europe (Austria, Belgium and Luxembourg, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Italy, Netherlands, Spain, Sweden, Switzerland, and the UK); four were in Latin America and the Caribbean (Brazil, Ecuador, Mexico, and Bahamas); two in North America (USA and Canada) and at least four in Pacific countries (Australia, Papua New Guinea, New Caledonia and other countries in Oceania). Although Belgium and Luxembourg are separate countries, they are combined as one entity in the statistical reports.

Europe was the major importer of Indonesian frogs' legs (83.2% of the total exported), with Belgium and Luxembourg the principal destination (47.6%), followed by France (27.6%) and the Netherlands (21%). Export to Europe tended to fluctuate but increased dramatically after 1985. The second-largest importer was Asia (around 12%), with the majority going to Singapore (50.5%), Hong Kong (22.9%) and Malaysia (18.3%). Export to Asia tended to increase slightly after 1985 and stabilized at around 500 t annually from 1988 (Figure 4).

The results reported above correspond with those arising from the interviews. All exporters reported that most exports go to Europe (Belgium, France, Netherlands, and Switzerland) and a small number to the USA and Singapore. They also reported that demand for frogs from overseas has been increasing and that it was sometimes hard to meet demand owing to limited supplies, particularly during the dry season (February to August). Large increases in demand occurred during the 1980s; from the 1990s to date the market has been relatively constant, increasing at slow rates as compared to the 1980s.

²the relationship between two random variables (in this case total weight and length) with a straight line fit to the data. The linear regression model postulates that $Y = a + bX + e$. Where the "residual" e is a random variable with mean zero, the coefficients a and b are determined by the condition that the sum of the square residuals is as small as possible.

Species	Mass < 80 g		Mass > 80 g	
	No.	%	No.	%
<i>Fejervarya cancrivora</i>	504	90.8	51	9.2
<i>Fejervarya limnocharis</i>	43	100.0	0	0.0
<i>Limnonectes macrodon</i>	99	71.7	39	28.3
Total	646	87.8	90	12.2

Table 8. Number and percentage of frogs captured in Category A (body mass > 80 g) and other categories (body mass < 80 g), based on harvest from West Java and East Java, Indonesia.

The origin of exported frogs' legs

Based on interviews with exporters, most frogs come from the island on which the company operates, although some frogs originate from other islands. Since it is difficult to estimate the number taken from each province, it is assumed that frogs originated on the islands on which exporters are based. On this basis, it is likely that most exported frogs come from Java and Sumatra.

Export records show that there are 19 ports of export. These are situated on five main islands: Java (7 ports), Sumatra (11 ports), Kalimantan (3 ports), Sulawesi (one port) and Bali (one port). Based on interview data, the majority of frogs' legs from Java were exported from ports in three provinces - Jakarta, East Java and central Java - and most frogs' legs from Sumatra originate in north Sumatra and south Sumatra provinces. The contribution of frogs' legs from Sumatra to the total number of exports increased over the study period as the contribution from Java decreased; however during 1999 to 2003 the contribution from Java rose again (Figure 5).

There are no data to show whether exported frogs originated from frog farms or were removed from the wild. There is no farming of native species. The frog farm industry in Indonesia began in 1982 with the introduction of *Rana catesbeiana* as part of an Indonesian Government programme to increase frogs' legs exports (Susanto, 1989). In 1999, the government, through the Ministry of Fisheries, launched a programme to increase fisheries production for export (PROTEKAN) by developing various aspects of fisheries commodities, including freshwater aquaculture, by 2003. The freshwater aquaculture industry is primarily directed at three commodities: *Tilapia Tilapia*, *Rana catesbeiana*, and freshwater turtles. The Directorate General of Fisheries (1999) estimated that frog farms might produce 1650 t/year by 2003, which is around one third of the volume of annual mean frogs' legs exported during the period 1999 to 2002. However, discussion with staff from BBAT and one frog farmer in East Java revealed that many farmers had stopped farming *Rana catesbeiana* because of high maintenance costs and vulnerability of the species to disease. This indicates that frog farms are unlikely to contribute substantially to future exports.

Domestic trade

Determining the total extent of the frogs' legs trade in local markets is difficult because the number of markets is not known; nor is the number of sellers. The survey found at least 15 local markets in Jakarta selling frogs' legs. Two of five large supermarkets surveyed in Jakarta were selling live frogs and in much lower numbers than at local markets. Unlike for exports, there are no records kept on the number of frogs sold domestically. Assuming that the export market uses large frogs (Category A, maximum 12 frogs/kg wet weight, each frog weighing approximately 80 g) almost exclusively, the proportion of captured frogs that enter local markets can be estimated as being the proportion of those captured that do not fall into this category, or approximately 88% of frogs (Table 8). This suggests that the local market could be at least seven times as large as the export market. However, there is reason to believe that the assumption about trade focus on Category A specimens only might be incorrect. If Category B frogs are also exported, then the local market, while still representing a substantial level of use, might in fact be only twice as large as the export market. The actual size of the domestic market is therefore uncertain.

As the world's major exporter of frogs' legs, Indonesia's frog harvest has been the subject of concern by several investigators of the trade (Barfield, 1986; Niekisch, 1986; Martens, 1991; Patel, 1993; Schmuck, 2000). Much of the debate on this trade has focused on the harvest for international trade and has ignored the fact that domestic consumption could also be high. The estimated numbers in trade show that the domestic trade should be taken into account during efforts to manage this harvest.

Sustainability

Ten out of 13 harvesters in East Java and nine out of 14 harvesters in West Java remarked that yield per year tends to decrease. Almost all (90%) middlemen in East and West Java noted the same trend. However, traders and exporters did not share this perception; they only remarked that sometimes supplies were low depending on the season. Harvesters and middlemen believe that the declines they have noticed are caused by: 1) increasing numbers of harvesters; 2) increasing numbers of middlemen, allowing harvesters to go to other middlemen; and, 3) habitat change, as more rice fields have been developed for other uses.

DISCUSSION

The mean weight of frogs captured varied among species, however it is clear that harvesters select frogs based on their size. Frogs taken for export were usually large mature individuals. However, for local consumers, size is not important and can include young mature frogs. The SVL at maturation of *Fejervarya cancrivora* is around 45 mm for females and 50 mm for males (Jaafar, 1994).

FROG HARVESTING IN INDONESIA

Frog harvests in Indonesia occur throughout the year; however the rate of harvesting fluctuates. Peak harvests occur during the wet season and when there is no moon visible. During the peak season the number of harvesters tends to rise as part-time harvesters enter the workforce. Harvesting is not a highly skilled job and provides a substantial income for unskilled workers. Lights powered by carbide or batteries are used to help in the capture of frogs. This has led to this occupation being called *pengobor* (West Java) or *penyuluh* (East Java), which literally means men who use torches. To capture frogs, most harvesters walk in or along areas of frog habitat such as rice fields, small fish ponds, ponds inside forested areas, and irrigation ditches near sugar cane or along river banks. Only one harvester from Sukabumi (West Java) indicated he caught frogs while using a dinghy on the River Cikarang.

Frog harvesting in rice fields is limited by the stage of rice-plant growth. However, rice fields are considered as areas open to the public and there is no need to ask permission from rice field owners to capture frogs, provided the rice plants are not damaged during the process; in order to minimize any damage, the harvesters rarely venture inside the rice blocks except during certain times, for example, after rice has been harvested. Thus their capture effort is usually limited to areas within a one-metre radius of the block borders, which also serve as pathways. Harvesters from other areas usually bring identification and sometimes ask permission from heads of villages.

The total distance traversed during searches is up to 10 km a night. Working time usually starts at around 7.00 p.m. and finishes around 1.00 a.m. The route taken is rarely far from harvesters' homes or from the middleman's area of operation; this minimizes travel costs. Harvesters use a long bamboo pole with a net at the end (West Java) or a long bamboo pole with a three-headed spear (East Java). The long pole helps harvesters to capture frogs that are further from where they are standing. The three-headed spear is useful for capturing frogs hidden in crevices. Harvesters usually try to avoid spearing frogs in their legs because the resulting bruises would lead to the specimens being rejected, especially for export purposes. However, sometimes it is difficult to avoid such injury, especially when frogs are hiding. Captured frogs are then placed in special bags.

West Javan harvesters avoid frog mortality during capture because frogs are usually sold alive. In the local markets, live frogs are sold in a bundle of 10; the customer selects a bundle and chooses whether to have the frogs killed and skinned at the market or to bring them home alive. Most customers prefer that sellers cut the legs off the frogs; the remaining body parts are usually discarded. Smaller frogs are usually sold in kilogrammes as skinless legs. Other frog products sold at the markets include skin chips (for snacks) and dishes with frogs' legs as the primary ingredients.

East Javan harvesters do not care whether frogs are alive or dead since most captured frogs are destined for export and are usually passed on to middlemen. As soon as the middlemen weigh their catch, the frogs' legs are removed and skinned by the middlemen or, more usually, by someone employed by them. The middlemen then despatch the skinned legs, packed in ice, to the exporting companies. There, each frog's legs are sorted according to size and quality. Bruised legs are discarded. Those that are of an acceptable quality are washed and weighed and arranged in trays, after which they are packaged and frozen.



REDDY RACHMADY



ANI MARDIASTUTI



ANISA FITRI



IAN BUDARTO

PHOTOS FROM TOP:

HARVESTING FROGS BY TORCHLIGHT IN CARINGIN, WEST JAVA;

A BUNDLE OF 10 FROGS ON SALE IN A LOCAL

MARKET IN BOGOR, WEST JAVA; SKINNED FROGS' LEGS IN A LOCAL

MARKET IN JAKARTA; FROGS' LEGS BEING PROCESSED

IN EAST JAVA.

The authors found that the most commonly harvested edible frogs are *F. cancrivora* and *Limnonectes macrodon*. Both are large species and could be found in areas accessible to harvesters. They are probably the species most frequently caught for export purposes, especially in Java. However, based on the surveys where *Fejervarya cancrivora* are predominant in the harvest, it may be likely that this species is harvested the most as indicated by Veith *et al.* (2000). *Fejervarya cancrivora* is at its most widespread in habitats associated with humans and is the most common frog found in rice fields (Church; 1960; Alcalá, 1962; Berry, 1975; Jaafar, 1994; Iskandar, 1998).

Although East Javan harvesters mentioned the occurrence of stream frogs that match the description of *Limnonectes macrodon*, the surveys in East Java were carried out during dry periods in which most streams were at low levels, and considered by harvesters as unsuitable periods for harvesting stream frogs. Thus, this species was not sighted in markets or in the catches of frog harvesters in East Java. Additional analysis of specimens in the Zoology Museum in Bogor revealed no specimens of this species from East Java. Iskandar (1998) mentioned that this species is endemic in Java and could also be found in southern Sumatra. There are several possible explanations for the absence of this species from museum and frog-harvester collections: the species may occur in East Java but simply not have been encountered in the surveys under discussion, or by museum collectors, or, species traded in East Java could be other species from the same family.

It is not clear from the statistics which species are taken for the frogs' legs trade or in what numbers. As the frogs' legs are usually exported without their skins, the species are difficult to identify. Even if they were identified, the documentation in export papers may be incorrect (Veith *et al.*, 2000). The species that are harvested are likely to vary among locations. As an archipelago, Indonesia consists of several large islands, each with its own unique fauna. There is a possibility that frog species taken from outside Java could be species other than the four already mentioned above.

Although more than 20 years have passed since *Rana catesbeiana* was introduced to Indonesia for frog farming, there is no indication that bullfrog farming has succeeded. It appears that most supplies of frogs' legs derive from frogs taken in natural habitat rather than produced in frog farms. From an ecological point of view, the introduction of bullfrogs to Indonesia was unwise. *Rana catesbeiana* is a predator and is known to prey on local frogs where it has been translocated in the USA, and is implicated in the decline of populations of some frog species (Moyle, 1973; Hayes and Jennings, 1986; Lanoo, *et al.*, 1994; Lawler *et al.*, 1999). There is no evidence that *Rana catesbeiana* has become established in the wild in Indonesia, although Iskandar (1998) mentioned that this could happen. This species was not seen during the course of this study. However, apparent lack of control of frogs by frog farmers makes it possible that this frog may spread into natural habitats. Two harvesters from Sukabumi indicated that they had found



bullfrogs in rice fields at least once. It is also possible that this frog may spread diseases to wild frogs. Mazzoni *et al.* (2003) found mass mortality caused by *chytridiomycosis* in farmed *Rana catesbeiana* in South America.

While some exported frogs were probably transported between islands, it is likely that almost all originated on the island where each exporting company operates. This is mainly to ensure a continuing supply of fresh frogs and lower transportation costs. Even assuming that 20% of frogs from Java could have originated from other nearby islands, data analyses still show that harvest from Java is always bigger than that of Sumatra. The greater number of frogs taken from Java is likely to be correlated with the fact that Java has the largest area of rice fields of all Indonesia's islands, which are the most suitable habitat for edible frogs and the areas most accessible to frog hunters.

Based on the findings of this study, the major European importer of Indonesia's frogs' legs since 1988 has been Belgium and Luxembourg, although Patel (1993) found that France was the principal recipient of Indonesia's frogs' legs exports before the 1990s. Data show that frogs caught for export purposes rose significantly between 1969 and 1988. In 1985 two edible frog species from India and Bangladesh (*Rana hexadactyla* and *Rana tigerina*) were included in CITES Appendix II owing to the decline in their populations (Abdulali, 1985; Pandian and Marian, 1986; Dash and Mahanta,



1993). Comparison of export data of Indonesian frogs' legs with those for India and Bangladesh shows that Indonesian exports rose markedly as exports from Bangladesh and India decreased, as suggested by Schmuck (2000b).

Because the majority of the Indonesian population are Muslims (85% based on a 2002 census) and Islam forbids the consumption of amphibian meat, frogs' legs are not a major food for Indonesians. Assuming that most of the remaining 15% (non-Muslim) of the 234 million people in Indonesia (BPS, 2002) do eat frog meat, the domestic market may still be substantial, with up to 35 million potential consumers. Still, almost half of non-Muslim Indonesians are ethnic Chinese and, based on interviews and market surveys, like to eat more frog meat than other non-Muslims. The estimation that higher numbers of frog are harvested for domestic markets means that attempts to regulate the harvest of frogs' legs will be impossible without acknowledging the already established domestic market for frogs' legs and the stakeholders. Harvesting occurs on almost all Indonesian islands, making law enforcement difficult. Even if an export quota were set, controlling the domestic market will be complicated and most likely will not succeed. The majority of harvesters are uneducated and poor and will not accept quotas or acquiesce if the practice of harvesting frogs - which has provided livelihoods for many years and is not objected to by most rice field owners - is controlled or stopped by the government.

It is clear from the surveys that frog harvests are economically important. There is always a high influx of new harvesters and traders and there is obviously increased competition among harvesters and middlemen. This is likely to lead to declines of frog populations if it continues. However, it is unclear whether edible frog populations in Indonesia, especially in Java, are in decline. Interviews did indicate that lower numbers of frogs were caught by each harvester and traded by each middleman, however this could reflect stable frog populations and total harvesting rates, spread across an increased number of harvesters and traders.

Data from India suggest that the number taken for export before the ban in that country was around 60 million individuals a year (Pandian and Marian, 1986). Although the total estimate ranges widely (Table 6), it suggests that the annual mean number of frogs harvested in Indonesia is larger than it was in India. This does not necessarily mean that the Indonesian species are threatened by harvesting. They differ in breeding regimes, environmental conditions, and available area of habitat.

Few data are available on the biology, conservation status, and rates of harvesting of Indonesian edible frogs. Although there was concern that *Fejervarya cancrivora* seems to be hard to find in some rice fields (Schmuck, 2000a; Veith *et al.*, 2000), it is difficult to say that the species had declined in some areas considering that *F. cancrivora* is difficult to catch and moves to other rice fields, especially during dry periods. A population study of *F. cancrivora* in West Java showed that the populations are relatively large (39.76 individuals/ha) and there is an indication that the low capture rates of this species

reflect its ability to avoid capture, rather than indicating low population sizes (Kusrini, unpublished data).

Both *Fejervarya cancrivora* and *Limnonectes macrodon* have a high reproductive rate and breed all year long (Sugiri, 1979; Premo, 1985; Jaafar, 1994). *Fejervarya cancrivora* thrives best in man-made habitat - in this case, rice fields. It is found most abundantly in rice fields rather than natural habitat such as ponds and streams. It has the ability to survive the harsh conditions of rice fields where it thrives along with *F. limnocharis* (Kusrini, unpublished data). Although it could not be said that the rice fields are a specialized place for the captive breeding of frogs, it is obvious that humans have provided a suitable non-natural breeding habitat for this species. Thus, a large population of *F. cancrivora* is assured with the availability of rice fields.

During the last four years for which data were available (1999 to 2002), the level of exports of frogs' legs declined slightly. This decline does not necessarily indicate declining harvests, but may reflect a shift from international to domestic markets, or a reduction in international demand. Domestic markets offer a simpler structure, with no limits on the size of frog and the possibility of a greater profit to middlemen than is provided by international markets. Because of the unregulated nature of this product, the size of individual frogs taken is governed by market demand. Smaller frogs are acceptable in the domestic market and are more plentiful than larger frogs: the smaller species like *Fejervarya limnocharis* and some of the smaller-sized, subadult specimens of *F. cancrivora* are easier to harvest and their availability in the field is not as dependent on the season as is the case with *Limnonectes macrodon*, which is rare during the dry season. Furthermore, middlemen also sell large frogs to customers in the domestic market and to restaurateurs. The incentives derived from selling large frogs to local markets are the same as those gained from selling to exporters, but without the added cost of transportation to factory or ice packing, for example. Thus the middleman profits more from focusing on domestic trade, and selling large and small frogs.

While this study focuses on the trade from Java island, the results are likely to give the overall picture of frogs' legs trade in Indonesia. Specimens are harvested mostly from rice fields, where they are at their most abundant and access for hunters is easier, or from areas near human habitation, rather than forested areas. The same trend is probably true for other islands. It is recommended that monitoring of the frogs' legs trade should occur not only in Java but also from other mainlands, especially Sumatra.

This study indicates that most harvest of frogs in Indonesia for export purposes occurs in Java. The island comprises less than 10% of the total area of Indonesia and yet contains sixty percent of the nation's population. The demand for land for development makes Java's rice fields vulnerable to change (Whitten *et al.*, 1997). Faced with the likelihood of reduced rice fields in Java in the future, the harvest for export will doubtless shift to other islands, such as Sumatra, Bali, Kalimantan and Sulawesi.

ACKNOWLEDGEMENTS

The Australian Development Scholarship, Wildlife Conservation Society, James Cook University Internal Resources Allocation Fund, Bogor Agricultural University and Indonesian Reptile and Amphibian Trader Association (IRATA) provided funding for air transport, local travel and other research expenses in Indonesia. Additional funding was received from subcontracts to Ross A. Alford from US National Science Foundation Integrated Research Challenges in Environmental Biology grants IBN-9977063 and DEB-0213851 (J.P. Collins, Principal Investigator). The authors would like to thank Ani Mardiasuti, Djoko T. Iskandar, Tonny Soehartono and George Saputra for support and advice, and ibu Mumpuni for access to Museum Zoologicum Bogoriense collections. The authors are grateful to Yoshiko Hikariati who assisted the authors in collecting data from the library of the Statistical Bureau of Indonesia. Anisa Fitri, Sudrajat, Reddy Rachmady, Ian Budarto, Dede M. Nasir, Sumantri Radyansah, Hijrah Utama and Ita Novitasari are also thanked for their assistance. Ani Mardiasuti and Tonny Soehartono kindly reviewed an early draft of this manuscript. Special thanks go to Wanto, a frog trader in Caringin, West Java, who kindly introduced the first author to the world of frog harvesting.

REFERENCES

- Abdulali, H. (1985). On the export of frog legs from India. *Journal of the Bombay Natural History Society* 2:347-375.
- Alcala, A.C. (1962). Breeding behaviour and early development of frogs of Negros, Philippine Islands. *Copeia* 1962(4):679-726.
- Barfield, S. (1986). Indonesia's frog legs. *Journal of Environmental Health* 48(6):324.
- Berry, P.Y. (1975). *The amphibian fauna of peninsular Malaysia*. Tropical Press, Kuala Lumpur.
- Biro Pusat Statistik (BPS) (1969-2002). Statistik Perdagangan luar negeri Indonesia (Indonesian foreign trade statistics) Vols I and II. Biro Pusat Statistik Indonesia, Jakarta.
- Biro Pusat Statistik (BPS) (2000). Survey Pertanian: Luas Lahan Menurut Penggunaannya di Jawa. *Agricultural Survey Land Area by Utilization in Java*. Biro Pusat Statistik, Jakarta.
- Biro Pusat Statistik (BPS) (2002). Statistik Kesejahteraan Rakyat: Survey Sosial Ekonomi Nasional. Biro Pusat Statistik, Jakarta.
- Church, G. (1960). The effects of seasonal and lunar changes on the breeding pattern of the edible Javanese frog, *Rana cancrivora* Gravenhorst. *Treubia* 25(2):215-233.
- Dash, M.C. and Mahanta, J.K. (1993). Quantitative analysis of the community structure of tropical amphibian assemblages and its significance to conservation. *Journal of Bioscience* 18(1):121-139.
- Directorate General of Fisheries (DGF) (1999). *Program peningkatan ekspor hasil perikanan 2003 (A programme to boost fisheries export 2003)*. Jakarta, Indonesia, Ministry of Fisheries. Directorate General of Fisheries.
- Hayes, M.P. and Jennings, M.R. (1986). Decline of ranid frog species in western North America: are bullfrogs (*Rana catesbeiana*) responsible? *Journal of Herpetology* 20:490-509.
- Iskandar, D.T. (1998). *Amfibi Jawa dan Bali*. Puslitbang Biologi-LIPI, Jakarta.
- IUCN (2004). *2004 IUCN Red List of Threatened Species*. www.iucnredlist.org.
- Jaafar, I.H. (1994). The life history, population and feeding biology of two paddy field frogs, *Rana cancrivora* Gravenhorst and *R. limnocharis* boie, in Malaysia. Ph.D. thesis. Faculty of Science and Environmental Studies, University Pertanian Malaysia, Malaysia.
- Jennings, M.R. and Hayes, M.P. (1985). Pre-1900 overharvest of California red-legged frogs (*Rana aurora draytonii*): the inducement for bullfrog (*Rana catesbeiana*) introduction. *Herpetologica* 41:94-103.
- Lanoo, M.J., Lang, K., Waltz, T., and Phillips, G.S. (1994). An altered amphibian assemblage: Dickinson county, Iowa, seventy years after Frank Blanchard's survey. *American Midland Naturalist* 131:311-319.
- Lawler, S.P., Drits, D., Strange, T., and Holyoak, M. (1999). Effects of introduced mosquitofish and bullfrogs on the threatened California red-legged frog. *Conservation Biology* 13(3):613-622.
- Martens, H. (1991). Trade in frog legs of wild SE Asian rana species: Some facts and considerations. Scientific Authorities of CITES, Germany.
- Martin, R.E. (2000). Other aquatic life of economic significance: frogs and frog legs. In: Martin, R.E., Carter, E.P., Flick, G.J.J. and Davis, L.M. (Eds). *Marine and Freshwater Products Handbook*: Technomic Pub. Co. Inc., Lancaster. Pp.279-287.
- Mazzoni, R., Cunningham, A.A., Daszak, P., Apolo, A., Perdomo, E. and Speranza, G. (2003). Emerging pathogen of wild amphibians in frogs (*Rana catesbeiana*) farmed for international trade. *Emerging Infectious Diseases* [serial online] Aug 2003. www.cdc.gov/ncidod/EID/vol9no8/03-0030.htm
- Ministry of Agriculture (1993). Pedoman teknis pemanfaatan dan pengolahan paha kodok beku. Badan Penelitian dan Pengembangan Pertanian Pusat Penelitian dan Pengembangan Perikanan.
- Ministry of Fisheries (2000). Profil perusahaan pengolahan dan eksportir hasil perikanan Indonesia. 2000. Jakarta, Departemen Eksplorasi Laut dan Perikanan Direktorat Jenderal Perikanan.
- Moyle, P.B. (1973). Effects of introduced bullfrogs, *Rana catesbeiana*, on the native frogs of the San Joaquin Valley, California. *Copeia* 1973:18-22.
- Niekisch, M. (1986). The international trade in frogs' legs. *TRAFFIC Bulletin* 8(1):7-10.
- Paltridge, R. and Nano, T. (2001). Digging for frogs in the Tanami desert. *Australian Geographic* (January-March 2001):25-26.
- Pandian, T.J. and Marian, M.P. (1986). Production and utilization of frogs: an ecological view. *Proceedings of the Indian Academy of Sciences (Animal Sciences)*, 95(3):289-301.
- Patel, T. (1993). French may eat Indonesia out of frogs. *New Scientist*. 1868:7.
- Premo, D.B. (1985). The reproductive ecology of a Ranid frog community in pond habitats of West Java, Indonesia. Ph.D. Dissertation. Department of Zoology, Michigan State University.
- Schmuck, J. (2000a). Amphibians in human nutrition. In: *The Encyclopedia of Amphibians*. (Ed. R. Hofrichter). Pp.214-217. Key Porter Books Limited, Ontario.
- Schmuck, J. (2000b). Trade and species conservation. In: *The Encyclopedia of Amphibians*. (Ed. R. Hofrichter). Pp.214-217. Key Porter Books Limited, Ontario.
- Sugiri, N. (1979). Beberapa aspek biologi kodok batu (*Rana blythi*) Boulenger, Ranidae, (anura-amphibia) di beberapa wilayah Indonesia dan kedudukan taksanya. Ph.D. Dissertation. Fakultas Pasca Sarjana, Institut Pertanian Bogor, Bogor.
- Susanto, H. (1989). *Budidaya kodok unggul*. Jakarta, Penebar Swadaya.
- Szillard, N. and Csengele, K. (2001). Amphibian harvesting in Romania. *FROGLOG* (44).
- Török, Z. (2003). Action plan for sustainable exploitation of *Rana ridibunda* stocks from the Danube delta biosphere reserve (Romania). *FROGLOG* (60).
- Truong, N.Q. (2000). Amphibian uses in Vietnam. *FROGLOG* (38).
- Veith, M., Kosuch, J., Feldmann, R., Martens, H. and Seitz, A. (2000). A test for correct species declaration of frog leg imports from Indonesia into the European Union. *Biodiversity and Conservation* 9:333-341.
- Vredenburg, V., Wang, Y. and Feller, G. (2000). Scientific meeting raises awareness of amphibian decline in Asia. *FROGLOG* (42).

Mirza D. Kusrini School of Tropical Biology,
James Cook University, Townsville 4811, Queensland,
Australia, and Department of Forest Resources Conservation,
Faculty of Forestry, Bogor Agricultural University, Indonesia.
E-mail: mirza_kusrini@yahoo.com

Ross A. Alford School of Tropical Biology,
James Cook University, Townsville 4811, Queensland,
Australia. E-mail: ross.alford@jcu.edu.au