Table 1. Species of fish and percentage mortality caused by *Cryptocaryon irritans* in marine aquaria

Total Species	Number number	Number affected	Mortality dead	(%)
Chaetodon collaris	40	40	20	50
octofasciatus	8	8	8	100
Chaetodon sp.	5	5	5	100
Acanthurus sp.	35	35	20	57
Lutianus rivularis	27	27	25	93
Pomocanthoides annularis	1	1	1	100
Lethrinus sp.	50	50	2	4
Carangid	1	1	1	100
Plectorhincus sp.	20	20	12	60
Box fishes	10	8	—	—
Cow fishes	8	5	—	—

treatment was continued for five days, no further mortality of fish was observed. Flush treatment with copper sulphate was also continued for five days. All the box fishes, cow fishes and *Lethrinus* sp. which were infected could thus be completely saved from aggravation and became normal. Although a few of the treatment patterns by chemical, physical and other means were suggested earlier[1,2,8], this new method of antibiotic and copper sulphate is useful as it controlled both the bacterial and ciliate infections.

Analyses of the enzootic in this study indicate that the following environmental and other parameters could help in the onset and spread of Cryptocaryonisis in marine aquarium: (i) introduction of infected fish in any one of the aquarium during recent collections; (ii) crowding of fish, which reduces the host resistance and favours the spread of disease; (iii) lowering of salinity owing to the monsoon. This coupled with the drawing of water from the vicinity of the aquarium drainage whenever possible, initial excystment and release of tomites could also have aggravated the spread of the disease.

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1. Sinderman, C. J., *Principal Diseases of Marine Fish and Shellfish*, Academic Press, New York, 1970, pp. 369.
2. Kinne, O. (ed), *Diseases of Marine Animals*, Part – I. Pisces, Biologische Austalt Helgoland, Hamburg, 1984, vol. IV, pp. 541.
3. Brown, E. M., *Proc. Zool. Soc. London*, 1951, **120**, 11, 1–2.
4. Brown, E. M., *1st International Congress on Protozoology, Prague*, Aug. 1961, Academic Press, New York, 1963, pp. 284–287.
5. Cheng, P. J., Nigrelli, R. F. and Ruggieri, G. D., *J. Fish Dis.*, 197?, **2**, 93–97.
6. Chinabut, S. and Danayadol, Y., in *Fish Quarantine and Fish Diseases in Southeast Asia* (eds Oswald, E. and Huise, J. H), Report of a workshop held in Jakarta, Indonesia, 7–10 Dec. 1982. UNDP/FAO/IDRC/ pp 64–67.
7. Colorni, A., *Dis. Aquat. Org*, 1985, **1**, 19–22.
8. Colorni, A., *Aquaculture*, 1987, **67**, 1, 236–237.
9. Roberts, R. J. (ed), *Fish Pathology*, Bailliere Tindall, London, 1978, pp. 318
10. Laird, M., *Aspects of Fish Parasitology*, Proc. Second Joint Symp. Sci. Soc. Malaya Malayan Math. Soc., 1956, pp. 46–54.
11. Nigrelli, R. F. and Ruggieri, G. D., *Zoologia. NY*, 1966, **51**, 97–102.

Mineral composition of different regions of the scale of an endangered fish *Tor putitora* (Hamilton) using energy-dispersive X-ray microanalysis technique

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Presence of Ca, P, Al and Fe has been recorded in the fish scale. It has been observed that the fall in the level of Fe and increase in Ca result in the formation of an annulus in *Tor putitora* (Hamilton) from Gobindsagar. The rolling of the margin of the scale appears to be related to the excess deposition of Al.

SCALES of fishes have been employed in the identification[1–3], life history[4] and growth studies[5,6]. It is generally considered to be a calcified structure. The number of scales on a fish's body remains constant. Therefore, with the increase in body size, the scales grow. Hence, a straight line relationship exists between the total fish length and the scale radius with high degree of correlation coefficient in majority of Indian freshwater fishes[5,6].

Scales of golden mahseer *Tor putitora* (Hamilton), an endangered species, have been reported to be as big as the

Table 1. Mineral composition expressed in weight per cent of different parts of the scale of *Tor putitora* (Hamilton)

Mineral	Anterior circuli	Intercirculus space	Posterior circuli	Annulus	Scale margin	Mean and SD
Ca	45.20	37.79	38.02	52.79	35.72	41.90 7.60
Al	8.45	10.50	16.21	14.00	25.68	14.97 6.70
P	27.85	27.89	24.41	28 92	27.54	27.32 1.70
Fe	18.50	23.81	21.36	4 29	11.06	15.80 8.02

SD, Standard deviation.

size of a palm[7]. Its cycloid scale has been successfully employed for age determination and growth studies[8, 9]. Information regarding its mineral composition in different regions and the minerals responsible for annulus formation is lacking.

To determine the mineral composition of different parts of the scale of *T. putitora* from Gobindsagar, such as anterior circuli, intercirculus space, posterior circuli, annulus and the margin, energy-dispersive X-ray micro-analysis (EDX) was done. A scale was removed from below the dorsal fin above the lateral line from the second row. This dried scale was cut into small pieces and dust particles were removed by placing the pieces in a sonicator for 10 min, then air-dried and mounted on a carbon stub keeping the dorsal surface facing upward. The mineral composition of different regions was determined by adjusting the scanner of Kevex Delta Class Analyser attached to JEOL JSM 255 scanning electron microscope for 50 s. The material was studied in vacuum of the order of 10^{-4} Torr at an accelerating current of 20 kV at a magnification of 1000×. The data were analysed using a DEC LSI 11/23 Minicomputer with 0.5 MB memory and displayed on the screen.

The scale contains four minerals, viz. Ca, P, Al and Fe. Regionwise analysis (Table 1) indicated that annular zone has the maximum concentration of Ca and minimum of Fe, Al being maximum on the scale margin and minimum in the circuli. Maximum deposition of Fe was recorded in the intercirculus space and an almost similar amount in the posterior circuli immediately behind the focus of the scale, whereas minimum amount of this mineral was recorded in the annular zone. The concentration of P in all the regions of the scale does not show much variation. From the above account it can be inferred that the annulus formation in *T. putitora* is due to the maximum deposition of Ca and minimum of Fe. The brittleness of the margin of the scale is due to high deposit of Al. The anterior circuli have moderate amounts of all elements. Hence, it can be concluded that 'circuli' or 'growth rings' are formed when all the elements are added to them in optimum amount, whereas 'check' or 'break' or 'annulus'[10] is formed either due to excess deposition of Ca or low deposition of Fe.

It may be stated that Van Oosten[11] described Ca, Mg and P as major mineral constituents of the scales of *Cyprinus* and *Labeo* along with traces of Na and S[11].

Formation of an annulus on the scales of commercial carps has hitherto been attributed to several factors such as low feeding intensity, spawning, change in electrical conductivity of water and water temperature[12–14]. It is possible that these biotic and abiotic factors result in the disproportionate occurrence of the recorded elements, leading to annulus formation (breaking up of the circuli) in *T. putitora* from Gobindsagar.

1. Lagler, K. F., *Freshwater Fishery Biology*, Wm. C Brown Company Dubuque, Iowa, USA, 1956, p. 421.
2. Tandon, K. K. and Sharma S. K., *Vestn. Cesk. Spol. Zool.*, 1977, **41**, 218–222.
3. Matsui, I., *J. Schimonoseki Coll. Fish.*, 1949, **1**, 33–49.
4. Creaser, C. W., *Misc. Publs. Univ. Michig. Mus. Zool.*, 1926, **17**, 1–82.
5. Johal, M. S. and Tandon, K. K., *Fish. Res*, 1992, **14**, 83–90.
6. Johal, M. S. and Kingra, J S., *Himalayan J. Env. Zool*, 1992, **6**, 1–6.
7. Norman, J. R., *A History of Fishes*, Revised by P. H. Greenwood, 3rd edn, Ernest Benn Ltd., 1977, p. 467.
8. Tandon, K. K., Johal, M. S. and Kaur, J., in: *Advances in Limnology* (ed. Singh, H. R.), Narendra Publishing House, 1993, p. 366.
9. Tandon, K. K. and Johal, M. S., *Indian J. Fish.*, 1983, **30**, 171–175.
10. Chugunova, N. I., *Age and Growth Studies in Fish*, National Science Foundation, Washington, 1963, p. 132.
11. Van Oosten, J., in *The Physiology of Fishes* (ed Brown M. E.), Academic Press, New York, 1957, p. 447.
12. Jhingran, V. G., *Nature*, 1957, **79**, 468–469
13. Menon, M. D., *J. Bombay Nat. Hist. Soc.*, 1953, **51**, 623–635.
14. Johal, M. S. and Tandon, K. K., *Vestn Cesk. Spol. Zool.*, 1987, **51**, 252–280.

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