PREDICTING THE IMPACT OF THE FROG LEG TRADE IN INDONESIA: an ecological view of the indonesian frog leg trade, emphasizing javanese edible frog species

Mirza Dikari Kusrini

PhD candidate, School of Tropical Biology, James Cook University, Qld 4811 AUSTRALIA.
Email : mirza.kusrini@jcu.edu.au
Lecturer, Department of Forest Resources Conservation, Faculty of Forestry, Bogor Agricultural University, PO Box 168, Bogor 16000, Indonesia

Abstract: This paper summarises two years of progress in my research on the Indonesian frog leg harvest. I take an ecological view of the frog leg trade, concentrating on Javanese edible frog species *(Fejervarya limnocharis,* F. *cancrivora* and *Limnonectes macrodon).* Market surveys were conducted in Jakarta, West Java and East Java to gather information on species traded and collected in the island of Java. In this paper, I present my methods and preliminary results on: 1) distribution and population status of the species and (2) other environmental conditions that might affect the populations of these species.

Keywords: frog leg trade, Indonesia, wildlife harvest, wildlife utilization

Pendugaan dampak perdagangan kaki katak di Indonesia: sebuah kajian ekologis dari perdagangan kaki katak, dengan tekanan pada jenis-jenis katak yang dapat dikonsumsi dari Jawa.

Abstrak : Tulisan ini mengetengahkan hasil awal penelitian tentang pemanenan katak konsumsi dilihat dari segi ekologi, terutama untuk jenis-jenis yang dipanen dari Pulau Jawa (Fejervarya limnocharis, F. cancrivora and Limnonectes macrodon). Survei pasar dilakukan di Jakarta, Jawa Barat dan Jawa Timur untuk memperoleh informasi mengenai jenis yang dijual dan ditangkap di Pulau Jawa. Tulisan ini juga mengulas metoda yang digunakan serta hasil awal tentang : 1) penyebaran dan status populasi spesies serta (2) kondisi lingkungan yang diduga dapat mempengaruhi populasi dari ketiga spesies tersebut.

Kata kunci: perdagangan katak, pemanenan, Indonesia, pemanenan satwa liar, pemanfaatan satwa liar

Kusrini, M.D., A. Mardiashtti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

INTRODUCTION

The utilization of frog legs as food and the possibility that this harvest may have contributed to declines in several frog species have been discussed in several previous reports (Alford and Richards, 1999; Jenning and Hayes, 1985; Patel, 1993; Schmuck, 2000a). Indonesia has exported frogs to many countries since 1969 with increasing production in the last decade (Susanto, 1989; Kusrini, 2003a). The number of frog legs exported is very high, for instance, the mean annual quantity of frog legs exported during the period 1991-2000 is 4,125 tons or around 9,593,023 frogs sacrificed each year (Kusrini, 2003a). Critics have targeted the Indonesian frog legs trade (Barfield, 1986; Bazilescu, 1997; Patel, 1993; Schmuck, 2000). This criticism is based on research in India and Bangladesh, where the authors pointed out that the frog leg trade decreased the standing populations of frogs and led the increasing use of pesticides because of the loss of frogs role as biological controls (Abdulali, 1985; Barfield, 1986; Oza, 1994).

Despite the growing interest concerning the frog leg trade in Indonesia, no comprehensive research has been done on the extent and effects of this trade. Analysis of frog export data has shown that more than half of frog legs exported probably come from Java (Kusrini, 2003), a relatively small island which has a high human population density and a major place in Indonesian political and socio-economic life. I am presently carrying out research on the frog leg trade in Java, with the aim of assessing whether the current level of frog leg harvesting is sustainable, especially in West Java. However, before attempting to model the sustainability of the harvest, several important questions must be addressed, 1) how many species are traded and which species are the most collected, especially in Java, 2) where do the species occur and what is their population status, and 3) are the population sizes of these species being affected by environmental conditions other than harvesting? The present paper summarizes two years of progress towards these answering these questions.

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

STUDY AREA

Observations on frogs traded were made by visiting several markets and exporters in Jakarta, West Java province (Bogor and Sukabumi) and East Java provinces (Mojokerto, Pasuruan, Madiun, and Surabaya). Information regarding species traded, habitat and distribution are taken from literature reviews, specimens' information at the Museum of Zoology Bogor, and trader information. Based on this information I selected two main habitats to observe, paddy fields and streams. Six sites in paddy fields in West Java (Karawang, Subang and Bogor) were selected for population studies. The sites are non-terraced, lowland paddy fields (less than 500 m elevation). Three streams in the Bogor district (Caringin and Ciapus) were selected as representative of areas commonly used by professional catchers to hunt *L. macrodon*. Three other streams were selected within protected areas (Cilember, Mount Walat and Cisaketi) that are subjected to low or no frog hunting. From these streams, two locations in Ciapus and Cilember (one with high levels and one with low levels of frog hunting) were selected for a year long detailed population and ecology study.

METHODS

At each paddy field site, a number of plot (block size depended on the length and width of borders) was sampled for 3 days in a row, twice in one planting season. Frogs in each site were captured by hand and then marked by clipping their toes. For every frog captured, I recorded capture date, plot number, time, location on the plot, sex, body size, mass, clip code and also environmental data such as water level, water temperature, substrate temperature, percentage of cloud cover and relative humidity. After marking, frogs were released. On the second and third days of surveys, marked frogs were noted and unmarked frogs were marked.

To check for sampling bias in paddy field surveys (since frogs are caught mostly when they are within 0.5 m from the borders), during the 2002

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

second sampling I sampled frogs in Caringin simultaneously by catching all frogs found within 50 cm perimeters from the borders and catching all frogs encountered inside the square. Due to a limited workforce, we only managed to sample 2 blocks thoroughly from the total 4 blocks. Frogs were treated the same as in the first sampling, by marking and releasing them afterward for 3 consecutive nights.

The occurrence and abundance of stream species was studied in streams subjected to heavy frog hunting and streams with low or no known frog hunting. A 400 m transect was established at each location. At each location, surveys were done 2 nights in a row each month. I recorded data on each individual of *L. macrodon* found. The SVL, sex (if possible), weight, microhabitat, position along transect, and behaviour of each individual was noted, and measurements of environmental conditions (water, air and substrate temperatures, and humidity) at the time of capture will be recorded. Frogs are marked based on the Hero (1989) numbering system and then released. The four other locations were surveyed twice within the year, during the dry and wet seasons.

PRELIMINARY RESULT

1. Species in trade

The number of species involved in the Indonesian frog leg trade is not clear. A report by Schmuck (2000) indicated that 14 species of Indonesian frogs are involved in the frog leg trade, plus as many as 10 other species of South East Asian origin that may possibly come from Indonesia (see Table 1). However, some of the frogs mentioned in this table are probably not used for the export market because the size of the frogs. Local markets usually demand live frogs, as such, the outward appearance of frogs is important. Interviews with local trader revealed that species such as *Rana hosii* which has glands that smell and *L. kuhlii* which has wrinkled skin, are not traded for this reason.

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

Table 1. Indonesian's edible frog species and their endangered status +

Species	Local Consumption in	Exported to	Population	Comments
Fejervarya cancrivora	Indonesia, Malaysia, Philippines	Europe, America	at risk	
F. limnocharis	Thailand, Philippine, Bangladesh, India, Indonesia	Europe, America	at risk	Not possible for export, too small
Limnonectes blythii	Indonesia, Malaysia	Europe, America	at risk	
L. grunniens	Indonesia	Europe, America		
L. ibanorum	Indonesia	Europe, America	at risk	
L. ingeri	Indonesia, Malaysia	Europe, America	endangered	
L. kuhlii	Indonesia	Europe, America	at risk	Outward skin appearance not like by consumer in Java
L. macrodon	Indonesia	Europe, America	endangered	Endemic Java
L. paramacrodon	Indonesia	Europe, America	endangered	
R. arfaki	Indonesia	Europe, America	-	
R. catesbiana	USA, Indonesia	Europe	at risk	Cultured in Indonesia
*R. magna**	Indonesia, Phillipines	Europe, America	-	
*R. malesiana**	Indonesia	Europe, America	-	
R. miopus	Indonesia	Europe, America	-	
R. erythraea	South East Asia	-	-	Common in Java but not found in the market
R. glandulosa	South East Asia	-	-	
R. hosii	South East Asia	-	-	Have glands in skin, probably not edible
R. livida	South East Asia	-	-	
R. nigromaculata	South East Asia	-	-	
L. raja	South East Asia	-	-	
Paa. liebigii	South East Asia	-	-	
P. spinosa	South East Asia	-	-	
P. sternosignata	South East Asia	-	-	
Rana andersonii	South East Asia	-	-	

*the taxonomic status of these species has changed in recent years

** comment is not in the original table, put by the author

+ adapted from Schmuck, 2000.

Most authors have reported that the common edible frogs of Indonesia usually consist of *Fejevarya cancrivora, F. limnocharis, Limnonectes macrodon* and an introduced species *Rana catesbeiana* (Berry, 1975; Church, 1960; Iskandar, 1998; Susanto, 1989). This picture can become

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

more complicated because of changes in taxonomy. To prevent this, all species names mentioned here are those used by Iskandar& Colijn (2001). Another source of difficulty is that species names on export documentation are unreliable. For instance, Veith, et al. (2000) performed DNA analyses to compare imported frog legs from Java and Sumatra with frozen tissues of Indonesian Ranid species. The result showed that four species, documented as *L. macrodon, F. cancrivora, F. limnocharis* and *Rana catesbiana,* were in fact *F. cancrivora.*

Based on my market surveys, frogs sold usually consist of *Fejervarya cancrivora, F. limnocharis* and *Limnonectes macrodon.* I rarely saw *Rana catesbeiana* in local markets; only one supermarket in Jakarta (Ranch 99) sold bullfrogs. *Fejervarya cancrivora* and *Limnonectes macrodon* are usually sold by number rather than by weight. Local consumers select frogs while they are still alive. The trader either supplies them live or butchers them for the consumer and supplies only the legs. Small frogs such as *F. limnocharis* are also usually sold alive by number for fish food or are sold by weight as skinless frog legs.

Frogs exported consist of *F. cancrivora, L. macrodon* and sometimes *Rana catesbeiana.* Most of the frogs sent by the big collectors (who usually have several frog hunters) to exporters are already in the form of skinless frog legs. Exporters maintain quality control, which in some case leads to the rejection of frog legs that show bruise marks or have evidence of salmonella.

1. The habitat and distribution of Javanese edible frogs

Fejervarya cancrivora and *F. limnocharis* are the two most common frogs found in rice fields. They are also found in streams, ponds, ditches, and swamps in non-forested areas and are most common in habitats associated with humans (Alcala, 1962; Berry, 1975; Church; 1960; Iskandar, 1998). They are distributed widely in Asia (Frost, 1985). *Limnonectes macrodon* mostly lives near rivers or in small streams (Iskandar, 1998). The distribution of *L. macrodon* is from Burma to

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

Malaya,Thailand and Malaysia; Java and Sumatra (Indonesia), and the Rioux Archipelago (Frost, 1985). In Indonesia this species is considered endemic in Java, but also found in Lampung, South Sumatera. There is some confusion about the identity of this species; most specimens reported as *L. macrodon* from outside Java actually belong to other species (Iskandar, 1998).

Spatial model analysis allows wildlife managers to model geographic distributions and habitat use, and to detect changes in these patterns over time. Geographic Information Systems (GIS) have become an important tool in studies of ecology and wildlife habitat use (Ji-Wei and Clinton 2000). Habitat suitability models for amphibian has been used for several years in the USA, for instance the California Gap Analysis project in the 90's (Scott, et al., 1993). In Indonesia, the use of GIS for wildlife is mostly focused on large mammals (Nyhus, et al., 2000). I will use spatial analysis to produce distribution maps of edible frog species in Sukabumi based on their ecological requirements. I will produce predicted distribution maps for *F. limnocharis, F. cancrivora* and *L. macrodon* by analysing layers of habitat (taken from Landsat TM), elevation (taken from Digital Elevation Model) and data from my ground truth study.

Iskandar (1998) mentioned that both *Fejervarya cancrivora* and *F. limnocharis* can be found up to 700 m. My preliminary research in 5 paddy fields in West Java suggests that *F. cancrivora* is more abundant at lower elevations than *F. limnocahris* and was not found at elevation higher than 800 m above sea level (Kusrini, 2002). Other than that, detailed museum specimen data (if available) will also be used to obtain data on the elevational range of the species.

Landsat Thematic Mapper (TM) images were utilized to map the land user cover of Sukabumi. The most recent and good quality TM available is 21 May 2001 which contains less than 10% clouds. Various layer of map are also digitized from 33 topographic maps (1: 25,000) to produce a digital elevation model and a layer of roads and river systems. Figure 1

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

summarizes the approach used to produce the map. Result of this study will be reported elsewhere.

To produce distribution maps for the three species in Indonesia, I will attempt to georeference specimens stored at Museum of Zoology Bogor. However, this study is not finished.

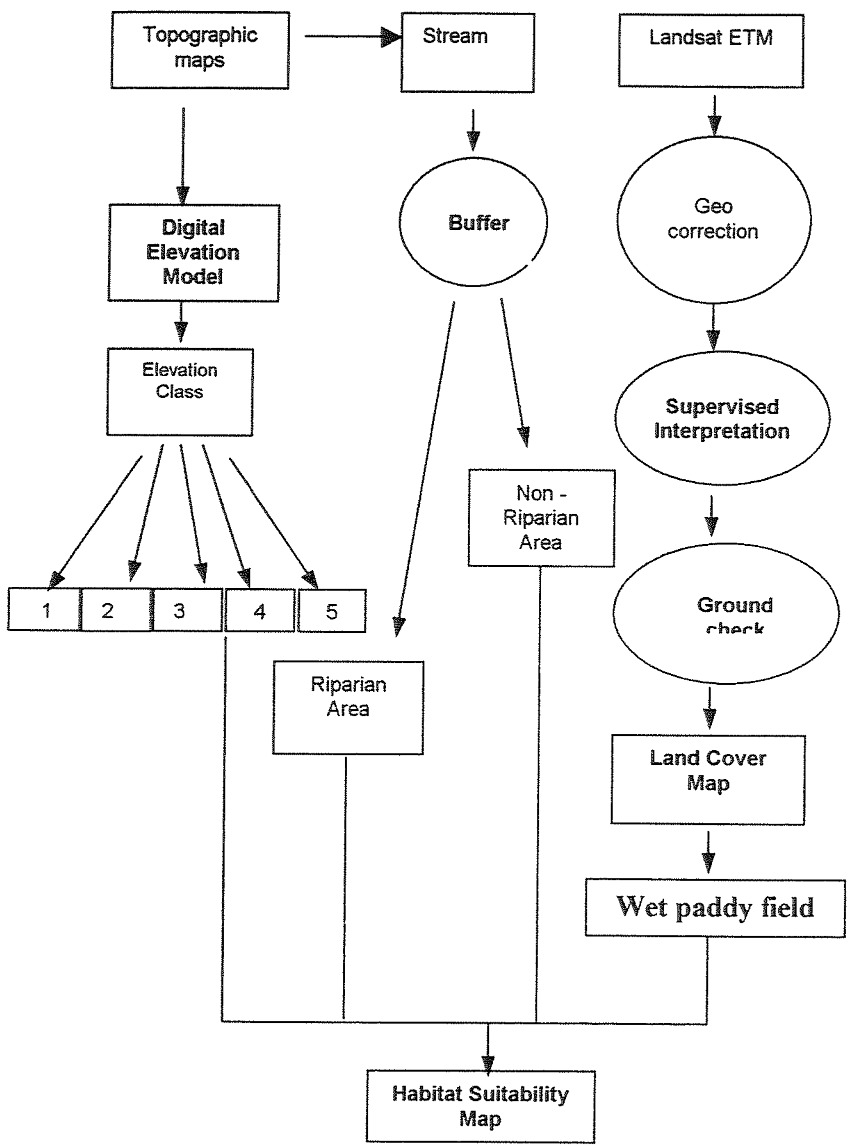

Figure 1. Framework to model habitat suitability of Javanese edible frog

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

3. *Population status of the three species of edible frogs*

In total, 2142 frogs from 7 species were sampled in paddy fields during 2002. The most abundant species were *F. limnocharis* (84,9%) and *F. cancrivora* (11,4%). *Occidozyga lima was* the third most abundant species found in paddy fields (3,2%). *Bufo melanostictus, Bufo asper, Bufo biporcatus* and *Polypedates leucomystax* are rarely found with the last three species found only once each.

Table 2. Traits of *F. limnocharis* among sites in 2002

Location	Sex	N	SVL (cm)				Mass (gr)			
			min	max	x	SD	min	max	x	SD
Caringin	Female	587	18.42	53.63	31.11	7.25	.80	14.70	2.99	2.34
	Male	294	21.66	52.50	38.82	5.02	1.00	12.30	4.85	1.50
	Juvenile	67	12.05	25.50	20.43	2.36	.35	1.40	.77	.20
Sawah Baru	Female	126	20.00	54.00	36.40	8.48	1.30	17.40	5.10	3.25
	Male	95	28.12	50.00	40.87	4.723	2.40	11.00	5.73	1.43
	Juvenile	11	7.00	23.00	16.45	5.39	.10	.80	.45	.19
Subang Non Pesticide	Female	103	20.00	49.12	27.23	5.17	.70	5.50	1.61	.89
	Male	45	19.50	46.31	28.61	5.79	.70	8.40	2.27	1.57
	Juvenile	143	11.00	24.98	18.99	2.92	.10	1.40	.63	.29
Subang Pesticide	Female	74	21.90	41.22	30.22	4.77	1.00	4.85	2.21	.987
	Male	13	18.00	42.36	33.76	7.93	.80	4.65	2.70	1.53
	Juvenile	41	10.50	24.72	17.21	4.33	.10	1.50	.57	.37
Karawang Non pesticide	Female	44	20.84	45.06	30.36	6.65	.80	7.70	2.50	1.66
	Male	7	26.00	35.30	30.83	3.24	1.35	3.20	2.39	.71
	Juvenile	5	19.30	20.73	19.82	.61	.60	1.30	.83	.27
Karawang Pesticide	Female	63	21.65	44.13	31.59	6.97	1.00	7.80	3.28	2.01
	Male	43	24.06	44.50	34.92	44.03	1.10	8.40	3.86	1.47
	Juvenile	30	10.52	26.46	19.33	3.03	.25	1.10	.65	.24

Demographic analysis of *F. limnocharis* was conducted for 6 sites in 2002. Table 2 summarises the traits of *F. limncharis* found in wet ricefields or *sawah*. More juveniles were found in the first sampling period than in the second sampling period. The first sampling period was during *sawah* preparation time, when farmers planted seed. The *sawah* are usually still flooded at this time. In the second sampling period, most *sawah* were near harvest or were already harvested and dried. It appears that

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

breeding by *F. limnocharis* coincides with the period of maximum water level in *sawah.*

Sampling comparing the results when entire plots were sampled intensely with those obtained from sampling around the plot border revealed that sampling on the border only accounted for approximately 1/3 of all frogs. Demographical traits for *F. cancrivora* are still being analysed. Mark-recapture data will be analysed using program MARK to estimate population and survival rate.

Limnonectes macrodon is a shy animal and hard to catch. Because the frog is big and has a distinctive posture that differentiates it from other large stream species (e.g., *Bufo asper*), it is possible to spot this species without actually catching it. Figure 2 summarizes the occurrence of this species in the Cilember over 12 months. Mark recapture data from the Cilember and Ciapus streams will be analysed using the program MARK and will be reported elsewhere.

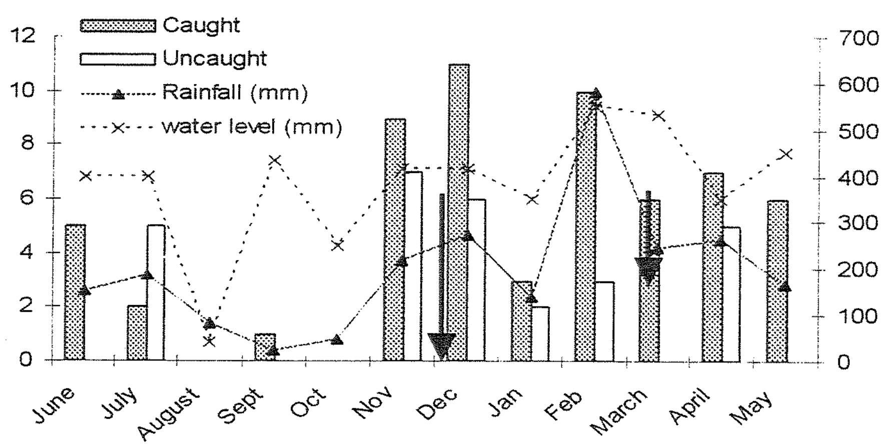

Figure 2. *Limnonectes macrodon* occurence in the Cilember stream. Park management cleared grass area within transect 0-100m during October 2002 and January 2003

3. *Other factors that may contribute to edible frog declines*

Several factors other than harvest may contribute to the decline of edible frogs. These include pesticide use, the introduction of *Rana catesbeiana,*

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

and diseases. Indonesia is well known as a country with one of the highest uses of pesticides. The high use of pesticides tends to increase in conjunction with the government's ambition to improve rice production in the country, which has led to the emergence of pesticide resistant pests such as the brown planthopper (Settle, et al., 1996; Van der Eng, 1994).

The increased use of pesticide in the world has led many scientists to believe that this is one of the factors that has led to many declines and disappearances of frogs. Concern regarding the positive feedback between frog hunting and pesticide use has been voiced a number of times by Abdulali (1985), Barfield (1985), Jaques (1999) Oza (1990) and Pandian and Marian (1985). Harvesting of frog legs can cause populations of pests to increase; this in turn will lead to higher use of pesticides. The result will be greater rates of disappearance of frogs.

The impact of pesticides on frogs has been documented by many authors such as Berrill, et al., 1998; Boone and Semlitsch, 2001; Mohanti-Hejmadi and Dutta, 1981. Most of the research has been conducted in temperate regions, and none has been done in Indonesia. Pesticides were also suspected as one of the causes of deformities found in frogs around the world (Oulett, et al., 1997; Helgen et al., 1998) although recent evidence suggests that parasites may cause many of these deformities (Kaiser, 1999). Parasitic copepods were found on tadpoles of West Java *Rana chalconota* with limb deformities (Leong, 2001).

A small number of deformed frogs were found on one night census of edible frogs from Sukabumi – Bogor in September 2001 (Kusrini, 2002). A small percentage of deformed frogs are also found in paddy fields (Kusrini, 2003b). Types of deformities found are mostly absence of all or part of a limb (ectromelia) and digit (ectrodactyly), which correspond with the findings of Ouellet, et al. (1997) in agricultural areas in Canada. Soil, water and frog tissue samples from 6 paddy fields were taken to assess the pesticide contents. The result will be reported elsewhere.

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

As in other wildlife, frogs are also exposed to various pathogens. Disease in amphibians has recently become a centre of attention, with recent investigation of emerging diseases like chytridiomycosis and ranaviral disease linked to frog population declines (Berger, et al., 1998; Daszak, et al., 1999). Stresses caused by predators or environmental toxicants are believed to increase frogs' susceptibility to diseases (Carey and Bryant, 1995; Thieman, 2000, Relyea and Mills, 2001). Recent research in Uruguay has shown that bullfrog farming was hit during the late 1990s by mass death which may have been caused by chytridiomycosis (Mazzoni et al., 2003). The Indonesian government through its aquaculture research centre in Sukabumi introduced *Rana catesbeiana*, the north american bullfrog, in 1983 to help meet the demand for frog legs. The introduction was considered a success and this species is now been distributed to other areas strictly for culturing (Arie, 1999). However, there are no studies on *Rana catesbiana* diseases or the impact of the introduction of *Rana catesbiana* on Indonesian native frogs. It is possible that this species may threaten native species either as a predator or vector of disease, as forewarned by Iskandar (1998).

One of the techniques to detect stress in wildlife is to measure fluctuating asymmetry (Palmer and Strobeck, 1986; Alford, et al., 1999). This method has been used to detect stress in various species from mammals to insects (Soule and Baker, 1968; Pankakoski, 1985; Clarke, 1994; Tsubaki 1998). I measured left and right limbs of frogs both from paddy fields and streams to detect any changes on levels of fluctuating asymmetry that may result from stress. In addition, toe clips taken from mark-recapture study are used to diagnosis possible infections by the amphibian chytrid fungus. The result of the study will be reported elsewhere.

ACKNOWLEDGEMENTS:

The research is made possible by funding support from Australian Development Scholarship 2001-2005, Indonesian Reptile Trader Association (2001-2003), James Cook University IRA Fund and IRA

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

Supplementary Fund (2002-2003), Research Office Bogor Agricultural University (2002), Wildlife Conservation Society-Research Fellowship Program Summer 2002 for Mirza D. Kusrini. I wish to thank Ross Alford of JCU Australia for advice and supervision and various people in Indonesia: George Saputra (IRATA), Ani Mardiastuti & Pakpahan family (Bogor), Lilik B. Prasetjo and GIS lab Faculty of Forestry (IPB), Asep Nugraha (Toxicology Lab, Bogor), Joko T. Iskandar (ITB), Mumpuni (MZB), Iwan Azof & Unocal, Kang Karmo & Kang Ade (Karawang&Subang), Yoshiko Hikariati (Jkt), Wanto (Caringin), Perum Perhutani through its Cilember management, Gunung Walat Forest Research Management, Anisa Fitri, Dede M. Nasir, Sumantri Radiansyah & volunteers and many others

REFERENCES

Abdulali, H. 1985. On the export of frog legs from India. *J. Bombay Nat. Hist. Soc.* 2:347-375.

Alcala, A.C. 1962. Breeding behaviour and early development of frogs of Negros, Philippine islands. *Copeia* 1962(4): 679 - 726.

Alford, R., K. Bradfield and S. Richards. 1999. Measuring and analysing developmental instability as a tool for monitoring frog populations. In A. Campbell. Declines and disappearances of Australian frogs. Canberra: 34-43.

Alford, R.A. and S.J. Richards. 1999. Global amphibian declines: A problem in applied ecology. *Ann.Rev. Ecol. Syst.* 30: 133-165.

Arie, U. 1999. Pembibitan dan Pembesaran Bullfrog. Penebar Swadaya. 104 p.

Barfield, S. 1986. Indonesia's frog legs. *Journal of Environmental Health* 48(6): 324.

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

Bazilescu, I. 1996. Trading in frog legs. *TED Case Studies NO 238 online on* http://www.american.edu/ted/FROGS.HTM 5(1).

Berger, L., R. Speare, P. Daszak, D.E. Green, A.A. Cunningham, C.L. Goggin, R. Stratcombe, M.A. Ragan, A.D. Hyatt, K.R. McDonald, H.B. Hines, K.R. Lips, G. Farantelli and H. Parkes. 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rain forest of Australia and Central America. *Proc.Natl.Acad.Sci. USA* 95: 9031-9036.

Berrill, M., D. Coulson, L. Mcgillivray and B. Pauli. 1998. Toxicity of endosulfan to aquatic stages of anuran amphibians. *Environmental Toxicology & Chemistry* 17(1): 1738-1744

Berry, P. Y. 1975. The amphibian fauna of peninsular Malaysia. Kuala Lumpur, Tropical Press. 127 Pages

Boone, M.D. and R.D. Semlitsch. 2001. Interactions of an insecticide with larval density and predation in experimental amphibian communities. *Conservation Biology* 15(1): 228-238.

Carey, C. and C.J. Bryant. 1995. Possible interrelations among environmental toxicants, amphibian development, and decline of amphibian populations. *Environmental Health Perspective* 103(Suppl 4): 13-17.

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.

Clarke, G.M. 1994. Developmental stability analysis: an early warning system for biological monitoring of water quality. *Australian Biologist* 7(2): 94-104.

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

Daszak, P., L. Berger, A.A. Cunningham, A.D. Hyatt, D.E. Green and R. Speare. 1999. Emerging infectious diseases and amphibian population declines. *Emerging Infectious Diseases* 5(6): 735-748.

Frost, D.R. 1985. Amphibian species of the world: a taxonomic and geographical reference. USA, Allen Press.732 p.

Helgen, J., R.G. McKinnell and M.C. Gernes. 1998. Investigation of malformed northern leopard frogs in minnesota.<u>In</u> Lannoo, M. J. (ed.) Status and conservation of midwestern amphibians. Iowa. University of Iowa Press : 288-297.

Hero, J.M. 1989. A simple code for toe clipping anurans. *Herp Review* 20(3): 66-67.

Iskandar, D.T. 1998. Amfibi Jawa dan Bali. Puslitbang Biologi –LIPI. 132 p.

Iskandar, D.T. and E. Colijn. 2000. Preliminary Checklist of Southeast Asian dan New Guinean Herpetofauna: I. Amphibians. *Treubia* 31(3 Supplement): 1-133.

Jacques, M. 1999. Bengali frog legs export and uses of pesticides. <u>in</u> TED Case Studies No 508 online on <u>http://www.american.edu/projects/mandala/TED/bangfrog.htm</u> Volume 9(1).

Jenning, M.R. and M.P. Hayes. 1985. Pre-1900 overharvest of California red-legged frogs (*Rana aurora draytonii*): the inducement for bullfrog (*Rana catesbiana*) introduction. *Herpetologica* 41: 94-103

Ji-Wei and J. Clinton. 2000. Spatial modeling of the geographic distribution of wildlife populations: A case study in the lower Mississippi River region. Ecological Modelling 132 (1-2): 95-104.

Kaiser, J. 1999. A trematode parasite causes some frog deformities. *Science* 284: 731-732.

Kusrini, M.D. 2002. An assessment of rice field frogs and frog leg trade in West Java Indonesia: a preliminary research to determine the impact of the frogs' leg harvest. Report to IRATA. Institut Pertanian Bogor. Bogor 10 p.

Kusrini, M.D. 2003a. Who Eats Our Frogs? An Overview of Indonesian Frog Leg Exports. Manuscrips. Townsville. 14 p.

Kusrini, M.D. 2003b. 2002. Progress Report: Impact of frogs' leg harvest in Indonesia. Progress Report to Indonesian Reptile and Amphibian Trade Association. Bogor Agricultural University. Bogor. 10 p.

Leong, T.M. 2001. Parasitic copepods responsible for limb abnormalities. *FROGLOG* 46(3).

Mazzoni, R., A.A. Cunningham, P. Daszak, A. Apolo, E. Perdomo, and G. Speranza. Emerging pathogen of wild amphibians in frogs (*Rana catesbeiana*) farmed for international trade. Emerg Infect Dis [serial online] 2003 Aug [7]. Available from: URL: http://www.cdc.gov/ncidod/EID/vol9no8/03-0030.htm

Mohanti-Hejmadi, P. and S.K. Dutta. 1981. Effects of some pesticides on the development of the Indian bullfrog *Rana tigerina*. *Environmental Pollution Series A* 24: 145-161.

Nyhus, P. J., R. Tilson, N. Franklin, Bastoni, Sriyanto, M. Yunus and Sumianto. 2000. Tigers, Cameras, and Satellites: Interdisciplinary efforts to map the habitat and threats to the last Sumatran tigers. Paper presented at 20th Annual ESRI International User Conference, San Diego, California.

Oulett, M., J. Bonin, J. Rodrigue, J.D. Granges and S. Lair. 1997. Hindlimb deformities (electromelia, ectrodactyly) in free-living anurans from agricultural habitats. *Journal of Wildlife Disease* 33(1): 95-104.

Oza, G.M. 1990. Ecological effects of the frog's legs trade. *Environmentalist* 10(39-41).

Palmer, A.R. and C. Strobeck. 1986. Fluctuating asymmetry: Measurement, analysis, patterns. *Ann.Rev. Ecol. Syst.* 17: 391-421.

Pandian, T.J. and M.P. Marian. 1986. Production and utilization of frogs: an ecological view. *Proc. Indian Acad. Sci. (Anim. Sci.)*, 95 (3):289 – 301

Pankakoski, E. 1985. Epigenetic asymmetri as an ecological indikator of muskrat. *J. Mamm.* 66(1): 52-57.

Patel, T. 1993. French may eat Indonesia out of frogs. *New scientist.* 1868: 7.

Relyea, R.A. and N. Mills. 2001. Predator-induced stress makes the pesticide carbaryl more deadly to gray treefrog tadpoles (*Hyla versicolor*). *Proc. Natl. Acad. Sci. USA.* 98(5): 2491-2496.

Schmuck, J. 2000. Amphibians in human nutrition. In R. Hofrichter (Ed). 2000. The encyclopdeia of Amphibians. Key Porter Books Lim. Ontario. p. 214-217.

Scott, J.M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderso, S. Caicco, F. D'Erchia, T.C. Edwards Jr, J. Ulliman and R.G. Wright. 1993. Gap analysis: a geographic approach to protection of biological diversity. *The Journal of Wildlife Management* 57(1): 5-42.

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.

Settle, W.H., H. Ariawan, E.A. Astuti, W. Cahyana, A.L. Hakim, D. Hindayana, A.S. Lestari and Pajarningsih. 1996. Managing tropical rice pests through conservation of generalist natural enemies and alternative prey. *Ecology* 77(7): 1975-1988.

Soule, M. and B. Baker. 1968. Phenetics of Natural Populations. IV. The population asymmetry parameter in the butterfly *Coenomympha tullia*. *Heredity* 23: 611-614.

Susanto, H. 1989. Budidaya Kodok Unggul, Jakarta: Penebar Swadaya.

Thiemann, G. W. 2000. Patterns and consequences of behavioural responses to predators and parasites in *Rana* tadpoles. *Biological Journal of the Linnean Society* 71: 513–528.

Tsubaki, Y. 1998. Fluctuating asymmetry of the oriental fruit fly (*Dacus dorsalis*) during the process of its extinction from the Okinawa Islands. *Conservation Biology* 12(4): 926-929.

Van der Eng, P. 1994. Development of seed-fertilizer technology in Indonesia rice agriculture. *Agricultural history* 68(1): 20-54.

Veith, M, J. Kosuch, R. Feldmann, H. Martens, and A. Seitz. 2000. A test for correct species declaration of frog legs imports from Indonesia into the European Union. *Biodiversity and Conservation* 9: 333-341.

Kusrini, M.D., A. Mardiastuti dan T. Harvey (Editor). 2003. Konservasi Amfibi dan Reptil di Indonesia.. Prosiding Seminar Hasil Penelitian Departemen Konservasi Sumberdaya Hutan.. Bogor 8 Mei 2003. Institut Pertanian Bogor. 181 hal.