Epidemiological analysis of epizootic ulcerative syndrome of fresh and brackishwater fishes of Karnataka, India

C. V. Mohan and K. M. Shankar
Department of Aquaculture, College of Fisheries, Mangalore 575 002, India

Epizootic ulcerative syndrome (EUS) has been causing large scale mortality of fresh and brackishwater fishes in several parts of south and south-east Asia since the early 1980s. It is an infectious disease of mixed etiology. EUS first surfaced in India in 1989 in the north-eastern states and then extended its range to become a serious menace to fresh and brackishwater fishes in several parts of the country. We present the epidemiological analysis of EUS in Karnataka and an overview of the current status of knowledge on EUS.

THE dreaded epizootic ulcerative syndrome (EUS) has taken a heavy toll of fresh and brackishwater fishes of India since 1989. A similar disease made its first appearance in Central Queensland, Australia in 1972[1]. Since 1979, EUS has spread unabated throughout south and south-east Asia posing a serious problem in fresh[2] and brackishwater[3] fisheries. The disease starts off as tiny red spots or lesions on the body surface of affected fishes. Gradually these lesions ulcerate to become very large and deep on various parts of the body. The disease invariably kills the affected fishes in a short time affecting a wide host range[4]. Several laboratories in south and south-east Asia, Australia and United Kingdom are actively working on EUS since its appearance. Virus, bacteria and fungi have been found to be associated with the disease, however, the precise primary etiological agent of the disease is still a mystery. The process of disease development, the role of various pathogens and the environmental factors which predispose the fish to the disease are largely unknown. The disease spreads rapidly and till date there is very little information on the mode of transmission of the disease. Development of therapy and management strategies to contain the disease have met with little success as the primary etiology is still uncertain.

Epidemiological analysis

Details of the outbreak of EUS in different parts of Karnataka and the way it spread between waterbodies are documented in Table 1. EUS first appeared in Karnataka in the Cauvery river system during Aug–Sept 1991, immediately after the floods. Later in Nov–Dec 1991 it spread to ponds, major and minor irrigation tanks of Coorg and Mandya districts. During early 1992 the disease was recorded in the reservoirs of Shimoga district. In August 1992 the disease was reported in the major and minor irrigation tanks of Hassan district. In early 1993, the disease first appeared in the coastal district of Dakshina Kannada (DK) affecting fishes in ponds, rivers and clay pits. During the monsoon months of 1993 when the salinity was very low (< 0.5 ppt), full blown EUS also occurred in the estuaries of Dakshina and Uttara Kannada districts for the first time causing mass mortality of several species of fishes. Later in 1993 the disease was seen in open irrigation wells of DK district where it had not occurred earlier. Recently (Dec 1993–Jan 1994) the disease has been causing mortality in the major and minor irrigation tanks of Tumkur and Shimoga districts of the state.

In several parts of the world the disease has been closely associated with heavy rains and flood. It was earlier believed that the run-off from agricultural land containing pesticides and insecticides was possibly predisposing the fish to EUS. Extensive work carried out in Bangladesh[5] and Philippines[6] found no evidence to support this school of thought. Barring few exceptions, the disease appears to occur during colder months of the year or with decreasing water temperature. The role of temperature with the occurrence of the disease is still not clear. Lowering of water temperature may lower the innate defence competence of the fish, thereby predisposing the fish to EUS. This hypothesis needs further investigation.

The disease appears to be specific to certain groups of fishes and there is a definite pattern in the way it causes mortality in different species. During an outbreak in freshwater, it first invariably affects bottom dwelling snakeheads (*Channa* spp.), followed by catfishes (*Mystus* spp., *Wallago* sp.), minor carps (*Puntius* spp.), featherbacks (*Notopterus* sp.), etc. Interestingly, EUS has not affected the Indian major carps (*Catla catla*, *Labeo rohita* and *Cirrhina mrigala*) and common carp (*Cyprinus carpio*) in Karnataka, though there are reports of EUS causing mortality of Indian major carps in North India. Studies in Philippines[6] and other south-east Asian

Table 1. EUS epidemiology in Karnataka State

Season		Waterbody	Species affected	Remarks
Aug–Sept	1991	Cauveri river system (Mysore)	*Puntius* spp., *Channa* spp., *Ompak* sp., *Notopterus* sp.	Immediately after the floods
Nov–Dec	1991	Ponds, irrigation tanks (Coorg, Mandya)	*Channa* spp., *Puntius* spp., *Mystus* spp.	
Mar–Apr	1992	Reservoirs (a) Bhadra (b) Shanthisagar	*Puntius* spp., *Channa* spp., *Notopterus* sp.	Indian major carps (IMC) and common carp stocked in these reservoirs were not affected
Aug	1992	Major and minor irrigation tanks (Hassan)	*Puntius* spp., *Channa* spp.	IMC stocked in these tanks were not affected
Feb	1993	Rivers (Dakshina Kannada)	*Puntius* spp.	Other species were not affected
Mar	1993	Ponds, clay pit ponds (Dakshina Kannada)	*Channa* spp.	*Clarius* sp. was not affected
July–Sept	1993	Estuaries (Dakshina Kannada and Uttara Kannada)	*Mugil* spp., *Sillago* sp., *Etroplus* sp., *Platycephalus* sp., *Epinephelus* sp., *Scatophagus* sp.	During monsoon when the salinity was very low (< 0.5 ppt)
Nov	1993	Open wells in Manjeshwar (Dakshina Kannada)	*Channa* spp.	*Clarius* sp. was not affected
Dec	1993	Minor and major irrigation tanks of Tumkur district	*Channa* spp., *Mystus* sp., *Heteropneustes* sp., *Puntius* spp.	IMC stocked in these tanks were not affected. Water temperature was quite low during the outbreak.
Dec 15th to Jan 15th	1993 1994	Tarikere tank (Shimoga district)	*Channa* spp., *Puntius* spp., *Mystus* sp., *Wallago* sp.	IMC and common carp were not affected. Mass mortality of weed fishes, catfishes, etc.

countries also strongly suggest that some groups of fishes particularly the tilapias and carps are resistant to EUS. This host specificity of EUS appears to be related to the competence of the non-specific defence components of the fish. Further investigations on these lines may throw more light on the host specificity of EUS.

In estuaries, EUS affected many of the euryhaline species. From the recent outbreak it is clear that bottom dwelling mullets are highly susceptible to the disease followed by other species. EUS is basically a disease of freshwater fishes. Its occurrence in brackishwater is always associated with monsoon floods and subsequent reduction in salinity.

EUS spreads rapidly between waterbodies which may or may not have connections. It occurred in ponds which are remote and isolated from other waterbodies. From the nature of outbreak it is certain that water may not be the only mode of disease transmission. The possibility of the disease spreading through air and birds still remains a strong possibility. Over the last three years, the disease has not reappeared in waterbodies where it had occurred once. Studies in Philippines show that a wider range of species are affected during the first occurrence than in subsequent outbreaks[6]. The question as to whether the survivors and those exposed to the pathogens once, develop immunity needs to be examined closely.

The disease takes a heavy toll of affected fishes in a short time scale. In a majority of the waterbodies studied in Karnataka the disease had wiped out the susceptible fish within a month of outbreak and later subsided and disappeared gradually. EUS badly affected fish marketing because of several misconceptions that fish-eating population has on this disease. There is no known evidence of human health hazard associated with EUS from any part of south and south-east Asia, where the disease has been playing havoc intermittently.

EUS is a highly infectious disease with mixed etiology. Virus[7,8], bacteria[9–11] and fungi[2–4,12] have been found to be associated with the disease. The primary etiology and the factors which predispose the fish are still largely unknown. Recently several laboratories[2–4,12] have shown the consistent involvement of broad, non-septate, highly invasive fungus of the *Aphanomyces* group with this disease. Fungal invasion is always associated with massive necrosis of the epithelium and musculature. Histological studies in our laboratory have demonstrated the consistent involvement of non-septate, highly invasive fungus in EUS-affected fishes collected from different ecosystems including mullets from estuaries (Figures 1–3). Our findings constitute the first report from India on the involvement of non-septate, highly invasive fungus with EUS of both fresh and brackishwater fishes. From the consistent involvement of fungus and the similarity

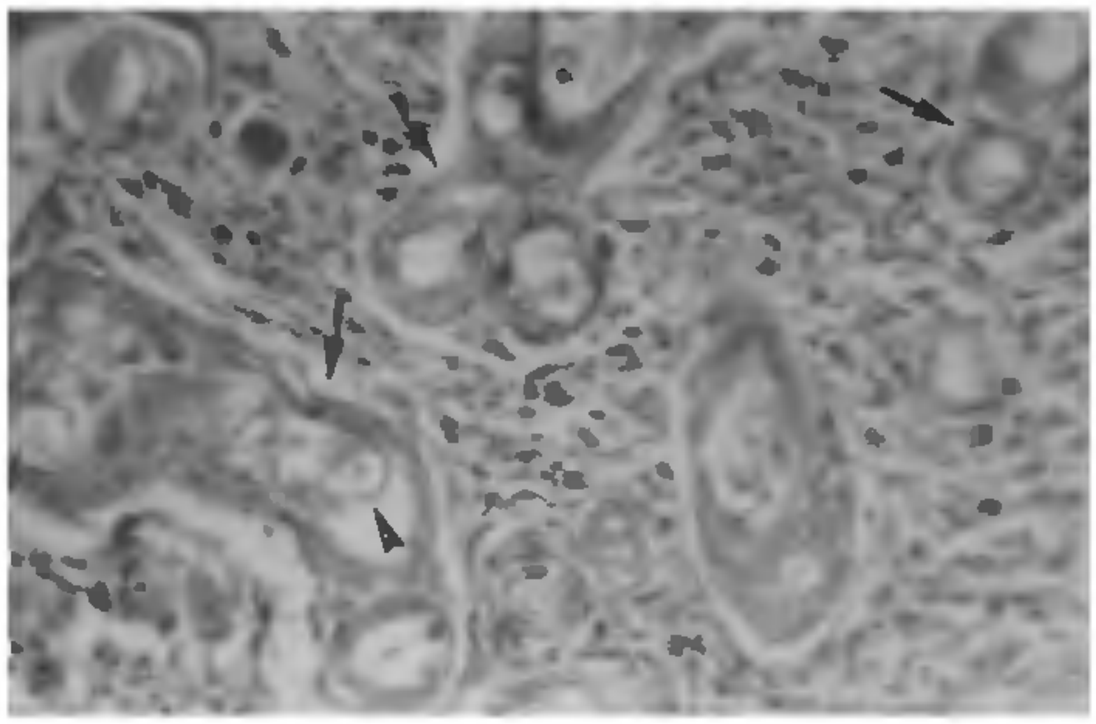

Figure 1. Section showing massive fungal invasion and well-developed granulomatous response (arrowed) in the skeletal muculature of mullet, *Mugil cephalus*. Note fungal hyphae (arrow head) sectioned in various planes inside the granuloma (H&E, ×200)

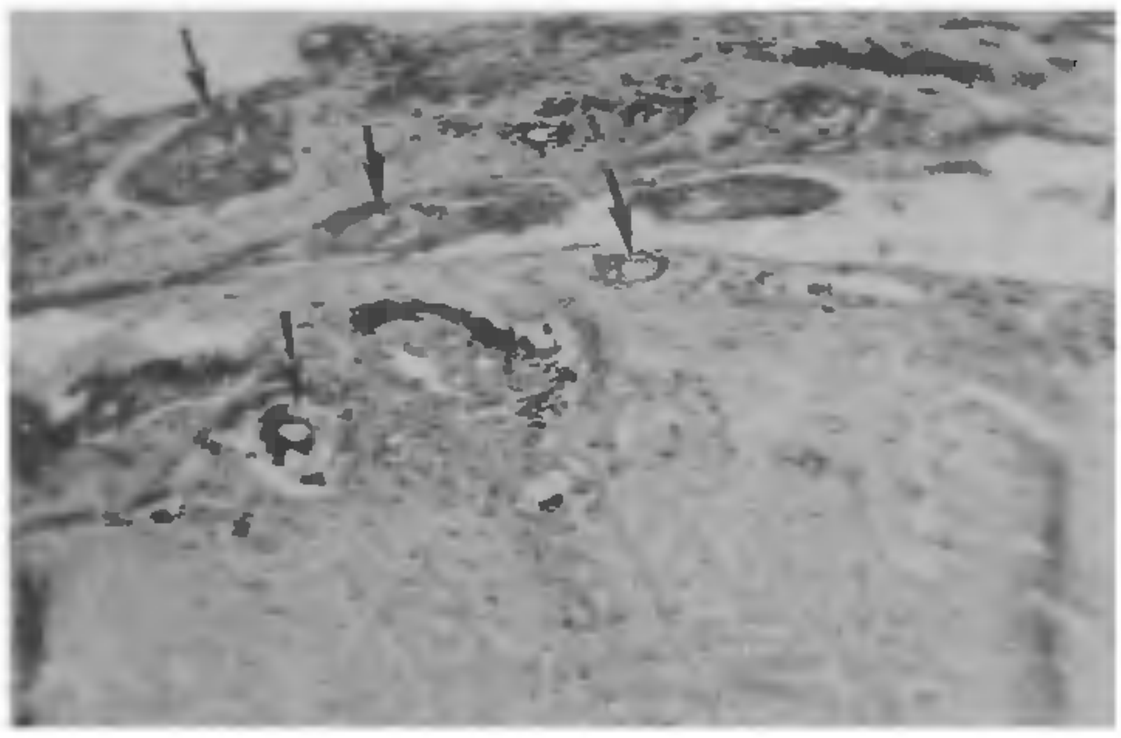

Figure 2. Section showing fungal hyphae invested in host inflammatory tissue (arrowed) in the epidermis and dermis of snakehead, *Channa* spp. away from the site of ulceration (H&E, ×200).

in pathological changes it is certain that fungus is one of the very important etiological agents of the EUS, though it may not be a primary pathogen in its own right. Our findings strongly support the recent school of thought[2], that bacterial invasion although frequent, is secondary to a highly invasive fungus.

The disease normally occurs in natural waterbodies like rivers, reservoirs, large irrigation tanks, estuaries, etc. It is impractical to resort to any chemical treatment in such large waterbodies. In small ponds and manageable aquaculture systems, the severity of the disease can be minimized by application of lime, antifungal and antibacterial agents. Chemical treatments like this may only minimize the secondary infections at the site of ulcer and may provide a better microenvironment for the ulcer to heal. Effective therapy directed against the

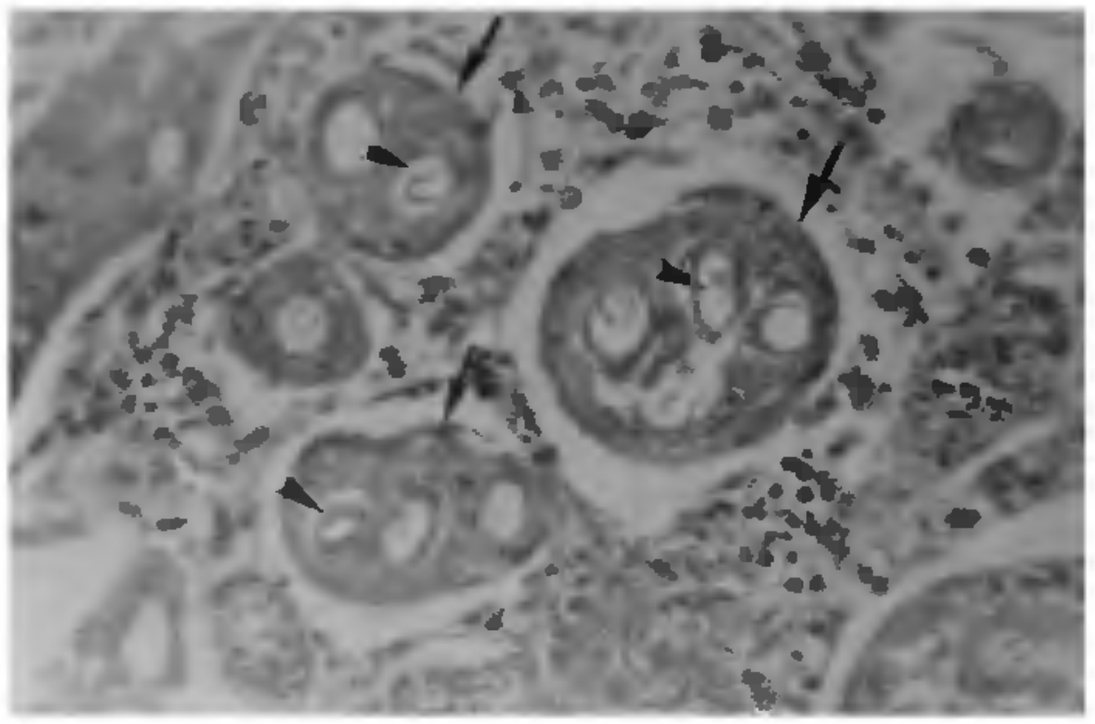

Figure 3. Early to mature granulomas (arrowed) in the skeletal musculature of minor carp, *Puntius* spp. with one to several fungal hyphae in the centre (arrow head) (H&E, ×200).

primary pathogen of the disease is yet to be developed, though there are several claims to this effect.

Several issues surrounding EUS are yet to be resolved. Multidisciplinary approaches being taken by several laboratories in the world and the ongoing co-ordination of research effort between different national and international research organizations could resolve the mystery in the near future.

1. Rodgers, L. J. and Burke, J. M., *J. Fish Dis.*, 1981, 4, 297.
2. Roberts, R. J., Frerichs, N. and Millar, S. D., *Dis. Asian Aqua.*, 1992, **1**, 431.
3. Fraser, G. C., Callinan, R. B. and Calder, L. M., *J. Fish Dis.*, 1992, **15**, 173.
4. Roberts, R. J., Willoughby, L. G. and Chinabut, S., *J. Fish Dis.*, 1993, **16**, 169.
5. Macintosh, D. J. and Phillips, M. J., Field and Laboratory investigations into ulcerative diseases in the Asia-Pacific Region FAO, Bangkok, 1986, 175.
6. Bondad–Reantaro, M. G., Lumaulan, S. C., Natividad, J M. and Phillips, M. J., *Dis. Asian Aqua.*, 1992, **1**, 475.
7. Frerichs, G. N., Millar, J. D. and Roberts, R. J., *Nature*, 1986, **322**, 216.
8. Ahne, W., Jorgensen, P. E. V., Olesen, N J. and Wattanavijarn, N., *J. Appl. Ich.*, 1988, **4**, 194.
9. Llobrera, A. J. and Gacutan, R. Q., *Aquaculture*, 1987, **67**, 273.
10. Ali, A. and Tamuli, K., *Fishing Chimes*, 1991, **11**, 43.
11. Chakrabarty, A. N. and Dastidar, S. G., *Indian J. Exp. Biol.*, 1991, **29**, 623.
12. Callinan, R. B., Fraser, G. C. and Virgona, J. L., *J. Fish Dis.*, 1989, **12**, 467.

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