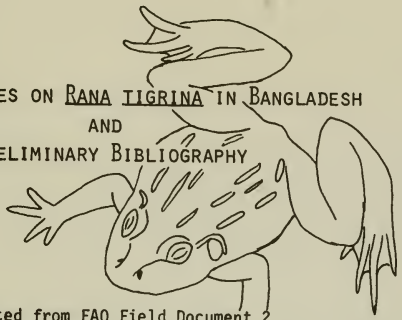
Biological Notes on *Rana tigrina* in Bangladesh and Preliminary Bibliography



Extracted from FAO Field Document 2
FI:DP/BGD/79/015 April 1983
"An evaluation of the populations of
the commercially exploited frog
Rana tigrina in Bangladesh"

CHARLES M. FUGLER

Department of Biological Sciences
University of North Carolina at Wilmington

SMITHSONIAN
HERPETOLOGICAL INFORMATION
SERVICE
NO. 60

1984

SMITHSONIAN
HERPETOLOGICAL
INFORMATION
SERVICE

The SHIS series publishes and distributes translations, bibliographies, indices, and similar items judged useful to individuals interested in the biology of amphibians and reptiles, but unlikely to be published in the normal technical journals. Single copies are distributed free to interested individuals. Libraries, herpetological associations, and research laboratories are invited to exchange their publications with us.

We wish to encourage individuals to share their bibliographies, translations, etc. with other herpetologists through the SHIS series. If you have such items please contact George Zug for instructions. Contributors receive 50 free copies.

Please address all requests for copies and inquiries to George Zug, Division of Amphibians and Reptiles, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560, U.S.A. Please include a self-addressed mailing label with requests.

INTRODUCTION

An intensive search of the literature pertaining to Rana tigrina and to other commercially exploited anurans of southeast Asia reveals a paucity of published data on the biology of the species in question. Those published studies pertaining to the biology of Rana tigrina concern populations of northern and western India in which the environmental conditions are significantly divergent from those of Bangladesh. The systematics and biogeography of Rana tigrina are well documented.

The data herein are the only significant biological information extant on Rana tigrina from the Indian subcontinent. In view of the temporal restrictions within which the field studies were pursued, the conclusions drawn are tentative.

Rana tigrina is widely distributed through the subcontinent of India and southeast Asia. Its populations are most abundant in wetlands, natural and artificial, and are absent from, or uncommon in, forested areas.

Rana tigrina is known to inhabit all districts of Bangladesh, avoiding, as far as known, the immediate coastal areas. The greatest population densities are in the Districts of Mymensingh and Sylhet. The species is less frequently encountered, exclusive of the coastal areas, in the Chittagong Hill Tracts.

The current study is concerned with the status of the Bangladeshi populations as it pertains to size-cohorts, reproductive data and food preferences.

AMPHIBIAN FAUNA OF BANGLADESH

Husain and Rahman (1978) reported eleven species from Bangladesh (Bufo melanostichus, Kaloula pulchra, Microhyla ornata, M. rubra, Rana cyanophlyctis, R. hexadactyla, R. limnocharis, R. tigrina, R. tytleri, Rhacophorus leucomastix, Rh. maculatus). Although incompletely documented, the amphibian fauna of Bangladesh, when compared to those of adjacent regions, is impoverished. Intensive field collecting may increase the number of species within the national boundaries. The absence of significant physiographic and phytogeographic diversity will negate a significant faunistic increase.

One species (R. tigrina) and possibly two other species (R. hexadactyla, R. limnocharis) are of significant economic value. Husain and Rahman (1978) noted, for the six-month period July 1975 to January 1976, the foreign exchange earned by the export of frozen frog-legs was Taka 6,474,434 (approximately U. S. $359,000) according to the official statistics of the Bangladesh Export Promotion Board.

REPRODUCTION

In Bangladesh, the breeding season is initiated at the onset of the first seasonal rains, usually mid-April. Reproductive activity is intense through mid-July (K. Z. Husain, personal communication). A seasonal rainfall will activate feeding and reproductive behavior. An early (February 1982) rainfall at Mymensingh was sufficient to initiate breeding responses. The larvae survived and subsequently metamorphosed because of abundant standing water. At Barisal, aseasonal rain induced breeding activity, but the larvae failed to survive in the absence of standing water. Rana tigrina, therefore, is an opportunistic breeder in which rainfall elicits reproductive behavioral responses. Reproductive activity continues well into the monsoonal season, diminishing in intensity and frequency correlative to the decrease in intensity and frequency of rainfall.

Rana tigrina oviposits in "new water" of the monsoon rather than in stagnant waters depleted of oxygen. In "new water" less particulate matter is present, the temperature is lower and the oxygen content is higher. The abiotic requirements for larval development are, in part, fulfilled.

At the advent of the breeding cycle the males, the first to emerge from underground retreats, begin frenetic pre-reproductive activities, establishing territories by emitting species-specific calls. The voiceless female is thereby attracted to the territorial male. The chorusing males are highly vulnerable to predators.

Daniel (1975) observed similar reproductive behavior in Rana tigrina near Bombay, India. The males, lemon-yellow in color, congregate in rainwater pools and ditches, chorusing loudly as they await the females. The arriving females are fought over, the nearest male clasping the female, fending off competitors by kicking strongly with the hind legs. The spawn is deposited in rainwater pools and in other transitory waters. The ova float upon deposition, thence sink to the bottom where they remain until hatching.

Dutta and Mohanty-Hejmadi (1978) concluded that Rana tigrina has the most rapid developmental rate among local (Vani Vihar, Bhubaneswar, India) amphibians. At the aforementioned localities hatching occurs 23 hours postfertilization, external gills at 44 3/4 hours, limb buds at 19 days, well defined limbs and tail at 30 days, and complete metamorphosis at 33 days. Rana tigrina attains metamorphosis at 43 days postfertilization under controlled laboratory conditions. Breeding during the monsoon and rapid larval development permit escape from the pressures of dessication and diminished larval predation attendant upon other sympatric amphibian species (Dutta and Mohanty-Hejmadi, 1978).

SIZE VARIATION

Few published references pertaining to the maximum snout-vent length of Rana tigrina are extant. Issac and Rege (1975) recorded on unsexed individual (unquestionably female) measuring 175 mm snout-vent length from Bombay. In western India, adult females occasionally exceed 160 mm snout-vent length. Males are invariably of lesser snout-vent length, although Mansukhani and Murthy (1970) claimed that males range from 178 mm to 188 mm, and females from 132 mm to 152 mm, snout-vent length, in Rajasthan, India. These data, obviously a size reversal of sexual morphometrics, are not corroborated by published observations. Murthy (1968) noted that females attain a larger size (178 mm - 188 mm) than males (143 mm - 165 mm) when sexually mature (Madras, India).

Eight population samples, randomly selected, of Rana tigrina from diverse districts of Bangladesh suggest that the mean snout-vent length of both sexes is significantly less than those of the Indian conspecifers although comparative data are minimal.

Males.--The mean size-cohort of males is 101-110 mm (24% of all males examined) although 23.1% of all males examined are in the 91-100 mm size-cohort. Thus, approximately 50% of the males examined measure from 91 mm to 110 mm in snout-vent length. Males greater than 150 mm snout-vent length were not encountered in the population sample (Table 1).

Males are the first emergents at the onset of the monsoonal rains. Those males of larger size are immediately removed from the reproductively active populations by the field collectors. The vociferous calls and breeding colors attract the attention of predators, human and others. The breeding stock, therefore, is composed of smaller males.

In the population samples obtained in early May and early June, the mean size-cohorts of males are 121-130 mm and 131-140 mm. The mean size-cohorts of later populations decline to 91-100 mm and 101-110 mm.

Females.--The mean size-cohort of females, 111-120 mm, includes 24.1% of all females examined. The size-cohort 121-130 mm contains 11.3% of all females examined. Less than 1% of the 915 females examined exceed 150 mm snout-vent length.

The mean size-cohorts of females in population samples of early May and early June are 111-120 mm and 131-140 mm. Later population samples, with slight fluctuation, decline to mean size-cohorts of 111-120 mm and ultimately to 91-100 mm.

Females emerge from hibernation after males and thence enter reproductive activities. The mean size-cohorts of the females, with slight fluctuation, exhibit a decline from early June (131-140 mm). The fluctuation in mean size-cohort may be attributable to local climatic conditions, primarily the onset of the monsoonal rains.

The distribution of snout-vent frequencies suggest that the populations of Bangladesh are severely stressed if the maximal snout-vent lengths of the Indian populations are characteristic of the species. That the Bangladeshi populations represent a geographic variant not conspecific with those of India is implausible should snout-vent length be considered a primary criterion.

Postmetamorphic growth.--The growth rates of Rana tigrina under natural and under laboratory conditions are unknown. The mean size-cohort frequencies of the populations obtained in May and June do not evidence bimodality characteristic of annual size-classes. It may be suggested that the mean size-classes represent those individuals surviving one growth-season and the following period of inactivity. Those individuals, with significant overlap, exceeding the mean size-cohort, may have survived two growth-seasons. Individuals of lesser snout-vent length are possibly recruits of the previous growth-season.

Base line data on this extremely important aspect of the biology of Rana tigrina are urgently required. It is certainly possible that growth rates vary within the districts of Bangladesh according to the length and abundance of rainfall, availability of food, intensity of predation and extremes of temperature.

SIZE AND TEMPORAL DISTRIBUTION OF GRAVID FEMALES

The ovaries of all females in the population samples were closely examined to ascertain the reproductive state, i.e., early oogenesis (minute, immature ova, few in number), later oogenesis (larger, immature ova, relatively abundant), mature (fully formed ova, pigmented, abdominal cavity extended) and depleted (postspawning, few or no ova remaining, oviducts greatly enlarged).

Gravid females comprise a significant preponderance of all females in the population samples examined between 16 May 1982 and 29 June 1982: 93.57%, 100% (5, 6, 9 June), 91.66%, 84.11%, 97.87% and 85.71% (Table 1).

Gravid females are present in the 71-80 mm size-cohort, the 161-170 mm size-cohort and all intervening size-cohorts. It is established, therefore, that individuals between 71-80 mm and 161-170 mm snout-vent length are reproductively mature.

The frequencies of gravid females larger than and smaller than the mean size-cohort of each population examined decline correlatively with the decrease of snout-vent frequencies. Except for the population obtained 5 June 1982 (141-150 mm), the mean size-cohorts of gravid females among the population samples vary from 111-120 mm, 121-130 mm and 91-100 mm.

The reproductive potential of larger females, producing larger egg masses and thereby more abundant larvae, is negated by their prompt removal from the reproductive pools. Females of smaller size produce fewer ova, thus reducing the recruitment potential, given the high level of larval mortality.

In certain, if not all, areas of Bangladesh in which Rana tigrina exists, females are reproductively mature by mid-May and remain so until at least early July. The data do not indicate if Rana tigrina oviposits single or multiple clutches throughout its geographic range or if the frequency of spawning varies regionally. In females from the Districts of Mymensingh and Sylhet the field data suggest that multiple spawning may occur during lengthy and unabated monsoonal seasons. In other districts in which the monsoon is of shorter duration, multiple spawning is not indicated by the data.

The sex-ratios of the populations examined varied thusly (males-females): 51.17 - 48.83%, 45.07 - 56.93%, 84.0 - 16.0%, 59.3 - 40.0%, 67.0 - 33.0%, 40.0 - 60.0%, 52.1 - 47.9%, and 63.0 - 37.0%.

Males are predominant in the larger population samples and females in the smaller. Males emerge before the females after the advent of the monsoons, and establish temporary breeding territories. The ceaseless nocturnal chorusing and intensified breeding colors attract predators and collectors. Thus, the sex-ratio strongly favors males in all population samples obtained from mid-May to late June. The females, emerging later from estivation than males, are voiceless and less spectacularly colored. They are more easily overlooked by predators and collectors. The sex-ratios of the population samples are strongly biased in that collectors seek or are attracted to the males.

The percentage of gravid females of all females examined varied from 38.93% to 98.0% in large population samples (Table 1). The lesser percentage is derived from females perhaps obtained prior to the beginning of the permissible collecting period and retained in holding tanks. The higher percentages indicate that a significant number of reproductively mature females are removed from the breeding populations.

FOOD PREFERENCES

In Bangladesh, a preliminary analysis of the stomach contents of Rana tigrina was undertaken on specimens collected in the Districts of Mymensingh, Chittagong, Noakhali, Sylhet, Khulna, Jessore, Rangpur and Bogra.

One-hundred-ten individuals were examined, ranging in snout-vent length from 33 mm to 140 mm. The mean (42.7%) ranged from 61 mm to 90 mm, followed by 31 mm to 60 mm (31.8%), 91 mm to 120 mm (17.2%), 121 mm to 150 mm (7.2%) and 151 mm to 180 mm (0.9%).

The one-hundred-ten specimens were obtained between 16 September and 13 November 1976 (data obtained from the Faculty of Fisheries, Bangladesh Agriculture University). Air temperature varied from 21.5°C to 30.5°C during the collecting period. Water temperature varied from 19°C to 30°C. All specimens were captured either in aquatic habitats or those characteristically moist throughout the year.

As reported in the study of Rana tigrina near Bombay, India (Issac and Rege, 1975), Coleoptera constitute the greatest volume of prey, followed in decreasing volumes by Orthoptera, Anura, Hymenoptera and Arthropoda (decapod crustacean). Coleopterans were the most frequently encountered organisms in 94 stomachs (16 contained no organisms) followed in decreasing frequencies by Hymenoptera, Orthoptera, Diptera, Lepidoptera and Hemiptera. The dietary elements indicate the abundance of prey species from mid-September until mid-November. The prey species consumed by Rana tigrina at other periods are not documented. In that Rana tigrina is a carnivorous, indiscriminate predator, the diet unquestionably reflects the relative abundance of invertebrates.

In Bangladesh, as well as in India, Rana tigrina is a significant agent of biological control. In those areas in which the populations are stressed, observations indicate that noxious insects and agricultural pests have rapidly increased. The ultimate control of the insects, therefore, may depend upon the use, or the increased use, of insecticides.

TABLE 1

Meristic and Reproductive Characteristics of Rana tigrina Obtained in the Districts of Faridpur, Khulna, Kustia, Comilla, Mymensingh, Barisal, Sylhet and Chittagong, 16 May-29 June, 1982

Snout-Vent Length in mm	% of Total Males in Size-Cohort	% of Total Gravid Females in Size-Cohort
161 - 170	-	0.1
151 - 160	-	0.6
141 - 150	1.3	3.8
131 - 140	7.0	12.7
121 - 130	14.7	21.3
111 - 120	17.5	24.1
101 - 110	24.1	19.0
91 - 100	23.1	13.1
81 - 90	10.6	4.6
71 - 80	1.2	0.3
61 - 70	0.1	-
Total Males Examined - 960		Total Gravid Females Examined - 821
		Total Females Examined - 915

TABLE 2

Analysis of Stomach Contents of Rana tigrina From Eight Localities in Bangladesh

Taxonomic Group	Total Number of Items Found in Stomachs	Number of Stomachs	% Volume of Food Items in all Stomachs
Ephemeroptera	1	1	0.020
Odonata	1	1	0.161
Orthoptera	(33)	-	21.158
Tridactylidae	1	1	0.121
Gryllotalpidae	2	1	0.800
Acrididae	2	2	0.242
Gryllidae	28	20	19.995
Dermaptera			
Forficulidae	2	2	0.323
Hemiptera			
S. O. Heteroptera	(8)	-	0.040
Reduviidae	4	1	0.242
Coreidae	1	1	0.040
Pantatomidae	2	2	0.484
S. O. Homoptera	2	1	0.080
Cicadellidae	1	1	0.121
Neuroptera	1	1	0.201
Lepidoptera	(9)	-	2.381

Pyralidae	1	1	0.121
Geometridae	1	1	0.201
"Hairy Caterpillar"	4	3	1.050
Diptera	(21)	-	2.099
Tipulidae	2	2	2.201
Muscidae	14	10	1.456
S. O. Cyclorrapha	5	1	8.242
Homoptera	(212)	-	8.922
Formicidae	209	35	7.549
Vespidae	3	2	1.131
Coleoptera	(160)	-	34.935
Carabidae	109	55	29.921
Curculionidae	17	7	1.959
Scarabaeidae	22	9	1.745
Staphylinidae	3	3	0.262
Coccinellidae	1	1	0.161
Chrysomellidae	6	8	0.686
Grub	1	1	0.121
Aquatic Beetle (Coleoptera)	1	1	0.080
Annelida	15	3	3.958
Crab (Crustacea Decadapoda)			
Complete	1	4	7.109
Fragments	23		

Millipede (Diplopoda)	9	5	1.050
Spider (Arachnida)	6	6	0.686
Snail (Gastropoda)	19	9	2.302
Cyriniformes (Pisces)	2	2	4.039
Anura	3	3	11.391
Plant Material	-	8	-
Rice	2	2	-
Rocks	2	2	-
Mud	-	7	-

A PRELIMINARY BIBLIOGRAPHY OF RANA TIGRINA DAUDIN

Abrol, P. 1969. Nuclear extrusions in the male germ cells of Rana tigrina. Res. Bull. Panjab. Univ. Sci. 20(3-4):427-428.

Agarwal, S. K., and I. A. Niazi. 1980. Development of mouthparts in the tadpoles of Rana tigrina. Proc. Indian Acad. Sci. Anim. Sci. 89(2):127-132.

Agharkar, S. P. 1912. The diet of the bullfrog (R. tigrina). J. Bombay Nat. Hist. Soc. 21(2):687.

Ali, Jabir. 1955. Hunting the land crab (Paratelphusa guerini). J. Bombay Nat. Hist. Soc. 52:941-945.

Annandale, N. 1907. The fauna of brackish ponds at Port Canning, Lower Bengal. Rec. Indian Mus., Calcutta 1:42.

Annandale, N. L., and C. R. N. Rao. 1918. The tadpoles of the families Ranidae and Bufonidae in the plains of India. Rec. Indian Mus., Calcutta 15:26-40.

Annandale, N., and G. Boulenger. 1920. Monograph of the South Asian, Papuan, Melanesian and Australian frogs of the genus Rana. Rec. Indian Mus., Calcutta 20:1-226.

Balasubramanian, A., and S. Ramakrishnan. 1982. Cyclic AMP phospho-diesterase activity in fat body and testes of male rates and the effect of aspirin on the same. Indian J. Exp. Biol. 20(1):77-78.

Basu, S. L. 1968. Effects of testosterone metabolism and estrogen metabolism on spermatogenesis in Rana hexadactyla. J. Exp. Zool. 169(2):133-152.

Basu, S. L. 1969. Effect of hormones on the salientian spermatogenesis in vivo and in vitro. Ed. M. R. N. Prasad. General and Comparative Endocrinology. Supplement 2, 1969. Academic Press, Inc., New York, 1969. Pp. 203-213.

Benerji, A. 1954. Food of the bullfrog. Journ. Bombay Nat. Hist. Soc. 52(1):639.

Bhaduri, J. L. 1933. A note on the occurrence of Rana hexadactyla Lesson in Bengal. J. Bombay Nat. Hist. Soc. 36:515-516.

Bhaduri, J. L. 1944. Further locality records of Rana hexadactyla Lesson in Bengal with brief notes on its tadpoles. J. Bombay Nat. Hist. Soc. 44:484.

Boulenger, G. 1890. The fauna of British India. Reptilia and Batrachia. London. Taylor and Francis. Pp. xviii + 541.

Chakko, G. 1968. Salinity tolerances in some south Indian anurans: Rana crassa, Rana hexadactyla, Ramanella variegata, Bufo melanostictus. Proc. Indian Acad. Sci. Sect. B 67(5):233-236.

Charan, D. 1973. Pelvic region of Rana tigrina and Bufo andersoni. Ann. Zool. (Agra) 9(1):1-40.

Chibber, H. M. 1911. The food of the bullfrog. J. Bombay Nat. Hist. Soc. 20(3):865.

Daniel, J. C. 1975. Field guide to the amphibians of western India. J. Bombay Nat. Hist. Soc. 72(2):506-522.

Das, C. R., P. L. N. Rao, S. N. Mohanty, and V. Panigrahi. 1975 (1976). A note on some interesting observations on the breeding behavior of Rana hexadactyla in captivity. J. Inland Fish., Res. Substat., Cuttack, Orissa, India 7:120-122.

Das, C. R., P. L. N. Rao, S. N. Mohanty, and V. Panigrahi. 1978. Spring breeding of the aquatic green frog Rana hexadactyla and its significance. J. Inland Fish. Soc. India 10(0):121-122.

Daudin, F. M. 1802. Histoire naturelle des rainettes, des grenouilles et des crapauds. 108 pp. Paris

Davidson, N. 1916. Food of the bullfrog (Rana tigrina). J. Bombay Nat. Hist. Soc. 15(1):152.

Deshpande, D. S. 1935. The common Indian frog, Rana tigrina devouring a sparrow. Proc. 22nd Ind. Sci. Cong. Abstracts, Zool. Sec., p. 321.

Dharamaraju, E. 1960. The bullfrog (Rana tigrina) as a predator of poultry. J. Bombay Nat. Hist. Soc. 57:423-424.

Dutta, S. K., and P. Mohanty-Hejmadi. 1978. Life history and pesticide-susceptible embryonic stages of the Indian bullfrog, Rana tigrina. Indian J. Exp. Biol. 16(6):727-729.

Ezekil, M. 1931. Food of common Indian frog, Rana tigrina. Proc. Indian Sci. Cong., p. 231.

Ferguson, H. S. 1904. A list of Travancore batrachians. J. Bombay Nat. Hist. Soc. 15:499-509.

Gambhir, S. C., R. J. Tripathi, and P. R. Das. 1978. Studies on mast cells of Rana tigrina. Eur. J. Pharmacol. 49(4):437-440.

Gay, T. Food of the bullfrog (Misc. Notes). J. Bombay Nat. Hist. Soc. 52(1):212.

Gostling, D. 1895. The food of the bullfrog. J. Bombay Nat. Hist. Soc. 10(1):150.

Gupta, S. P., and R. C. Gupta. 1977. Phosphatase activity in ganeotigrinum from Rana tigrina. Z. Parasitenkd. 54(1):89-94.

Guraya, S. S. 1976. Comparative histochemical observations on the steroid synthesizing cellular sites in the testes of non-mammalian vertebrates. Z. Mikrosk. - Anat. Forsch. (Leipz.) 90(4):705-719.

Husain, K. Z., and M. M. Rahman. 1978. Amphibian fauna of Bangladesh. Bangladesh J. Zool. 6(2):157-158.

Ilyas, R. 1980. Oxysomatium mehdii, new species from the common frog Rana tigrina in Marathwada, India. Riv. Parassitol. 41(1):77-80.

Issac, S., and M. S. Rege. 1975. Food of Rana tigrina. J. Bombay Nat. Hist. Soc. 72(1):143-157.

Jamuar, M. P. 1976. Some observations on the ultrastructure of spermiogenesis in certain vertebrates. J. Cell Biol. 70(Part 2):253A.

Jayasunder, S., S. M. Periyasamy, and N. K. Bhide. 1973. Pharmacological study of antihistaminic principles in Rana tigrina tissues. Indian J. Physiol. Pharmacol. 17(3):213-225.

Joshee, A. K. 1968. Food habits of the Indian bullfrog (Rana tigrina Daud.). J. Bombay Nat. Hist. Soc. 65:498.

Kameswari, M., S. S. Simha, and L. N. Rao. 1980. Seasonal variations of three trematodes of Rana tigrina and observations on the genus Mehraorchis. Helminthologia (Bratisl.) 17(1):11-16.

Kasinathan, S., A. Balasubramanian, and S. L. Basu. 1980. Cyclic AMP-phospho-di-esterase activity in the testes and fat body and the effect of prostaglandins and cyclic AMP in green frog Rana hexadactyla. Indian J. Exp. Biol. 18(1):62-64.

Kasinathan, S., and S. L. Basu. 1970. Effect of stilbestrol on spermatogenesis on Rana hexadactyla. Indian Sci. Cong. Assoc. Proc. 57(4):356-357.

Kasinathan, S., and S. L. Basu. 1971. Recovery of spermatogenesis after the withdrawal of testosterone treatment in Rana hexadactyla. Acta Morphol. Acad. Sci. Hung. 19(2):151-158.

Kasinathan, S., and S. L. Basu. 1972. Effects of pituitary extracts on the spermatogenesis of the green frog Rana hexadactyla. Endocrinol. Jap. 19(1):59-67.

Kasinathan, S., and S. L. Basu. 1972. Seasonal variation and exogenous hormonal effect on the interrenal glands of Rana hexadactyla. Proc. Indian Acad. Sci., Sec. B 75(4):191-200.

Kasinathan, S., and S. L. Basu. 1973. Effect of hormones on spermatogenesis in hypophysectomized Rana hexadactyla. Acta Morphol. Acad. Sci. Hung. 21(3):249-259.

Kasinathan, S., S. L. Basu, and V. Sriramulu. 1974. Effect of pituitary extracts on the hypophyseal gonadotropes and its relation to the spermatogenesis in Rana hexadactyla. J. Exp. Zool. 187(2):233-238.

Kasinathan, S., S. L. Basu, and V. Sriramulu. 1977 (1978). Cell types of the pars distalis seasonal changes in secretory activity and effect of steroids on spermatogenesis in Rana hexadactyla. Acta Morphol. Acad. Hung. 25(1):35-50.

Kasinathan, S., S. L. Basu, and V. Sriramulu. 1979. Subtotal gonadectomy and its effect on the spermatogenesis in Rana hexadactyla. Comp. Physiol. Ecol. 4(1):7-10.

Kasinathan, S., G. A. Singh, and S. J. Basu. 1978. Adenohypophyseal histophysiology of gonadectomized fatectomized and steroid-treated male frogs, Rana hexadactyla. Acta Morphol. Acad. Sci. Hung. 26(3-4):187-196.

Kasinathan, S., G. A. Singh, and S. L. Basu. 1977. Gonadal fat body a major reproductive strategy in Rana hexadactyla. Comp. Physiol. Ecol. 4(4):201-206.

Kasinathan, S., G. A. Singh, and S. L. Basu. 1978. Fat bodies and spermatogenesis in South Indian green frog Rana hexadactyla. Boll. Zool. 45(1):15-22.

Khan, M. S. 1969. A normal table of Rana tigrina Daudin. 1. Early development (stages 1-27). Pak. J. Sci. 21(1-2):36-50.
Khan, M. S. 1973. Food of the tiger frog, Rana tigerina Daudin. Biologia (Lahore) 19(1-2):93-107.
Khan, M. S. 1976. An annotated checklist and key to the amphibians of Pakistan. Biologia (Lahore) 22(2):201-210.
Khan, M. S. 1979. Collection of amphibians from northern Punjab, Pakistan, and Azad, Kashmir, with ecological notes. Biologia (Lahore) 25(1-2):37-50.
Klemmer, L. 1975. The frog: Experimental animal or research object. Nat. Mus. 105(6):192-197.
Krishnamurthy, R., and S. G. Shete. 1981. Rectal flagellates of Indian amphibians. 3. Trichomitus aurangabadensis new species. Arch. Protistenk. 124(4):405-409.
Krishnamurthy, R., and S. G. Shete. 1981. Rectal flagellates of Indian amphibians. 2. Monocercomonas. Arch. Protistenk. 124(4):398-404.

Lakshmipathi, V., K. V. R. Rao, and K. S. Swami. 1979. Electrophoretic patterns of proteins in three species of frogs: Rana hexadactyla, Rana tigrina, Rana cyanophlyctis. Indian J. Exp. Biol. 17(3):298-300.
Lakshmipathi, V., K. S. Swami, and K. V. Ramana Rao. 1980. Properties of lactate dehydrogenase EC-1,1,1,27 isozymes in Rana hexadactyla, Rana tigrina and Rana cyanophlyctis. Proc. Indian Acad. Sci. 89(1):53-67.
Laksman, A. B. 1965. Structural changes in the pituitary glands of female frogs and toads during different seasons of the year. Acta Anat. 61:108-126.

Mansukhani, M. R., and T. S. N. Murthy. 1970. Fauna of Rajasthan India. Part 6. Amphibia. Rec. Zool. Survey India 62(1-2).
Mathur, U., and L. S. Ramaswami. 1976. Effect of cadmium on the testis of the Indian bullfrog Rana tigrina. Folia Biol. (Cracow) 24(3):285-292.
McCann, C. 1932. Notes on Indian batrachians. J. Bombay Nat. Hist. Soc. 32:152-180.
McCann, C. 1934. Occurrence of the six-toed frog (Rana hexadactyla) in the Bombay presidency. J. Bombay Nat. Hist. Soc. 37:742.
McCann, C. 1940. A reptile and amphibian miscellany. J. Bombay Nat. Hist. Soc. 42:57.
McCann, C. 1943. A "bushman's holiday" in the Abu hills. J. Bombay Nat. Hist. Soc. 43(2):206-217.
Minton, S. A., Jr. 1966. A contribution to the herpetology of West Pakistan. Bull. Amer. Mus. Nat. Hist. 134(Art. 2):1-184.
Mohanty-Hejmadi, P. 1974 (1977). Amphibian fauna of Orissa, India. Prakruti Uktal J. Sci. 11(1-2):89-98.
Mohanty-Hejmadi, P. 1974 (1977). Care and maintenance of Indian frogs, juveniles and adults. Prakruti Utkal Univ. J. Sci. 11(1-2):75-80.
Mondal, A. K. 1970. On the distribution, occurrence, culture possibilities and food of Rana hexadactyla lesson. Aci. and Cult. 36:138-143.

Mullan, J. P. 1912. The food of a bullfrog (Rana tigrina). J. Bombay Nat. Hist. Soc. 21(4):1341.
Murray, J. A. 1884. The vertebrate zoology of Sind. A systematic account. xvi+424 pp. Richardson and Co., London.
Murthy, T. S. N. 1968. On a collection of amphibians from Madras and its neighborhood. J. Univ. Poona Sci. Technol. 34:63-71.

Narasimhan, C., and D. N. Kamat. 1970. A comparative account of the distribution of mucopolysaccharides in the vertebrate adrenal medulla. Folia Histochem. Cytochem. 8(3):261-267.
Nigam, H. C. 1978. Structure and function of the glandula carotica and the glandula intercarotica in the Indian bullfrog, Rana tigrina. Zool. Anz. 201(1-2):151-157.
Nigam, H. C. 1979. Tonsils and other leukocytopoietic centers in the Indian toad Bufo melanostictus. Bioresearch (UJJain) 3(1):51-54.

Oliver, R. C. D. 1979. Wildlife conservation and management in Bangladesh. UNDP/FAO Project BGD/72/005. Field Document No. 10.

Paranjape, S. Y., and L. Mulherkar. 1979 (1980). Dry skin preparation of frogs and toads as aids for their taxonomy. J. Bombay Nat. Hist. Soc. 76(2):231-239.

Ramachandran, P. 1977. Observations on pentastomids in the reptiles of Kerala India. First contribution with notes on the cytology and transplantation of Raillietiella gehyrae in Rana hexadactyla. Zool. Anz. 198(1-2):84-88.
Ramaswami, L. S. 1962. Endocrinology of reproduction in fish and frog. Gen. Comp. Endocrinol. 2:286-299.
Rao, L. N. 1972. Egg shell formation in three trematode parasites of Rana tigrina, Varanus bengalensis and Chameleo zeylanicus. Indian Sci. Cong. Assoc. Proc. 59(Part 3):499.
Rastogi, R. K., and L. Iela. 1980. Steroidgenesis and spermatogenesis in anuran amphibia: A brief survey. G. Delrio and J. Brachet (Ed.), Steroids and their mechanism of action in non-mammalian vertebrates. xi+239 pp. Raven Press, N. Y.
Ray, R., and A. K. Mandal. 1976. Pirhemocyton ranarum, new species of protozoa from the blood of the Indian bullfrog Rana tigrina. Proc. Zool. Soc. (Calcutta) 29(1-2):67-72.
Ray, R., and A. K. Mandal. 1978 (1980). Coccidia (Protozoa:Sporozoa) of Indian amphibia. 1. Occurrence of Lankesterella minima, a hematozoan from Rana tigrina. Proc. Zool. Soc. (Calcutta) 31(1-2):85-90.
Roy, P., and B. Dasgupta. 1971. Behavior of Chrysomya megacephala and Hemipyrellia ligurriens as parasites of living animals under experimental conditions. S. Afr. J. Med. Sci. 36(4):85-91.

Saidapur, S. K., and V. B. Nadkarni. 1974. Steroid synthesizing cellular sites in the amphibian ovary. A histochemical study. Gen. Comp. Endocrinol. 22(4):459-462.

Saidapur, S. K., and V. B. Nadkarni. 1974. A study of the female reproductive cycle in two species of frogs: Rana cyanophlyctis and Rana tigrina. J. Karnatak Univ. Sci. 19:22-27.

Saidapur, S. K., and V. B. Nadkarni. 1974. Steroid synthesizing cellular sites in the amphibian ovary: A histochemical study. Gen. Comp. Endocrinol. 22(4):459-462.

Saidapur, S. K., and V. B. Nadkarni. 1975. The effect of 17-beta estradiol acetate on the testis and thumb pad of Rana cyanophlyctis and Rana tigrina. Gen. Comp. Endocrinol. 27(3):350-357.

Saidapur, S. K., and V. B. Nadkarni. 1975. Histochemical localization of 5-delta-3 beta steroid dehydrogenase glucose 6-phosphate...in testis of R. Hexadactyla and Cacopus systoma. Histochem. J. 7(6):557-561.

Saidpur, S. K., and V. B. Nadkarni. 1972. Steroidogenic sites in the testes of Rana tigrina. Indian Sci. Cong. Assoc. Proc. 59(Part 3): 468.

Seshagiri Rao, B. V., and K. Subba Raju. 1976. Large-scale incidence of sexual abnormality in the frog Rana tigrina. J. Bombay Nat. Hist. Soc. 73(1):226.

Shortridge, K. F., M. Kobayashi, A. Oya, and R. Dussan. 1977. Japanese encephalitis virus antibody in cold-blooded animals. Trans. Royal Soc. Trop. Med. Hyg. 71(3):261-262.

Shrivastava, R. K. 1975. Studies on sterol steroid biosynthesis from DOPA. Acta Histochem. 54(2):236-240.

Singh, K. 1976. Studies on the serum protei of the common Indian frog Rana tigrina. Zool. Anz. 197(1-2):39-43.

Singh, K. 1978. Studies on the blood-sugar level in Indian frog Rana tigrina. Zool. Beitr. 24(1):11-18.

Sood, P. P. 1978. Histochemical mapping on the distribution of beta galactosidase in the central nervous system of frog Rana tigrina. Cell. Mol. Biol. 23(1):21-32.

Sood, P. P. 1978. Chemoarchitectonics of the optic tectum of the frog Rana tigrina. Cell. Mol. Biol. 23(2):195-206.

Sood, P. P. 1979. The chemoarchitectonics of the diencephalon of the frog Rana tigrina. J. Neurosci. Res. 4(1):45-58.

Sood, P. P., and H. B. Tewari. 1974. Histochemical studies on the distribution of acid and alkaline phosphatases among the constituents of various layers of olfactory bulbs of frogs and toads. Zool. Anz. 193(5-6):428-440.

Suvarnalatha, M., and H. B. D. Sarkar. 1974. Effect of steroids on hemi-castration induced compensatory hypertrophy of the testis in the frog Rana hexadactyla. Horm. Metab. Res. 6(5):417-421.

Thyagaraja, B. S., and H. B. D. Sarkar. 1972. Occurrence of compensatory testicular hypertrophy in the South Indian frogs Rana hexadactyla and Rana tigrina. J. Mysore Univ., Sec. B 25(1-2): 45-49.

Varute, A. T. 1970. Histoenzymology of frog adrenal beta aglucuronidae. A histochemical model for hormone enzyme relation. Acta Histochem. 37(1):125-135.

Varute, A. T. 1970. Histoenzymology of kidney beta-glucurionidae of male frogs in seasonal breeding-hibernation cycle. Acta Histochem. 37(1):125-135.

Varute, A. T. 1971. Histoenzymorphology of beta glucuronidae in the ovary of the frog Rana tigrina during seasonal breeding-hybernation cycle. Acta Histochem. 41(2):276-292.

Varute, A. T. 1971. Histoenzymorphology of beta glucuronidase in the spermatogenetic epithelium, Leydig cells and Sertoli cells of the frog testes in seasonal breeding-hibernation cycle. Acta Histochem. 41(2):256-275.

Varute, A. T. 1972. Histoenzymology of glucuronidase in the Leydig cells of testes of the frog Rana tigrina and its relation to their annual secretory cycle. Folia Histochem. Cytochem. 10(2):181-192.

Varute, A. T. 1972. Beta glucuronidase in testes and ovaries of the frog Rana tigrina. A correlation of observations on histochemistry and biochemistry. Acta Histochem. 42(1):77-78.

Varute, A. T. 1972. Histoenzymology of beta glucuronidase in the Leydig cells of the testes of the frog Rana tigrina and its relation to their annual secretory cycle. Folia Histochem. Cytochem. 10(2):181-192.

Venkateswarlu, T., and T. S. N. Murthy. 1972 (2974). Fauna of Bihar State India. Part 2. Amphibia. Indian J. Zootomy 13(3):129-130.

Venugopal, Reddy S., I. G. Samuel, and Mohan K. Raja. 1980. Effect of steroid hormones on the levels of serum calcium cholesterol and glucose in the Indian bullfrog Rana tigrina during pre-spawning period. Indian J. Exp. Biol. 18(7):740-741.

Wadekar, U. L. 1963. The diet of the Indian bullfrog (Rana tigrina Daud.). J. Bombay Nat. Hist. Soc. 60(1):263-268.

Zutshi, B. N. 1926. A bullfrog (Rana tigrina) swallowing a rat. J. Bombay Nat. Hist. Soc. 31(1):228.