Plants, CSIR, New Delhi, 1956, p. 179.
24. Jain, S. K., *Dictionary of Indian Folk Medicine and Ethnobotany*, Deep Publications, New Delhi, 1991, p. 133.
25. Iyer, T. G. R., *Handbook of Indian Medicine, The Genesis of Siddha System*, Sri Satguru Publication, 1981, pp. 432–433.
26. Badam, L., Deolankar, R. P., Rojatkar, S. R., Nagsampgi, B. A. and Wagh, U. V., *Indian J. Med. Res.*, 1988, **87**, 379–383.
27. Mishra, P., Pal, N. L., Guru, P. Y., Katiyar, J. C. and Tandon, J. S., *Int. J. Pharmacol.*, 1991, **29**, 19–23.
28. Chopra, R. N., Chopra, I. C., Handa, K. L. and Kapoor, L. D., *Indigenous Drugs of India*, U.N. Dhar & Sons Pvt. Ltd, Calcutta, 1958, p. 519.
29. Doreswamy, R. and Sharma, D., *Indian Drugs*, 1995, **32**, 139–154.
30. Mohanty, R. B. and Padhy, S. N., *Ethnobotany*, 1996, **8**, 60–65.
31. Tona, L. *et al.*, *J. Ethnopharmacol.*, 1999, **68**, 193–203.

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Food of the snail, *Pomacea bridgesi*, introduced in India

Ampullariid snails (*Pomacea bridgesi*) are polyphagous as well as voracious in nature[1]. Because of their feeding habit, they compete with some of the indigenous species in many countries where they have been introduced[2–7]. In some cases the indigenous species have failed to survive due to severe competition with these snails[6]. These snails (*P. bridgesi*) have been introduced in India[8] in recent years in connection with aquarium trade and there exists every possibility of their escape from the aquaria to the open-air water bodies. Hence an attempt was made to gain knowledge on their foods in India, experimentally, under laboratory conditions with a view to apprehend possible impact of *P. bridgesi* on the natural community concerned.

Three glass aquaria, each measuring $30 \times 20 \times 26$ cm were taken for the experiment. Each aquarium was filled with pond water up to 23 cm of its depth. A total of 30 snails, 10 belonging to each of the three groups – juvenile (14–16 mm), sexually mature (30–32 mm) and aged (38–40 mm) *P. bridgesi* individuals, were released into the aquaria separately as regards to the group. The snails were fed with lettuce (*Lactuca sativa*) for a week. Thereafter, different kinds of food in different states (Table 1) were supplied to these snails, either singly or in different combinations *ad libitum*. In all cases observations were continued for a period of 10 days. To get the required amount of food according to specifications, necessary steps were taken to maintain the stock in the laboratory. The water along with the faecal pellets and the leftover food materials, skeletons, bones and dead snails if any, was removed from the aquarium regularly at an interval of 24 h.

P. bridgesi, irrespective of their groups, exhibited similar type of food selection and feeding (Table 1). In all cases, animal food was preferred to plant food. However, *Tubifex* sp. and *Branchiodrilus* sp. preferred semi-decomposed food over fresh ones of the same kind. *Tubifex* and *Branchiodrilus* were equally preferred by *P. bridgesi*, though the live individuals were consumed prior to dead ones. Dead earthworms were always eaten first in presence of live and/or dead *Tubifex* and *Branchiodrilus*. The semi-decomposed prawn (decapods) and molluscan flesh, irrespective of species, was preferred to oligochaete worms. The flesh of prawns and molluscs was equally acceptable to *P. bridgesi*. The order of preference for the fishes was: *Setipinna phasa* > *Xenentodon cancila* > *Puntius ticto* > *Colisa fasciatus* > *Ambylopharyngodon mola* > *Labeo rohita* > *Labeo bata*. The fishes, irrespective of species, were consumed first in presence of prawn and molluscan flesh. *Gallus gallus* was preferred to *Capra hircus*. The order of preference for plant foods was: *L. sativa* > *Solanum tuberosa* > *Rumex vascicarius* > *Brassica juncea* > *Raphanus sativus*. *Cobamba* sp. and *Eichhornia crassipes* were equally preferred.

The results indicate that the snails, *P. bridgesi*, have a wide range of food acceptability. These snails would find no problem to establish their colony in India. Consequently, the native macrophytophagous, zoophagous and microphagous species would face severe competition for food, if *P. bridgesi* find access to the natural water bodies. This may lead to extinction of some indigenous species as is evident from the disappearance of different species belonging to the genus *Pila* in certain parts of south-east Asia[5]. Besides, in the long run, to meet their need they may start feeding on the paddy plants, as has been noted in some countries where

Table 1. Mode of feeding in *Pomacea bridgesi*, following supply of different kinds of food, experimentally, in the laboratory

		Food supplied		
		State		
Species	Part	Fresh/live	Freshly dead	Semi-decomposed
Plants				
Weeds				
Cobamba sp.	Whole plant	Devoured completely	–	Devoured completely
Eichhornia crassipes	Whole plant	Devoured completely	–	Devoured completely
Garden vegetation				
Brassica juncea	Leaves	Devoured completely	–	Devoured completely
Lactuca sativa	Whole plant	Devoured completely	–	Devoured completely
Raphanus sativus	Leaves	Devoured completely	–	Devoured completely
Rumex vasicarius	Whole plant	Devoured completely	–	Devoured completely
Solanum tuberosa	Slices of the bulb	Devoured completely	–	Devoured completely
Animals				
Oligochaetes				
Tubifex sp.	Whole animal	Devoured completely	Devoured completely	Devoured completely
Branchiodrilus sp.	Whole animal	Devoured completely	Devoured completely	Devoured completely
Metapheria pagura	Whole animal	Devoured completely	Devoured completely	Devoured completely
Decapods				
Macrobrachium rosenbergi	Whole animal	Did not attack	Devoured completely, except the exoskeleton	Devoured completely, except the exoskeleton
M. dayanum	Whole animal	Did not attack	Devoured completely, except the exoskeleton	Devoured completely, except the exoskeleton
Palaemon (Exopalaemon) styliferus	Whole animal	Did not attack	Devoured completely, except the exoskeleton	Devoured completely, except the exoskeleton
Penaeus indicus	Whole animal	Did not attack	Devoured completely, except the exoskeleton	Devoured completely, except the exoskeleton
Molluscs				
Indoplanorbis exustus	Whole animal	Did not attack	Devoured completely	Devoured completely
	Eggs	Devoured completely	NS	NS
Lamellidens marginalis	Whole animal	Did not attack	Devoured completely	Devoured completely
Lymnaea (Radix) luteola	Whole animal	Chased	Devoured completely	Devoured completely
	Eggs	Did not attack	NS	NS
Fishes				
Ambylopharyngodon mola	Whole animal	NS	Devoured completely, except the skeleton	Devoured completely, except the skeleton
Colisa fasciatus	Whole animal	NS	Devoured completely, except the skeleton	Devoured completely, except the skeleton
Labeo bata (fingerlings)	Whole animal	Did not attack	Devoured completely, except the skeleton	Devoured completely, except the skeleton
L. rohita (fingerlings)	Whole animal	Did not attack	Devoured completely, except the skeleton	Devoured completely, except the skeleton
L. rohita (cut pieces)	Pieces of flesh with skeleton	–	Devoured completely, except the skeleton	Devoured completely, except the skeleton
Puntius ticto	Whole animal	Did not attack	Devoured completely, except the skeleton	Devoured completely, except the skeleton
Setipinna phasa	Whole animal	NS	Devoured completely, except the skeleton	Devoured completely, except the skeleton
Xenentodon cancila	Whole animal	NS	Devoured completely, except the skeleton	Devoured completely, except the skeleton
Birds				
Gallus gallus	Cut pieces of meat with bones	Devoured completely, except the bones	–	Devoured completely, except the bones
Mammals				
Capra hircus	Cut pieces of meat with bones	Devoured completely, except the bones	–	Devoured completely, except the bones

NS, not supplied.

P. bridgesi has been introduced[5,6]. Therefore, adequate measure is urgently needed to stop their access into the open-air water bodies in India.

1. Cazzaniga, N. J. and Estebenet, A. L., *Hist. Nat.*, 1984, **4**, 213–214.
2. Anon, *Agric. Res.*, 1967, **11**, 8–9.
3. Cazzaniga, N. J. and Estebenet, A. L., *Revta Malezas*, 1985, **13**, 23–29.
4. Cazzaniga, N. J., *Ann. Trop. Med. Parasitol.*, 1990, **83**, 97–100.
5. Acosta, B. O. and Pullin, R. S. V., *Environmental Impact of Golden Snail (Pomacea* sp.) *on Rice Farming Systems in Philippines*, Freshwater Aquaculture Centre, Central Luzon State University, Munoz, Nueva Ecija, Philippines and International Centre for Living Aquatic Resources Management, Manila, Philippines, 1991, p. 34.
6. Godan, D., *Pest Snails and Slugs*, Springer-Verlag, Berlin, 1983, p. 445.
7. Cowie, R. H., *J. Med. Appl. Malacol.*, 1993, **5**, 61–67.
8. Raut, S. K. and Aditya, G., *Curr. Sci.*, 1999, **77**, 1389–1390.

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Endurance exercise-induced alterations in antioxidant enzymes of old albino male rats

Antioxidant defence prevents the formation of active oxygen radicals and lipoperoxides and the antioxidant capacity decreases[1] with advancement of age. This increased production of reactive oxygen species with age leads to oxidative damage and mutations in DNA molecules. These damaged molecules transcribe and translate to produce dysfunctional protein subunits that give rise to defective enzymes[2].

Normally the free radicals that are generated are disposed off quickly by antioxidant defence system (ADC) present in cells. The ADS consists of free-radical scavenging enzymes like MnSOD, Cu, ZnSOD, catalase and antioxidants such as reduced glutathione (GSH), vitamin C, vitamin E, etc. An imbalance caused by increased generation of free radicals and decreased functional efficiency of ADS has been suggested to be one of the primary factors that contributes to the aging process[3]. An acute bout of exercise is known to increase the activities of antioxidant enzymes, including SOD and catalase in the tissues of rat[4–7]. The threshold and magnitude required for activation appear different among different enzymes and tissues. The studies on the impact of age and exercise on these enzymes are limited. In the present study an attempt has been made to know the effect of endurance exercise on free-radical scavenging enzymes in the tissues of old albino rats.

Healthy male albino rats (Wistar) were maintained in the animal house at 30 ± 2°C with photoperiod of 12 h light and 12 h darkness and fed standard rat diet supplied by Hindustan Lever Limited, Mumbai, India and water *ad libitum*.

The age-matched rats were divided into two batches of six each. One batch of rats was subjected to treadmill exercise, 30 min/day, maintaining a running speed of 23 m/min for 5 days/week for 12 weeks. The other batch of animals served as control. Both sets of rats were sacrificed by cervical dislocation 48 h after completion of exercise protocol. Liver, brain and heart were excised at 4°C and weighed immediately and homogenized in specified media.

The lipid peroxides (LP) were determined by the TBA method of Hiroshi *et al.*[8]. Xanthine oxidase (XOD) activity was estimated by the dye reduction method of Srikanthan and Krishna Murthy[9]. Superoxide dismutase (SOD) was assayed according to the method of Beauchamp and Fridovich[10]. Catalase (CAT) activity was measured by the method of Chance and Machlin[11].

Table 1 presents the changes in the activity levels of SOD, catalase, xanthine oxidase and lipid peroxides in liver, brain and heart of rats as a function of age and endurance exercise. The results indicated a drop in the activity levels of free-radical scavenging enzymes (SOD, catalase) with advancement of age. Three months endurance exercise to the rats reversed the age-induced changes in the activities of these enzymes almost to normal level.

The levels of XOD activity and lipid peroxides, the major indicators of oxidative stress, were found to increase in the tissues with age and exercise training caused further elevation in the activity.

Xanthine oxidase generates superoxide radicals during the reduction of O_2 to H_2O_2 and an age-related increase in the activity of XOD was observed in the present study (Table 1). The increase in enzyme activity with age shows increased production of oxygen radicals during aging. Further elevation in the activity levels of enzyme was observed due to exercise-induced oxidative stress and consequent increase in the production of radicals in the rat tissues. Xanthine oxidase was more in the tissues of young rats which were studied than in old rats, after three months exercise.

Lipid peroxidation is a complex process and the cell membranes enriched with PUFAs are more prone to lipid peroxidation, resulting in the loss of their fluidity and permeability properties leading to tissue damage in old