Figure 1. *Piper sarmentosum* Roxb. (procumbent branches with a runner).

The taxonomic description is as follows: *P. sarmentosum* Roxb. ex Hunter, Fl. Indica 1 : 162. 1820; *P. longum* (*auct. non.* L.) Fl. Brit. India *l.c.* 5 : 83.

Glabrous, creeping, terrestrial herbs with procumbent branches. Leaves 6–16 cm × 5–9 cm, thin, lower leaves usually ovate–cordate, upper leaves rather oblong or ovate–oblong, ovate to obliquely or rounded at base, shortly acuminate at apex, 5–7 radiating nerves from base, dark-green above; petiole 2.5–5 cm long. Spikes short, dense, blunt, cylindric in procumbent branches; male flowers 0.7 cm long, female flowers 0.7 cm long; bracts more or less circular, white, stamens short, stigma 3 to 4; fruit obovoid 1.5 cm × 1 cm, sweet to taste.

P. sarmentosum Roxb. has earlier been reported from the tropical belt of the Indo-Malaysian region, from Northeast India to South China and Malaysia. The recent discovery of this species from the Andaman Islands has much relevance in the study of phytogeography. The species is found along the edges of semi-evergreen type forests at the sea level. Live specimens of this species collected from the North Bay have been introduced into the Field Gene Bank of Tropical Botanic Garden and Research Institute, Thiruvananthapuram, as a part of the conservation programme of Andaman species undertaken by the Institute. The species has good ornamental value and can be grown in pots as bush pepper by pruning the creeping branches. The bushy, procumbent branches are 40–50 cm in height and fruiting season is usually during October–December.

Specimen examined: South Andamans, Mount Harriet, North Bay; 12. 11. 1992, S.P. Mathew 20882 (PBL, TBGT & L).

1. Airy Shaw, H. K., *A Dictionary of the Flowering Plants and Ferns*, Cambridge University Press, 1973, p. 905.
2. Vasudeva Rao, M. K., *J. Econ. Tax. Bot.*, 1986, **8**, 107–184.
3. Kurz, W. S., *J. Asiat. Soc. Bengal*, 1876, **45**, 105–164.
4. Sreekumar, P. V. and Ellis, J. L., *J. Andaman Sci. Assoc.*, 1990, **6**, 105–106.

ACKNOWLEDGEMENTS. We thank Dr M. M. J. van Balgooy, Rijksherbarium, Leiden, The Netherlands for confirmation of identification and the Department of Biotechnology, Government of India for financial assistance towards the National Gene Bank for Medicinal and Aromatic Plants.

Received 2 January 2004; revised accepted 25 March 2004

SAM P. MATHEW*
A. MOHANDAS
G. M. NAIR

Tropical Botanic Garden and Research Institute,
Palode,
Thiruvananthapuram 695 562, India
**For correspondence.*
e-mail: sampmatthew@rediffmail.com

Glossiphonia weberi, an effective predator of the freshwater limpets *Ferrissia baconi*

Even after suspecting the involvement of *Ferrisia tenuis* with the spread of schistosomiasis in human beings in Gimvi village, Ratnagiri district, Maharashtra[1,2], no attention has been paid so far to study the bioecology of limpets occurring in India. Since limpets are prone to serve as intermediate host of the worm parasite *Schistosoma haematobium*, it is essential to develop strategies to control them. In recent years, we have had the opportunity to observe predation of the freshwater glossiphoniid leeches *Glossiphonia weberi* on the limpet *F. baconi* occurring in Dhakuria lake, Kolkata. As an individual leech was seen to destroy the limpet by way of feeding on the same, we carried out experiments to judge the efficacy of *G. weberi* in monitoring the *F. baconi* population, with a view to utilize these predators as biological control agents against any of these limpet species, if needed, in future. The results are presented here.

G. weberi and *F. baconi* were collected from Dhakuria lake. They were kept separately in aquaria. After 2 days they were measured and the leeches were grouped into five size-classes, viz. 2–3, 4–5, 6–7, 8–9 and 10–11 mm with respect to their total body length at rest, while the limpets were grouped into three size-classes, viz. ≤ 2, 2.1–3 and 3.1–4 mm on the basis of their shell length. Plastic containers, each measuring 72 mm in diameter and 32 mm in depth, and containing 100 ml pond water were used to carry out the following experiments with a view to note the rate of predation of *G. weberi* on *F. baconi* during the period of 24 h of a day.

Experiment I: Fifteen limpets belonging to a size-class (either ≤ 2, 2.1–3 or 3.1–4 mm) were exposed to a leech belonging to a particular size-class (either 2–3, 4–5, 6–7, 8–9 or 10–11 mm).

Experiment II: Fifteen limpets belonging to all the three size-classes (≤ 2, 2.1–3, 3.1–4 mm) in different combinations, taking at least two but never more than ten individuals from a size-class together were used.

Control experiments were carried out simultaneously to note the normal mortality in *F. baconi* with a view to determine the actual rate of predation. In all cases equal numbers of *F. baconi* accord-

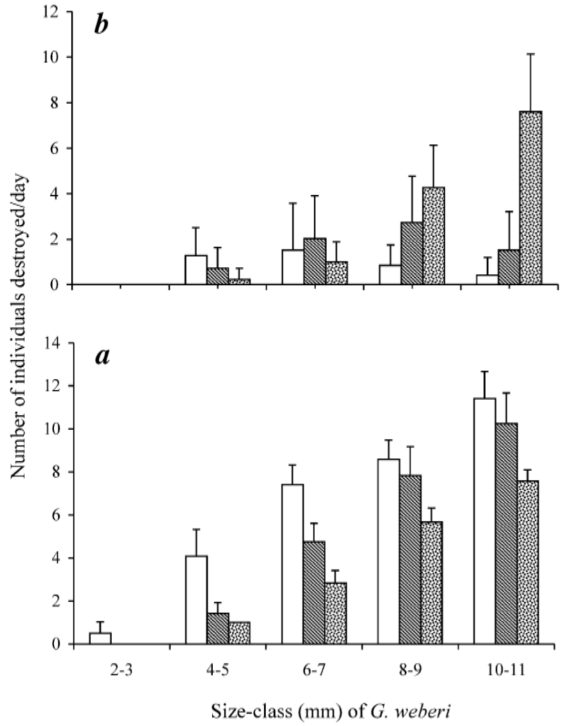

Figure 1. Daily rate (mean ± SE) of predation by a *G. weberi* belonging to different size classes on *F. baconi* belonging to size-classes ≤ 2 mm (□), 2.1–3.0 mm (▦) and 3.1–4.0 mm (▦) when supplied separately with regard to size-class (***a***) and mixed size-classes (***b***) in different combinations. SE bar is omitted when the value is zero.

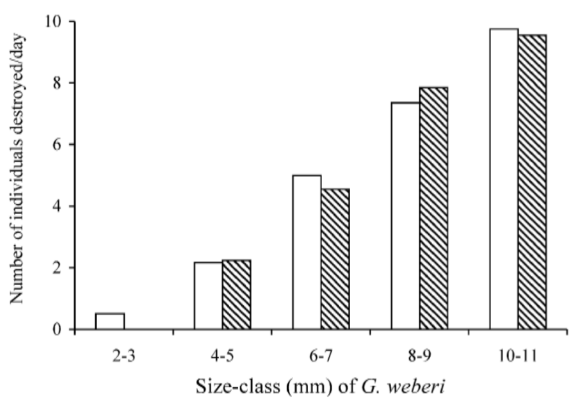

Figure 2. Comparative account of mean rate of daily predation by a *G. weberi* belonging to different size-classes with respect to supply of prey limpet *F. baconi* belonging to size-classes, ≥ 2, 2.1–3.0 and 3.1–4.0 mm separately (□) and together as mixed size-classes (▦) in different combinations.

ing to size-group specifications with respect to the experimental set-up were kept in plastic containers of similar specifications.

The water in the experimental containers was changed with fresh pond water, daily at an interval of 24 h. The number of limpets destroyed was counted and noted at the end of every 24 h. In case of experiment II, measurement of the length of the shells dropped down following predation was taken at the time of data collection and recorded to note the rate of predation with respect to the size of the prey individuals concerned. In experiment I, a total of 180 trials, 36 with each size-class of leech, while in experiment II, a total of 165 trials, 33 with each size-class of leech were performed. Mean and standard errors (SE) were determined with respect to the data obtained in these two experiments. In experiment II, the total number of limpets destroyed by a leech in 33 trials was counted and noted with respect to the size-classes considered on the basis of shell length of *F. baconi* dropped down following predation by the leech. The mean (± SE) rate of predation per trial (24 h) by a leech with respect to the size-classes of *F. baconi* was determined to present the data. Randomized block design analysis of variance (ANOVA) was applied[3] to justify the effects of size of the leech and the limpets on the rate of predation. One-way ANOVA was applied[4] to justify the differences in the rate of predation on the prey individuals belonging to the size-classes concerned, in experiments I and II. The method of Rapport and Turner[5] was followed to determine the relative preference coefficients for the size classes of *G. weberi* with respect to the *F. baconi* individuals supplied.

In control trials, not a single *F. baconi* died. In both the experiments (I and II), *G. weberi* except the size-class 2–3 mm, destroyed *F. baconi* by way of swallowing the whole organic soft mass in different numbers daily (Figure 1 *a* and *b*). Though *G. weberi* (2–3 mm) was able to capture prey individuals belonging to ≤ 2 mm size-class offered in experiment I, it failed to handle the prey individuals belonging to the remaining two size-classes. In experiment I, in all the trials *F. baconi*, irrespective of size-class was free from destruction while exposed to 2–3 mm *G. weberi* (Figure 1 *a* and *b*). Results of ANOVA tests indicate that the size-classes of both the predator and prey (Figure 1 *a*) have significant effect on the rate of predation, though the size of predator has a bigger effect ($F = 62.56$, $df = 4$, $P < 0.001$) than the size of the prey individuals ($F = 15.62$, $df = 2$, $P < 0.001$). At a glance, the mean rate of predation exhibited by a *G. weberi* with respect to the prey individuals supplied, in the experiments concerned, could be seen from Figure 2. From the ANOVA tests it is evident that the rate of predation differs significantly ($F = 347.76$, $df = 3$, $P < 0.001$) with the size of the concerned prey individuals.

The relative preference for *F. baconi* belonging to different size-classes by a *G. weberi* varied to a great extent with respect to its own size (Table 1). Since

Table 1. Relative preference coefficient for size classes of *G. weberi* (p_{12} = relative preference coefficient for size class ≤ 2 mm compared with size-class 2.1–3.0 mm; p_{13} = relative preference coefficient for size-class ≤ 2 mm compared with size class 3.1–4.0 mm; p_{23} = relative preference coefficient for size class 2.1–3.0 mm compared with size class 3.1–4.0 mm) with respect to predation on the three size classes (p_1 = ≤ 2 mm, p_2 = 2.1–3.0 mm, p_3 = 3.1–4.0 mm) of *F. baconi*

	Size-class (mm) of *G. weberi*				
	2–3	4–5	6–7	8–9	10–11
p_{12}	0	–3.08	–1.03	–0.27	–0.29
p_{13}	0	–5.07	–2.99	1.41	1.27
P_{23}	0	1.99	1.96	1.14	–0.98

relative preference coefficients can range from 0 to – 2 for negative preference and from 0 to + 2 for positive preference, it is evident that the leech preferred ≤ 2 mm *F. baconi* over 2.1–3 mm individuals, and 2.1–3 mm *F. baconi* over 3.1–4 mm individuals.

Though leeches are habituated to suck blood or haemolymph from the body of their prey individuals they are also adapted to swallow the living prey organisms as a whole as is evident by the dropping of shells of the limpets in the containers following predation by *G. weberi*. This sort of feeding has also been noted by Kutschera[6] in the leech *Erpobdella octoculata*, while feeding on *Chiromonus* larvae. However, whatever be the mode of feeding, *G. weberi* is undoubtedly a potential predator of *F. baconi*. It is most likely that these leeches would prove effective if they are considered as biological control agents for medically important limpets, be it *F. tenuis* or other species occurring in the tropical zone.

1. Gadgil, R. K. and Shah, S. N., *Indian J. Med. Res.*, 1955, **43**, 695–701.
2. Subba Rao, N. V., *Handbook: Freshwater Molluscs of India*, Zoological Survey of India, Kolkata, 1989, p. 289.
3. Bailey, N. T. R., *Statistical Methods in Biology*, Cambridge University Press, Cambridge, 1995, 3rd edn, p. 255.
4. Campbell, R. C., *Statistics for Biologists*, Cambridge University Press, Cambridge, 1989, 3rd edn, p. 446.
5. Rapport, D. J. and Turner, J. E., *J. Theor. Biol.*, 1970, **26**, 365–372.
6. Kutschera, U., *Int. Rev. Hydrobiol.*, 2003, **88**, 94–101.

ACKNOWLEDGEMENT. We thank the Head, Department of Zoology, University of Calcutta for the facilities provided.

Received 12 February 2004; revised accepted 1 April 2004

G. ADITYA
S. K. RAUT*

Ecology and Ethology Laboratory,
Department of Zoology,
University of Calcutta,
35, Ballygunge Circular Road,
Kolkata 700 019, India
**For correspondence.*
e-mail: jayantadhar@vsnl.net

Natural gas at shallow depth in the placer sands of Amalapuram coast, East Godavari district, Andhra Pradesh

The Krishna–Godavari basin (KG basin) is located in the central part of the eastern passive continental margin of India that is known for its hydrocarbon potential since the last two decades. Exploration by ONGC in this area has resulted in the estimation of about 1060 million tonnes of hydrocarbon resources[1]. Large accumulations of biogenic gas are found in Montana, USA and Saskatchewan, Canada[2].

The Atomic Minerals Directorate for Exploration and Research (AMD) has been actively involved in the exploration of heavy mineral-bearing beach placers along the east coast in general, and KG basin in particular. Exploration (field season 2000–01) of heavy minerals along the coastal tract between Goutami and Vainateyam Godavari rivers, a part of the KG basin, near Amalapuram was undertaken by Dormer drill machine which is operated manually, to a maximum depth of 15–18 m in the beach sands (Nageswara Rao and Desapati, T., unpublished AMD report, 2001). During the course of drilling near Amalapuram Engineering College (lat 16°25′44.3″N; long 81°59′04.7″E; Toposheet no. 65 H/15; Figure 1), which is 1.6 km away from the present-day coast, natural gas (highly combustible) was encountered in a borehole at a depth of 7.5 m.

To confirm the inflammability of this gas, it was lit with a matchstick. Two more boreholes were drilled 15 m away from the first borehole, covering about 30 m^2 area, in which also natural gas was observed at the same depth. The burning of gas was observed for about 20 min with normal pressure and gas emanation appears to be a continuous phenomenon. The flame was extinguished by covering the hole with mud and sand. The litholog of the borehole is also shown in Figure 1. The natural gas was observed after puncturing the silty layer at 7.5 m depth in all the three boreholes. The production wells of ONGC are located far away from this locality, where oil and gas occur at a depth of more than 1650 m.

During the current field season (2003–04) also, while carrying out heavy mineral exploration in the Amalapuram coast, we have observed natural gas that was intercepted at the same depth in five boreholes that were spread over a kilometre length oriented in NE–SW direction; the gas was collected in bottles and handed over to ONGC for analyses, to know whether the gas is biogenic or thermogenic. Analysis of the gas is given in