UNIVERSITI PUTRA MALAYSIA

THE LIFE HISTORY, POPULATION AND FEEDING BIOLOGY OF TWO PADDY FIELD FROGS, RANA CANCRIVORA GRA VENIIORST AND R. LIMNOCHARIS BOIE, IN MALAYSIA.

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By

IBRAHIM HAJI JAAFAR

Dissertation Submitted in Fulfillment of the Requirements for the Degree of Doctor of Philosophy in the Faculty of Science and Environmental Studies, Universiti Pertanian Malaysia

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This work is dedicated to: -

my wife of fifteen years, Hamidah Zulkifly

my children, Adam Muhammad

Ismail Ishaq

Ayyub Isa and

Harun Musa

my teachers, friends, colleagues and students

biologists, naturalists and environmentalists

past, present and future.

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m	meters
mm	millimeters
km	kilometers
cm	centimeters
m^2	meters square
m^3	meters cube
gm	gram
mg	milligram
ha	hectare
mg/l	milligrams per liter
µS/m	microSiemens per meter
µohms/m	micro mhos per meter
°C	degrees centigrade
N	North
E	East
hrs	hours
df	degrees of freedom
sd	standard deviation
SE	standard error
spp	species
e.g.	for example
et al.	and others
pers. obs.	personal observations
pers. comm.	personal communications
SUL	snout-urostyle length
SVL	snout-vent length
MARDI	Malaysian Agricultural Research and Development Institute
viz.	which is
OSR	operating sex ratio

Abstract of dissertation submitted to the Senate of Universiti Pertanian Malaysia in fulfillment of the requirements of the degree of Doctor of Philosophy.

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IBRAHIM HAJI JAAFAR

SEPTEMBER 1995

Chairman: Dr. Ahmad Ismail

Faculty : Science and Environmental Studies

The life history, population and feeding biology of two species of frogs (*R. cancrivora* and *R. limnocharis*) were studied from April 1992 through September 1993 in the rice growing district of Tanjung Karang, Selangor, Malaysia. The results showed that the breeding periods of the two frogs were correlated with the irrigation phase of the rice growing seasons and were not correlated with the rainfall. The frogs were also found to have two breeding peaks annually as opposed to a single peak for the same species in other localities.

Comparison of the life history aspects of the two species showed that *R. cancrivora* females produced more, and larger sized, eggs than *R. limnocharis*

females. This then produced a chain effect whereby *R. cancrivora* larvae developed faster and metamorphosed at a larger size than those of *R. limnocharis*, and then continued to grow at a faster rate, attained a larger size and reached sexual maturity earlier. These factors most probably contributed to the observed disparity in population size between these two frogs wherein *R. cancrivora* is about six times more numerous than *R. limnocharis*.

The fact that adults of these two species differ in size is also the main reason as to why they can coexist in the same habitat. Different body sizes allow them to ingest different sized prey items, as was discovered by analysis of their diets, thus avoiding competition for food. Survivorships from eggs to metamorphosis for both species are low but normal for lentic-water breeding amphibians, and they are deemed sufficient to maintain the population levels if human interference can be substantially reduced. Fluctuations in the population structure are mainly due to recruitment, natural mortality and human interference. The most important food items for both species are insects and about 80% of these insects are pests of rice. Hence these frogs are considered very important biological control organisms in the paddy field habitat.

Abstrak disertasi yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah.

RIWAYAT HIDUP, POPULASI DAN BIOLOGI PEMAKANAN DUA JENIS KATAK SAWAH, *RANA CANCRIVORA* GRAVENHORST DAN *R. LIMNOCHARIS* BOIE, DI MALAYSIA.

oleh

IBRAHIM HAJI JAAFAR

SEPTEMBER 1995

Pengerusi : Dr. Ahmad Ismail

Fakulti : Sains dan Pengajian Alam Sekitar

Riwayat hidup, populasi dan biologi pemakanan dua species katak (*R. cancrivora* dan *R. limnocharis*) yang biasa terdapat di habitat sawah padi telah dikaji dari bulan April 1992 hingga bulan September 1993, di kawasan tanaman padi Tanjung Karang, Selangor, Malaysia. Hasil kajian menunjukkan bahawa puncak musim pembiakan kedua-dua spesies katak ini adalah seiring dengan fasa pengairan musim menanam padi di tempat itu dan tidak berkorelasi dengan banyaknya hujan. Katak-katak itu juga didapati mempunyai dua puncak musim pembiakan setahun berbanding dengan satu puncak sahaja untuk spesies yang sama di tempat-tempat lain.

Perbandingan aspek-aspek riwayat hidup kedua-dua spesies itu menunjukkan bahawa *R. cancrivora* betina menghasilkan telur yang lebih banyak dan lebih besar daripada *R. limnocharis* betina. Ini pula menghasilkan suatu kesan rantai di mana larva *R. cancrivora* berkembang dengan lebih cepat dan

bermetamorfosis pada saiz yang lebih besar daripada larva *R. limnocharis*, dan kemudiannya terus membesar pada kadar yang lebih cepat dan mencapai kematangan seks dengan lebih awal lagi. Ini dipercayai menghasilkan perbezaan pada saiz populasi antara kedua-dua katak ini di mana terdapat lebih kurang enam kali ganda lebih banyak *R. cancrivora* daripada *R. limnocharis*.

Kemandirian dari telor ke metamorfosis adalah rendah bagi kedua-dua spesies tetapi ini adalah biasa untuk amfibia-amfibia yang membiak di air tenang, dan dipercayai sudah cukup untuk mengekalkan paras populasi jika gangguan dari manusia dapat di kurangkan. Juga didapati bahawa kemandirian berudu lebih tinggi di dalam keadaan makmal daripada di persekitaran alamiah. Perubahan-perubahan yang berlaku di dalam struktur populasi sebahagian besarnya disebabkan disebabkan oleh penambahan individu, kematian dan mungkin gangguan manusia.

Perbezaan saiz adalah sebab yang utama mengapa mereka boleh hidup bersama di dalam habitat yang sama. Dari analisis gizi didapati bahawa perbezaan saiz badan dan buka mulut membolehkan mereka memakan mangsa-mangsa yang berlainan saiz, dan dengan ini mengelakkan persaingan di dalam pemakanan. Bahan makanan yang paling penting bagi kedua-dua spesies adalah serangga dan lebih kurang 80% daripada serangga ini adalah musoh kepada tanaman padi. Oleh itu katak-katak ini dianggap sebagai organisma kawalan biologi yang sangat penting di habitat sawah padi.

CHAPTER I

INTRODUCTION

Peninsular Malaysia with its hot, wet tropical climate harbours about eighty-eight species of amphibians from six families (Berry, 1975). Despite the abundance of species, not much information has been published on the biological and ecological aspects of the amphibian fauna of Malaysia. Most studies on amphibians have centered on temperate species of North America and Europe, and presently there is a trend to work more on neotropical species from Latin America.

Duellman and Trueb (1986) stressed that there are two major threats to amphibians as a whole, namely habitat destruction and environmental pollution. This is unfortunately very true in Malaysia as rapid progress and development for the last fifteen years or so has witnessed the inevitable decrease of suitable amphibian habitats such as swamps, natural waterways, wetlands, forests, rural areas and agricultural lands. And whatever preferred habitats that are still available are chronically being poisoned by agricultural and industrial pollutants (such as heavy metals), electronics industry wastes,

anthropogenic wastes, and chemical fertilizers and pesticides. All these contaminations alter the habitats for the breeding, development and survival of the amphibians. To further aggravate the problems, collection of adult amphibians for human consumption, bait for sports fishing and food for certain big fishes in the ornamental fish industry has witnessed the decline of viable populations of the commoner amphibian species in certain areas of the peninsula.

Published studies on Malaysian anurans include some on population ecology, density and abundance (Inger, 1980a; 1980b), competition and community organization (Inger and Greenberg, 1966; Inger, 1969), breeding and reproduction (Berry, 1964; Inger and Bacon, 1968; Emerson, 1992), tadpoles and larval survival (Inger, 1966; Berry, 1972; Yorke, 1983), food and diet (Berry and Bullock, 1962; Berry, 1966; Bullock, 1966; Elliot and Karanukaran, 1974), descriptive notes, systematics and zoogeography (Boulenger, 1912; Smith, 1930; Inger, 1966; Kiew, 1972; 1973; Berry, 1975; Emerson, 1991; Inger and Stuebing, 1992), inventory and guides (Berry, 1975; Dring, 1979; Inger and Stuebing, 1989) and biodiversity and conservation (Kiew, 1984).

Except for the above mentioned reports, no other noteworthy studies or documented information on the life history and ecology of Malaysian frogs has been published. Therefore, it is urgent that studies on the life history and ecology of Malesian amphibian species be carried out to gather information and data on the relationship of these species with the environment and the biotic

community so that we could assess the impact of various environmental stresses on these species before time runs out. In view of the above circumstances, the objectives of this study are :

(a) firstly to examine some life history aspects (such as breeding and reproductive periods, eggs and fecundity, larval survival, and juvenile growth and maturity) and some ecological aspects (such as population, and food and feeding dynamics) of two common Malaysian frogs, namely *Rana cancrivora* Gravenhorst and *R. limnocharis* Boie, in the rice field habitat of Tanjung Karang, Malaysia and,

(b) secondly to compare the relationship between these two sympatric species with respect to their life history traits, population numbers and feeding biology in the Tanjung Karang area.

It is hoped that the data and information obtained from this study could help us to understand a little more about the biology of these two species and thus could also be used as a basis or guide for future management and conservation of the local amphibian fauna.

CHAPTER II

LITERATURE REVIEW

Life History

Collins (1975) wrote that any life history feature affecting reproductive potential is subject to natural selection, and just like morphological or behavioural traits, all life history characteristics should be considered adaptations. Other authors also support this view and assume that interspecific and interpopulational differences in life history traits represent adaptations to local conditions (Pianka, 1983; Gill, 1985). Although Alcala (1962), Berven et al., (1979) and Berven, (1982) conclude that only a small portion of amphibian life history variations is heritable and stable, they conceed that the rest are environmentally induced or due to adaptive radiation. Wells (1977) noted that in order to fully comprehend the selective forces that affect the breeding system of a species, it is necessary to know a variety of demographic and ecological factors that influence or constrain behaviour.

Life history traits are, more often than not, products of balancing between the individual's basic needs on the one side, and environmental variables

or uncertainties, on the other. Therefore body size, clutch size, growth rate and age at first reproduction, and all other life history components constitute a life history `strategy', and are simply adaptive responses accumulated by the species over time (Collins, 1975). Also Galatti (1992) indicated that patterns of reproduction and individual growth rates are two of the important factors that may affect the demographic processes of a population, and he believed that in amphibians both factors are probably influenced by weather and food availability.

Wells (1977) added that there is also a need for additional quantitative studies on all aspects of anuran life history, ecology and demography, since these factors are quite important in the evolution of anuran social behaviour. However, data for many of these parameters are difficult to obtain for anurans, primarily because many anurans are only visible during their relatively short breeding seasons, and otherwise are difficult to locate, or are inactive during the remainder of the year (Caldwell, 1987). Furthermore many, if not most amphibians are secretive, cryptic and nocturnal in their habits making them difficult subjects for study (Inger, 1966; Inger and Bacon, 1968; Porter, 1972; Duellman and Trueb, 1986). It is especially important to have additional information on tropical species since the vast majority of anurans live in the tropics (Wells, 1977; Duellman and Trueb, 1986; Inger, 1980a; 1980b).

Breeding and Reproductive Periods

Amphibian reproductive cycles are subject to endogenous hormonal controls which, within genetic limitations, respond to environmental variables and

produce certain patterns (Duellman and Trueb, 1986). Also, further constraints are imposed by the organisms' microhabitat, size, reproductive mode and parental practices (Duellman and Trueb, 1986).

Hence "It would be instructive to know not only by what physiological mechanism a just apportionment is made between the nutriment devoted to the gonads and that devoted to the rest of the parental organism, but also what circumstances in the life history and environment would render profitable the diversion of a greater or lesser share of the available resources towards reproduction" (Fisher, 1958).

The relative importance of temperature, rainfall and photoperiod to the initiation of amphibian breeding activity undoubtedly varies with the breeding habitat of different species and between tropical and non tropical populations (Porter, 1972). Thus two basic patterns of reproduction occur in anurans: (1) year round breeding in most tropical and subtropical species, controlled primarily by rainfall (Inger and Greenberg, 1963; Berry, 1964; Inger and Bacon, 1968), and (2), cyclic reproductive activity in most temperate forms which is heavily dependent on seasonal temperatures and rainfall (Pearson, 1955; Turner, 1958; Herreid and Kinney, 1966; Licht, 1969; Wilbur, 1972; Collins, 1975; Walters, 1975; Doty, 1978; Reading, 1984; Williamson and Bull, 1992; Tejedo, 1992), and photoperiod (Porter, 1972).

Amphibians are poikilothermous whereby their body temperatures are directly subjected to seasonal environmental temperature variations which in turn directly or indirectly affect their metabolic and reproductive activities

(Church, 1960a). In general, hormonal activity, such as secretions by the adenohyphophysis, is correlated with environmental changes wherein these changes act as primary stimuli to nerve receptors and are integrated by the central nervous system, which relays appropriate impulses to the hypothalamic neurosecretory nuclei (Duellman and Trueb, 1986).

In wet tropical Asia, both sexes of various anuran species are reproductively active year round as has been shown in *Bufo melanostictus* in Java (Church, 1960a), twelve anuran species in the Philippines (Alcala, 1962), *R. erythraea* in Sarawak (Inger and Greenberg, 1963), seven species in Singapore (Berry, 1964), six Borneon species (Inger and Bacon, 1968), *R. erythraea* in the Philippines (Brown and Alcala, 1970) and *Polypedates maculatus* in India (Kanamadi and Jirankali, 1992). This led Duellman and Trueb (1986) to conclude that amphibians in the wet tropics have continuous reproduction and may deposit several clutches of eggs per year, although the frequency of reproduction for tropical anurans is poorly known. There are indeed instances in which tropical female frogs breed more than once annually. For example Wells (1979) reported that some females of the Neotropical toad *B. typhonius* produced two clutches in six weeks, and Richards (1977) stated that the reed frog *Hyperolius viridiflavus* in Kenya bred at intervals of two to three weeks in captivity, while Tyler (1976) noted that the tropical Australian amphibian *Lymnodynastes tasmaniensis* may deposit eggs once every two weeks. Probably multiple