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Captive breeding and seed production of *Etroplus suratensis* in controlled systems

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Abstract

Pearlspot, *Etroplus suratensis,* the largest indigenous cichlid, breeds in shallow, peripheral waters and are most critically exposed to human interferences in Vembanad lake, the home ground of this species. The species exhibit a complex courtship behaviour involving pairing and nesting. Captive breeding of *E. suratensis* was undertaken, in specially designed artificial raceway tank, with depth situations ranging from 30 to 80 cm. Paired fishes were stocked for breeding in raceways provided with artificial spawning surfaces and breeding pits to facilitate egg attachment and 'pit caring', characteristic of the species. A total of 50 trials were carried out and in over 75 % of the cases, nest were confined to shallow depths between 12 and 45cm. The mean number of eggs within a nest was observed to be 32 cm^{-2}. Almost round the year breeding was possible in this controlled system and the breeding success was as high as 71 %, much higher than that in the traditional earthen pond system (60%). The fertilization rate in the confined raceway system fluctuated between 82 to 100%. When eggs were incubated allowing parental care, hatching rate varied from 63 to 99 %. Hatching of eggs occurred in 70-72 hrs at 25-27^{o}C. The hatched out larvae, were heavily yolked and were observed to become free swimming on the 6th day. The fry yield under the devised system is perceptibly high (61%), as compared to that in earthen ponds (28 %). The technique devised is a reliable system for large scale production of seeds of this species under controlled conditions.

Introduction

Development of standardized technologies for mass production of seeds by captive breeding is an accepted strategy to replenish and restore endemic species in natural systems and also for their utilization in commercial aquaculture. *Etroplus suratensis*, is the largest among the cichlids indigenous to peninsular India and Srilanka. They constituted almost 10 % of the total fish landings in the backwaters of Kerala during the sixties (George & Sebastain, 1970). However, this species is facing serious depletion in

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its home grounds, the Vembanad wetlands, owing to unbridled exploitation. With the boom of backwater tourism, the demand for pearlspots, the high valued food fish in Vembanad, has been on the increase. Since the most valuable species are generally exploited to the maximum, the fishery of this species is further subject to increasing pressures (Padmakumar et al. 2002). This is evident from the decline in average size of this species in catches. The fish breeds naturally in confined conditions. *E. suratensis* is compatible for polyculture with both freshwater and brackish water fish and prawn species. However, lack of required quantities of seed has been a serious constraint in intensive farming of the species. In nature, *E. suratensis* breeds in shallow, peripheral waters in isolated territories. Such shallow waters are the most seriously exposed to human interferences. Efforts for induced spawning of this species, has not been successful owing to their unique parental care, monogamously mating habits, small clutch size and their exclusive substrate breeding nature. These problems and the ever increasing demand for seeds for aquaculture, calls for efforts to develop artificial breeding techniques. In such a context, captive breeding of *E.suratensis* was undertaken, in specially designed artificial raceway tank under simulated natural conditions.

Materials and Methods

Captive breeding trials were undertaken in specially designed artificial raceway system by simulating natural breeding conditions that facilitated complex and unique courtship behavior. The raceway system comprised a trapezoidal tank of 70 sq.m, with slopping sides and bottom. The slope of the tank facilitated diverse depth situations ranging from 30 to 80 cm with in the tank. The raceway was provided with continuous water exchange that allowed a simulated breeding environment in terms of depth, temperature, transparency and flow regime. Artificial nesting substrates, comprising 30-35cm long cylindrical wooden poles fixed on cement concrete base, cement sinkers and fire clay pots were placed vertically, 50 cm away from the tank margin at varying depths, as spawning surfaces. The distance between the spawning surfaces were approximately maintained at 1-2 m, taking in to consideration the territorial requirements of the species. Prefabricated cement slabs with artificial pits measuring 6 cm diameter and 4 cm deep were also deposited close to the nest substrates to facilitate 'pit caring' of the hatchlings, characteristic to the species. In order to prevent formation of algal blooms and to avoid turbidity, the raceway tank was provided with adequate shading from the top, using 50% agro-shade netting. Captive stocks were raised separately in the holding ponds and the brood fishes were stocked in the breeding raceway system at 1:1 ratio. Altogether 70 pairs of brood fishes, of size 15- 23cm (90-250g) were released in the raceway tanks for controlled breeding.

Captive breeding was facilitated by promoting parental care by the paired spawners within the raceway system. On successful spawning, the nest containing the attached eggs were transferred to incubation tanks of 1.1 ton capacity, provided with continuous aeration, for hatching. Egg incubation and hatching were facilitated in two ways, (1) in the breeding tank by ensuring care of the breeding pairs (2) in Larval Rearing Tanks (LRT) without parental care. Spawning behavior, fecundity, incubation period, fertilization rate and hatching percentage were monitored. The early embryonic and larval developments were also examined and documented using a computer aided Magnus Imaging System.

Results

Shortly after release of the brood stocks in to the holding tanks, the fishes were found to form 2-3 groups. Breeding pairs were formed invariably from members with in the groups. After pairing, the pair gets separated from rest of the group and was found to search for the nesting substratum at shallow water depths. Presence of adequate number of spawning surfaces was observed to enhance pair formation. As pair bonding and mate selection was guided by some specific attributes among members within a group, pair formation was found enhanced by adding additional number of fishes in readiness to breed. Pair bonding among the mates was almost stable.

Males appeared brilliantly colored, and pigmentation of the males began to intensify as nest construction commences. In sexually motivated males, as a common pattern during courting, black occipital stripes were found to appear between the eyes prior to spawning. The swollen cup like ovipositor in females and intense pigmentation among males during courting period appeared to be the sexual motivation signs of the spawners. Such paired fishes could be easily seined out from the holding ponds, assessed of their maturity and stocked in the raceway system for breeding.

The paired mates were observed to clear off algal growth from the nesting substrate, by browsing with their truncated cone like snout. At this point of time, the male and female took positions parallelly one behind the other, lay flat to the spawning surface and began to attach their adhesive eggs on to the substrate using the modified

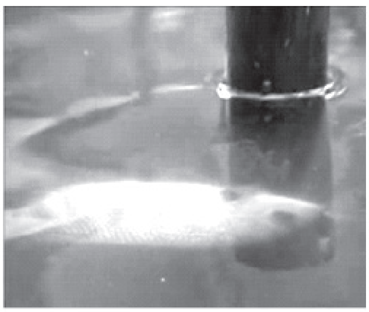

Figure 1. Egg placing on the substrate

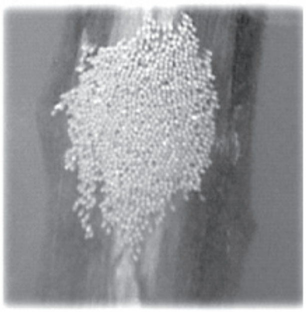

Figure 2. Attached eggs of *E.suratensis*

cup like ovipositor (Fig. 1). Eggs are never laid on top of other eggs but are placed in a single layer so that one egg just touched the other (Fig. 2). After the female has completed attaching one or two rows of eggs, the male fish was found to follow close behind and spontaneously hovered over the egg mass and fertilized by sprinkling milt over the egg patches. Duration of sperm motility was found to vary from 3 to 4 min. During spawning, the partners assumed a ritualistic side-by-side position. Body contact between male and female fish occurred only infrequently and incidentally as it did not appear to serve any particular function. The water temperature during courting and breeding varied from 25-27^{0}C.

In all, 50 nesting were observed by the stocked fishes during the experimental period of one year and over 75 % of the nests were confined to shallow clear areas at depths between 12 and 45cm. The maximum depth selected for nest formation with in the raceway was 53.5cm. The breeding performance of *E. suratensis* in the artificial raceway system is summarized in Table 1.

Table 1. Egg attachment of *Etroplus suratensis* in raceway systems

Sl.No.	Nesting substrate	Nest Area cm^2	No. of eggs	No.cm-2	Fertilisation %	Hatching %
1	Earthen pots	56	951	17	75.7	90*
2	CC. substrate	32	851	27	90	#
3	CC. substrate	52.5	1371	26	90	#
4	CC. substrate	32	420	13	100	63*
5	Wooden poles	18	792	44	82.32	20*
6	Wooden poles	37.8	1966	52	98	29*
7	PVC pipe	19	382	20	100	99
8	Fire brick	18.3	439	24	100	#
9	CC. substrate	18	633	35	95	63
10	CC. substrate	54.4	390	7	98	90
11	CC. substrate	27	1350	50	98.7	34*
12	CC. substrate	28	477	17	95.8	65

* incubation inside the laboratory # eggs are removed by the parents

In the tank breeding system, the percentage success of breeding was as high as 71%, much higher than the natural earthen pond system (60%). Evidently, the fish was found to exhibit a perceptible preference to cement concrete substrates as compared to wooden materials. The mean number of eggs within a nest was observed to be 32 cm^{-2}. The patch size of eggs per nest was observed to vary from 18 to 56cm^2 . The number of eggs released per spawning fluctuated from 382 to 1966 (Average 835). The number of eggs laid depend on the size of the fish and a female fish of average size (100g), was obser ved to lay around 250 eggs, while a fish of size 200-300g produced more than 1000 eggs. The breeding frequency was however higher, under raceway situations. The fertilization rate in the raceway system (75.7 to 100 %) did not exhibit any significant variation as compared to natural situations.

When the 'nest' along with the eggs was transferred to indoor incubation tanks and incubated without parental patronage, hatching of eggs occurred in 70-72 hrs under a temperature regime of 25-27^{o}C. The hatching was however, protracted and after the first hatching, complete hatching of the entire brood was observed to take place in a long interval of 24 to 26 hrs. The hatched out larvae, 'wrigglers', have a mean size of 4.5mm. They were heavily yolked, sink to the bottom and were found to instinctively congregate, creeping on the tank floor. The fry became free swimming on the 6th day, at an average size of 7-8 mm and move in shoals.

When the eggs were retained with in the spawning tank, undisturbed for hatching, both parents were found to take turns in guarding and exhibited a characteristic mouthing and fanning behavior. The fanning parents were observed to hold position close to the clutch. They were found to make currents through large amplitude beats of their pectoral fins which not only helped to increase oxygenation but also aided to prevent settling of dirt on the eggs. The parent fishes also continually picked up the eggs in their mouth, and in the process, the fish appeared to destroy the dead and infected eggs. The hatching rate of eggs under controlled conditions with parental patronage varied between 63 - 99 %. Under artificial incubation in Larval Rearing Tanks (LRT) without parental care, the eggs were observed to become increasingly infected with fungal elements and the hatching rate was also relatively low (20 - 90%) in such situations. When parents were also transferred to the larval rearing tanks along with the nest, the fish was found to devour their eggs under such disturbed conditions. A similar behavior was also noticed in the raceway breeding tanks, when water turned more turbid.

A comparison of the fry yield under artificial raceway breeding and natural breeding in earthen pond (Table 2) revealed that fry yield under tank breeding is perceptibly high (61 %), as compared to earthen pond system (28 %). Increased frequency of spawning, almost year round (Fig.1) and high seed recovery were characteristic to the tank breeding system. The capture of juveniles was also possible with less effort in controlled tank breeding.

Table. 2 Brood/ Nest characteristics of *Etroplus suratensis*

	Raceway system		Pond	
	Range	Mean	Range	Mean
Nest Area (cm^2)	18.0 - 56.0	32.75	20.0 - 49.5	34.41
No.of eggs	382 - 1966	835	250 - 1573	854
No./cm^2	7 - 52	28	5 - 60	30
Fertilisation %	75.7 - 100	93.63	70.0 - 100	94.25
Hatching %	20.0 - 90.0	61.44	2 .0- 70.0	27.86

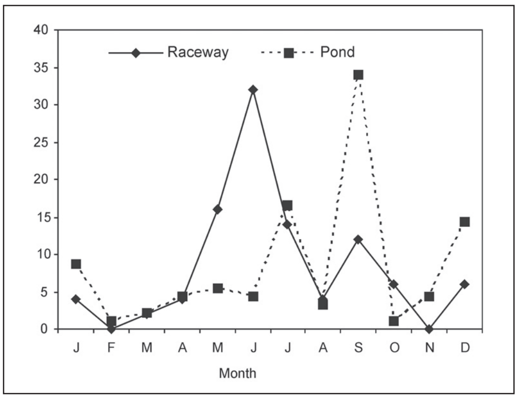

Figure 1. Breeding frequency of *Etroplus suratensis* in natural and artificial systems

Discussion

Breeding activities of *E. suratensis*, are unique which involved a series of events such as pairing, nest making and parental care. Hence the traditional methods of breeding inducement by hormonal manipulation have not been effective. Placement of brood stock in open ponds and pond spawning has been the only method of seed production of *E. suratensis*. Investigations on captive breeding of *E. suratensis* under controlled conditions by manipulation of the breeding environment revealed that in this species, breeding is preceded by a very complex pair bonding.

Although, the breeding biology of the fish with regard to incidence of gravid females and gonad maturation indicated that the major spawning season of *E. suratensis* in Vembanad Lake is from February-April and June-October, the fish could be made to breed almost round the year under captive conditions. Nevertheless, in controlled breeding system, maximum spawning success is achieved during June-September. In the artificial raceway system, apparently, the fish was found to breed profusely in conditions of low turbidity, facilitated through periodic water replacement. Visual contact between the parents and the offspring appear to be a critical requirement for spawning of *E. suratensis* (Breder & Rosen 1966; Keenleyside 1979; Blumer 1982; Gross & Sargent 1985). Ward & Samarakoon (1981) observed that *E. suratensis* reproduce twice during the year when water conditions were favorable for nest construction. *E. suratensis* is a visual feeder and so they preferred clear water for breeding, probably because this ensured better feed visibility for the young ones (De Silva et al.1984). In Kerala backwaters, *E. suratensis* has been reported to exhibit intense spawning during November-March with a peak during December-January (Jayaprakas 1980; Krishnan & Diwan 1990). This should be linked to high transparency of water with the cessation of monsoon and incursion of saline waters from the coastal seas. Jhingran (1991) also observed that in shallow confined waters, the fish breed almost round the year, while in backwaters, the fish breeds twice a year. Apparently, pearlspots prefer clear water conditions for breeding and it ensures visual contact with the young.

In the raceway system devised, *E. suratensis* could be stimulated to spawn round the year. Rapid removal of eggs and young ones from the breeding tanks and rearing them in separate systems, possibly have reduced their parental care period. Lee (1979) observed that parental care suppresses expression of full reproductive potential and removal of fry from the parent fish shortens the time interval between spawning. The present observations on round the year spawning under controlled raceway systems support the hypothesis that removal of brood from the caring parent can help to reduce the spawning interval (Peters 1983; Verdegem & McGinty 1987).

In the present study, in the raceway system *E. suratensis* was found to prefer breeding in shallow depths. In natural conditions *E. suratensis* has been reported to migrate to shallow open locations, devoid of vegetation, for breeding (Ward & Wyman 1975; Ward & Samarakoon 1981). The observations on the abundance of young ones and the breeding adults in the shallow littoral regions (Winn 1956), in their the natural breeding habitats indicate that conservation management of pearlspot calls for more co-ordinated efforts in shallow waters.

E. suratensis has been reported to prefer a variety of nest substrates in natural pond situations *viz.,* stones, coconut shells, coconut petioles, tiles, bamboo and wooden pieces. The higher rate of spawning in the artificial raceway system is apparently linked to increased availability of artificial nesting substrates provided with in the tanks. In fact, an upsurge in spawning frequency was observed when spawning surfaces were supplied. However, the artificial, pre-fabricated breeding pits provided were seldom utilized by the parent fish. The fish rather preferred to utilize the cleaned floor of the tank for hatchling care. Samarakoon (1985) also observed that *E. suratensis* spawned rapidly in ponds supplied with spawning surfaces as compared to situations without breeding substrates. The fish has been indicated to spawn on hard objects situated at a depth not more than 100 cm (Sultana et al. 1995). Despite closer spacing of the substrates in the raceway system, nesting occurred only at a wider space interval *i.e*., 2-4m. This apparently ensured the required degree of isolation for the nesting fish . This evidently highlights the territoriality of the species and it could be inferred that substrate spacing in isolated territories of approximately 2m favor breeding of *E. suratensis.*

Spawning fecundity was quite high for fishes bred in tank breeding trials as compared to natural system. This could be due to the better nutritional well being of the brood fish raised under captive conditions. The number of eggs released per spawning naturally increases with the physical well being of the fish. It appears that in the tank breeding, the total protection of the nest from predators also ensured higher survival. It has been reported that in earthen ponds, when stocked at 1:1 sex ratio, breeding success is only one third for *E. suratensis* (Samarakoon, 1985). The high percentage success of breeding in the raceway breeding system may also be linked to the relatively high group size of brood stock and enhanced probability of bringing together male and female fish with attributes necessary for successful pairing.

In tank incubation, with out parental patronage, egg masses were exposed to increased fungal menace. Some times, heavy infestation with fungal mat resulted in large scale mortality of eggs. However, egg masses cared by the parents were infected with aquatic fungi, less frequently. Egg guarding fishes are known to clean the eggs during guarding by two unique cleaning process *viz.,* 'mouthing' and 'snapping' (Takahashi et al. 2004; Keenleyside 1991). The more synchronized hatching of eggs under guarded conditions apparently explains the advantages of parental patronage. Similar to the present study, it has been reported that also in *E. maculatus*, another common cichlid, embryos kept separated from parents hatch over a more extended interval, than those attended by parents (Zoran & Ward,1983) .

Poor fry yield under tank incubation, without the support of the parents indicated that parents probably help in providing the required food and nutrients for the early hatchlings. Bioturbulation activity through fin digging and micro nipping, are reportedly two types of parental behavior characteristic of cichlids that ensure nutrition to early hatchlings.(Quertermus & Ward 1969; Williams 1972; Noakes 1979). During fin digging, the adults with their vigorous and rapid beats of the pectoral fins, apparently stirs up loose materials for feeding the fry. In 'micro nipping' the fry ingest mucous from the body of the parent. Both types of behaviour are reported to be regular and common in *E. suratensis* and *E. maculatus* (Ward & Wymann 1977). High epidermal mucous production during the fry-brooding period is reported in such fishes (Hildemann 1959). Since the major component of parental mucous is protein, apparently this assists in nutritional management of broods and larviculture (Khen & Chien 2006). This would imply that for better fry survival and maximum success in tank breeding, without parental patronage, there is a dire need to develop alternate sources of nutrition.

One of the problems encountered in the traditional pond breeding of pearlspot has been the lower yield of seeds in such systems. Another most serious practical difficulty encountered has been in capturing of the juveniles in earthen ponds. Such exhaustive collections also bring about unwanted disturbances to the other pair bonded brooders. This difficulty was overcome in the controlled raceway system, where the fish could be made to breed round the year with a higher seed recovery, an advancement towards the development of a standardized mechanism for mass production of seeds of this species.

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References

Blumer, L.S. 1982. A bibliography and categorization of bony fishes exhibiting parental care. Zoological Journal of the Linnean Society. 76(1): 1-22.

Breder, C.M and D.E.Rosen. 1966. Modes of Reproduction in Fishes. Natural History Press, Garden City. New York. 941 pp.

De Silva, S.S., P.Maitipe and R.T.Cumaranatunge. 1984. Aspects of biology of euryhaline Asian cichlid, *Etroplus suratensis*. Environmental Biology of Fishes 10(1/2): 77-87.

George, A.I. and M.J.Sebastian. 1970. Review of the backwater fisheries and brackishwater fish culture in Kerala state. In: Symposium on Coastal Aquaculture. Indo-Pacific Fisheries Council, Bangkok, 18-27 Nov. 1970. 12p. Report No. FI-IPFC/C70/SYM. 19.

Gross, M.R. and R.C. Sargent.1985. The evolution of male and female parental care in fishes. American Zoolologist 25:807-22.

Hildemann, W.H. 1959. A Cichlid fish, *Symphysodon discus*, with unique nurture habits. American Naturalist 93:27-34

Jayaprakas.V. 1980. Biology of *Etroplus suratensis* (Bloch). Ph.D. Thesis. Department Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram. Kerala, India. 434pp.

Jhingran, V.G. 1991. Fish and Fisheries of India. 3rd edition. Hindustan Publ.Co.Ltd. Delhi. 727pp.

Keenleyside, M.H.A. 1979. Diversity and Adaptation in Fish behaviour, Springer-Verlag, Berlin. 208pp

Keenleyside, M.H.A. 1991. Cichlid Fishes Behaviour, Ecology and Evolution. Chapman and Hall. New York. 378pp.

Khen, K.C.K. and A.C.S.Chien. 2006. Biotechnology in Ornamental Fish Research and Farming- A Malaysian Perspective. Ornamentals Kerala 2006. International Seminar on Ornamental fish breeding, farming and trade. Kerala. India. pp. 27-31.

Krishnan, L. and A.D.Diwan. 1990. Seasonal changes in gonads and their relationship with gonadotrophs of the pituitary in *Etroplus suratensis* (Bloch). Journal of Marine Biological Association of India 32(1&2): 5-9.

Lee, J.C. 1979. Reproduction and hybridization of three cichlid fishes, *Tilapia aurea* (Steindachner), *T.hornorum* (Trewavas) and *T.nilotica* (Linnaeus) in aquaria and in plastic pools. Ph.D. Dissertation. Auburn University, Auburn, AL. 84 pp.

Noakes, D.L.G. 1979. Parent- touching behaviour by young fishes: incidence, function and causation. Environmental Biology of Fishes 4: 389-400.

Padmakumar, K.G., Anuradha Krishnan, R.Radhika, P.S. Manu and C.K.Shiny. 2002. Openwater fishery interventions in Kuttanad, Kerala, with reference to fishery decline and ecosystem changes. In: Riverine and Reservoir Fisheries, Challenges and strategies. (ed. M.R. Boopendranath, B.MeenaKumari, J.Joseph, T.V.Sankar, P.Pravin and L. Edwin), pp.15-24. Society of Fishery Technologists (India), CIFT, Cochin.

Peters, H.M.1983. Fecundity, egg weight and oocyte development in tilapias(Cichlidae, Teleostei). ICLARM Translations 2. International Centre for Living Aquatic Resources Management , Manila , Philippines, 28pp.

Quertermus, C.G. and J.A.Ward. 1969. Development and significance of two motor patterns used in contacting parents by young orange chromides (*Etroplus maculatus*). Animal Behaviour 17: 624-35.

Samarakoon, J.I. 1985. Experimental seed production in *Etroplus suratensis* by induced pair formation and breeding through environmental manipulation. Aquaculture 4: 323-332.

Sultana. M, K.N.Krishnamurthy and S.M.Pillai. 1995. Biology, Fishery, Culture and Seed production of the Pearlspot *Etroplus suratensis* (Bloch). CIBA Bulletin No.7 .Central Institute of Brackishwater Aquaculture. Madras. 43pp.

Takahashi, D, H.Asada, T.Takeyama, M.Takahata, R.Katoh, S.Awata and M.Kohda. 2004. Why egg-caring males of Isaza (*Gymnogobius isaza*, Gobiidae)refuse additional females: preliminary field observations. Journal of Ethology 22(2): 127-133.

Verdegem, M.C and A.S. McGinty. 1987. Effects of frequency of egg and fry removal on spawning by *Tilapia nilotica* in hapas. Progressive Fish Culturist 49:129-131.

Ward,J.A. and R.L.Wyman. 1975. The cichlids of the resplendent isle. Oceans 8: 42-47.

Ward, J.A and R.L.Wyman. 1977. Ethology and ecology of cichlid fishes of the genus *Etroplus* in Sri Lanka: preliminary findings. Environmental Biology of Fishes 2: 137-145

Ward, J.A.and J.I.Samarakoon. 1981. Reproductive tactics of the Asian cichlids of the genus *Etroplus* in Sri Lanka. Environmental Biology of Fishes 6(1): 95-103.

Williams, G.C. 1972. On the ontogeny of behaviour of the cichlid fish *Cichlasoma nigrofasciatum* (Gunther) , Ph.D. Thesis. Univ.Groningen. Holland.

Winn, H.E. 1956. Egg site selection by three species of darters (Pisces: Percidae). Animal Behavior 5: 25-28.

Zoran, M.J. and J.A.Ward. 1983. Parental egg care behavior and fanning activity for the orange chromide, *Etroplus maculatus*. In: Predators and Prey in Fishes. (ed. D.I.G.Noakes, D.G.Lindquist, G.S.Helfman and J.A.Ward), pp. 139-148. Dr.W.Junk. The Hague.

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