EDITORIAL

This first issue of 1995 is rather thin because we are again short of articles from NTAS members and are awaiting responses from quite a number of authors to whom edited papers have been sent with questions to be answered before publication. Please include among your New Year Resolutions to send more items for *Aquabyte* and to respond promptly to editors. What we can publish depends upon you.

This issue has an interesting contribution from Randy Brummett on herbivorous tilapia in Africa and a larger than average crop of news items. Last issue's article on exotic species and genetically modified organisms has sparked some correspondence and hopefully this will continue. All the NTAS staff at ICLARM HQ wish the Network's members a Happy New Year and success in all their aquaculture endeavors. ***R.S.V. Pullin***

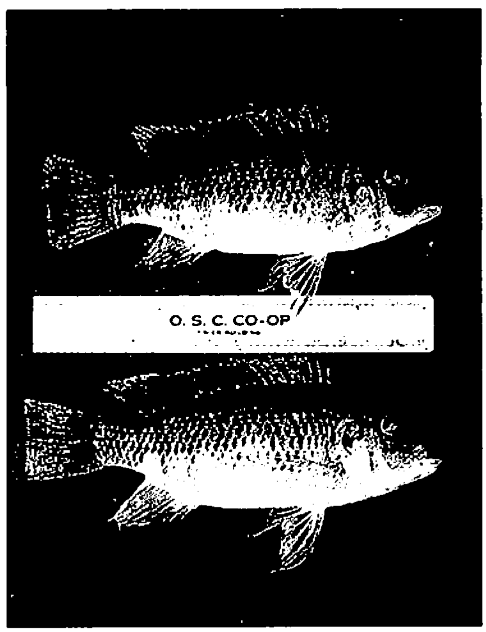
Weed Control by Adult and Juvenile *Tilapia rendalli* in Rainfed Ponds

RANDALL E. BRUMMETT

Fish production in seasonal ponds is currently under investigation in the Southern Region of Malaŵi. When these ponds dry during the hot season, weeds grow on their bottoms and their removal can be very labor intensive. When the ponds are subsequently in use again but with low productivity, due to limited material inputs, leaving the weeds in place might be advantageous. *Tilapia rendalli*, an indigenous species to Malaŵi, has been reported to feed on both aquatic and terrestrial macrophytes (Caulton 1976; Chikafumbwa et al. 1991). This research was conducted to determine whether labor-savings and fish growth enhancement could be achieved by stocking *T. rendalli* directly into ponds containing weeds left from a dry period.

Investigations at the National Aquaculture Centre

Two studies were conducted in consecutive years over the same time period (14 January - 1 July). Six replicate 200-m² ponds located at the Malaŵi National Aquaculture Centre, Domasi were drained, left dry for 63 days and natural growth of weeds was allowed. Areas under weed coverage were estimated for each pond by extrapolation from five randomly selected 1-m² quadrats. Weed specimens were collected and identified. Weed standing crop was extrapolated from a randomly selected 1-m² quadrat per pond, from which all plant materials were harvested and dried prior to flooding. From three ponds, weeds were removed by cutting at ground level prior to flooding. In three others, the weeds were simply inundated.



Tilapia rendalli: ***the upper fish is a male.*** *(PHOTO BY R.E. BRUMMETT)*

On 18 March, all ponds were stocked with 200 *T. rendalli* fingerlings (study I) or adults (study II) averaging 4.6 g (40 mm TL) and 47.7 g (130 mm TL), respectively.

Data collected on local smallholdings were used to design mixed daily inputs, according to the methods of Brummett and Noble (1994). Table 1 lists the wet materials, dry matter and nitrogen input to each fed pond. In study I, weedy ponds stocked with fingerlings received no external inputs, relying only on the standing crop of weeds at flooding, plus whatever grew during the study period. In study II, all ponds received inputs.

All ponds were harvested on 1 July after 104 days of growth. Stocked fish and offspring were separated, counted and batch weighed. Ten individuals from each pond, five juveniles and five adults (<100 and >100 mm TL, respectively), were taken for stomach content examination. Incidence of food organisms distinguished in three random passes at 40x through a 5-mg (dry weight) mounted sample, was recorded.

Immediately after draining, weed coverage and species composition were again estimated by the procedure described above.

Treatment variances and means were compared with Student's t-test (Zar 1974).

Results and Discussions

Harvest data are shown in Table 2. For *T. rendalli* juveniles, final standing stock,

Table 1. Total wet weight (per 200 m²/day), dry matter and nitrogen of feed materials used over 104 days in evaluating *Tilapia rendalli* for weed control in rainfed ponds in Malaŵi. Inputs were based on those used by local smallholding farmers.

Day	Goat manure (kg)	Maize bran (kg)	Sweet potato leaves (kg)	Napier grass (kg)	Nitrogen (g/m²/day)	Dry matter (g/m²/day)
0	-	0.50	-	-	0.084	2.26
8	-	0.35	-	0.35	0.074	2.03
15	-	0.35	-	0.35	0.074	2.03
21	0.10	0.40	-	0.30	0.093	2.61
28	0.10	0.40	-	0.40	0.098	2.74
36	0.25	0.70	-	0.20	0.159	4.46
45	0.40	0.70	0.30	0.20	0.191	5.37
52	0.40	1.00	0.30	0.20	0.242	6.73
59	0.40	1.00	0.30	0.30	0.251	8.18
66	0.40	1.00	0.30	0.20	0.242	5.37
73	0.30	1.00	0.30	-	0.191	4.30
79	0.30	1.00	0.30	-	0.191	4.30
87	0.40	1.00	0.30	0.20	0.242	5.37
94	0.40	1.00	0.30	0.20	0.242	5.37
101	0.40	1.00	0.30	0.20	0.242	5.37
Total	25.95	77.75	17.70	18.55	17.77	455.84[a]

[a]Equivalent to an average of 43.8 kg/ha/day dry matter input.

Table 2. Average stocking weight, average harvest weight, average harvest weight, average specific growth rate (SGR), weight of offspring produced and standing stock data for juvenile (J) or adult (A) *Tilapia rendalli* grown in weedy (W) and weedless (NW) ponds. In study I, only weedless ponds were fed. In study II, all ponds were fed. Values within columns within studies with different associated letters are significantly different (P<0.05).

Treatment/replicate	Average weight at stocking (g)	Average weight at harvest (g)	Specific growth rate (g/day)	Survival (%)	Total weight of offspring (kg)	Average weight of offspring (g)	Total standing stock (kg/ha)
Study I							
JNW/1	4.9	37.2	0.046	89.0	3.9	2.49	526.0
JNW/2	4.2	36.8	0.048	81.0	4.2	1.61	508.1
JNW/3	4.7	46.6	0.054	92.0	2.7	2.56	563.7
Average	4.6a	40.2a	0.049a	87.3a	3.6a	2.22a	531.0a
JW/1	4.5	12.0	0.018	71.0	0.15	1.69	92.5
JW/2	4.3	8.4	0.012	98.0	0.15	1.80	90.0
JW/3	5.0	11.6	0.016	57.0	0.5	2.61	91.3
Average	4.6a	10.7b	0.015b	75.3a	0.267b	2.03a	91.3b
Study II							
ANW/1	47.8	76.6	0.018	86.5	525	2.3	722.5
ANW/2	48.3	67.3	0.012	95.5	132	2.3	657.5
ANW/3	47.5	63.0	0.010	100.0	656	1.1	667.5
Average	47.9a	69.0a	0.013a	94.0a	438a	1.9a	682.5a
AW/1	47.7	75.4	0.017	93.5	176	1.1	715.0
AW/2	47.8	63.8	0.010	94.0	144	0.7	605.0
AW/3	46.8	56.5	0.007	100.0	110	2.3	577.5
Average	47.4a	65.2a	0.011a	95.8a	143a	1.4a	632.5a

$$SGR = \frac{3\left(w_t^{0.33} - w_o^{0.33}\right)}{t - t_o} \text{(Hepher 1988).}$$

growth and offspring production were significantly (P<0.05) better in fed than in weedy ponds. Average weights of fingerlings were significantly (P<0.05) different between the two treatments. For *T. rendalli* adults, final standing stock, growth and offspring production were not affected by the presence of weeds.

At flooding in study I, the weedy ponds, averaged 65.5% weed cover (Table 3). Average standing crop of weeds at flooding was 19.0 kg of dry matter per pond (950 kg/ha). The main weed species were grasses (63.8% of the total weed cover). Sedges (*Cyperus* spp.) represented 8.7%. The balance was composed of a mixture of 14 other species, mostly terrestrial herbaceous dicotyledons, all in relatively low individual numbers.

At harvest of study I, weed coverage was not significantly (P<0.05) different from that at flooding, averaging 66.3%. The species composition of weeds changed in favor of *Cyperus* spp. (56%) at the expense of the grasses (26.8%). Species diversity was reduced to six by flooding, excluding the sedges and grasses.

At flooding of study II, the weedy ponds averaged 62.5% coverage. Average standing crop of weeds at flooding was 18.3 kg of dry matter per pond (915 kg/ha). Of the total, 37.9% was grass and 30.7% were sedges. The remaining 31.4% was composed of mixed minor species. By day 79, no weeds were visible above the pond surface. At harvest, the standing crop of weeds was zero.

Frequency of food materials recorded from pooled stomach samples is shown in Table 4. In general, the variability in stomach contents was quite high. For most types of food organism, there were no significant (P<0.05) differences between the frequency of ingestion among adults and juveniles, or between treatments. There was, however, a significantly (P<0.05) greater density of macrophytic material and lower density of diatoms in stomachs of fish grown in weedy ponds than in weedless ponds. In addition, adults in weedless ponds ingested fewer diatoms in relation to their size than did juveniles. In both weedy and weedless ponds, large quantities of sand were ingested. Although its amorphous nature made it difficult to enumerate precisely, large quantities of

Table 3. Weed species frequency (% of total weeds) and total weed cover (% of pond area covered) before and after 104 days of inundation and consumption by *Tilapia rendalli* juveniles (J) or adults (A).

		Frequency			
		Pre-inundation		Post-inundation	
Weed	Family	J	A	J	A
Grasses	Graminae	63.8	37.9	26.8	0
Sedges	Cyperaceae	8.7	30.7	56.0	0
Commelina africana	Commelianaceae	6.7	4.4	15.7	0
Ageratum coryzoides	Compositae	4.2	9.7	0.0	0
Alternanthera sessilis	Amaranthaceae	3.9	5.8	0.5	0
Trifolium spp.	Leguminosae	2.6	4.8	0.0	0
Amannia auriculata	Lythraceae	1.1	1.2	0.5	0
Other weeds		9.0	5.5	0.5	0
Total weed cover		65.5	62.5	66.3	0

Table 4. Incidence/frequency of food organisms identified in juvenile and adult *Tilapia rendalli* stomach samples from ponds with and without weeds. Each record represents number of individual food organisms identified in three passes at 40x. Average incidence within columns with different associated letters are significantly different (P<0.05). Madeya is maize bran.

Treatment	Diatoms	Other phyto-plankton	Micro-crustacea	Other zooplankton	Macrophytes	Zoobenthos	Others
Juvenile/Weeds	148/0.74	35/0.17	4/0.02	0/0	13/0.06	1/0	sand
Juvenile/Weeds	209/0.89	16/0.07	1/0	1/0	9/0.04	0/0	sand
Juvenile/Weeds	151/0.73	40/0.19	2/0.01	2/0.01	11/0.05	1/0	sand
Adult/Weeds	179/0.73	33/0.13	5/0.02	2/0.01	20/0.08	6/0.02	madeya, sand
Adult/Weeds	126/0.66	47/0.24	6/0.03	1/0.01	12/0.06	0/0	madeya, sand
Adult/Weeds	45/0.56	22/0.28	0/0	0/0	13/0.16	0/0	madeya, sand
Juvenile average	169.3a	30.3a	2.3a	1.0a	11.0a	0.7a	
Adult average	116.7a	34.0a	3.7a	1.0a	15.0a	2.0a	
Weeds average	143.0a	32.2a	3.0a	1.0a	13.0a	1.3a	
Juvenile/No weeds	390/0.86	51/0.11	8/0.02	1/0	2/0	0/0	madeya, sand
Juvenile/No weeds	373/0.91	34/0.08	2/0	1/0	1/0	0/0	madeya, sand
Juvenile/No weeds	406/0.89	47/0.10	1/0	0/0	0/0	0/0	madeya, sand
Adult/No weeds	243/0.80	56/0.18	2/0.01	0/0	3/0.01	1/0	madeya, sand
Adult/No weeds	263/0.86	41/0.13	1/0	0/0	2/0.01	0/0	madeya, sand
Adult/No weeds	336/0.89	37/0.10	1/0.02	0/0	4/0.01	0/0	madeya, sand
Adult average	280.7a	44.7a	1.3a	0.0a	3.0b	0.2a	
Juvenile average	389.7b	44.0a	0.7a	0.7a	1.0b	0.0a	
Treatment average	335.2b	44.3a	2.5a	0.3a	2.0b	0.1a	

external inputs were found in the stomachs of fish from fed ponds.

The much higher growth rates of juvenile fish in the weedless ponds compared to all other groups is most likely due to the difference in relative feeding rates. Juveniles in weedless ponds received an average of 43.8 kg/ha/day of dry matter (12.5% of stocked fish body weight per day at harvest). In contrast, juveniles in weedy ponds received only 19 kg dry matter in total from the standing stock of weeds at flooding. Adults received the same amount of food as the juveniles in the weedless ponds, but this amounted to only 6.9% of stocked fish body weight per day at harvest.

The failure of weed biomass at the beginning of study II to enhance adult fish production is undoubtedly due to its relatively small contribution compared to external feed inputs. Standing crop of weeds at flooding of study II accounted for only 17% of total inputs to growth.

Implications for Tilapia Farming

The usefulness of *T. rendalli* as a cultured species in weedy rainfed ponds in Malaŵi is limited. What is needed is a fish that can be stocked at a small size and will then grow on a diet of the available plant material (supplemented later as weed standing crop is reduced by grazing). Unfortunately, while larger *T. rendalli* eat substantial quantities of weeds, juveniles do not.

Ontogenetic shifts in the diets of *T. rendalli* have been documented. Le Roux (1956) observed a shift away from chironomid larvae at about 130 mm TL. Munro (1967) noticed a trend away from consumption of cladocerans towards filamentous algae as fish grew above 50 mm TL. Caulton (1976) found that *T. rendalli* of less than 110 mm SL consumed significantly more diatoms than larger fish.

Stomach content data indicate that juvenile *T. rendalli* do eat macrophytes. However, it appears that *T. rendalli* of less than about 150 mm TL tend to target filamentous algae, submerged macrophytes (e.g., *Myriophyllum* and *Valisneria*) and only softer emergent vegetation. The juvenile *T. rendalli* stocked here at 40 mm TL and harvested at approximately 115 mm TL had probably not started eating the tougher weeds. This accounts for the shift in species composition away from grasses and herbaceous dicots towards the more fibrous sedges. Even though they were being starved (an assumption based on their poor growth), these small fish could not take advantage of the tougher plants.

In contrast, larger *T. rendalli* consume tough weeds, even in the presence of external inputs. It is, however, not generally practical to stock fish which are, by Malaŵian standards, already of harvestable size.

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References

Brummett, R.E. and R.P. Noble. 1994. Farmer-scientist research partnerships and smallholder integrated aquaculture in Malaŵi. Paper presented at the International Seminar on The Management of Integrated Agro-Piscicultural Ecosystems in Tropical Areas, 16-19 May 1994, Belgian Royal Academy of Overseas Sciences and the Technical Center for Agricultural and Rural Cooperation, Brussels.

Caulton, M.S. 1976. The energetics of metabolism, feeding and growth of sub-adult *Tilapia rendalli* (Boulenger). University of Rhodesia, Harare, Zimbabwe. Ph.D. Dissertation.

Chikafumbwa, F.J., B.A. Costa-Pierce and J.D. Balarin. 1991. Preference of different terrestrial plants as food for *Tilapia rendalli* and *Oreochromis shiranus*. Aquabyte 4(3):9-10.

Hepher, B. 1988. Nutrition of pond fishes. Cambridge University Press, Cambridge, U.K.

Le Roux, P.J. 1956. Feeding habits of the young of four species of *Tilapia*. S. Afr. J. Sci. 53:33-37.

Munro, J.L. 1967. The food community of East African freshwater fishes. J. Zool., Lond. 151:389-415.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

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In Memory of Dr. Giora Wohlfarth

Giora W. Wohlfarth, one of the pioneers of research on fish culture and genetic improvement of fish in Israel, a retired senior scientist at the Fish and Aquaculture Research Station, Dor, and a former Director of the station, was killed in a car accident on 22 August 1994.

Giora Wohlfarth got his B.Sc. (Genetics) from the University of Birmingham in 1951. He immigrated to Israel in 1952, and following military service and a couple of years in a kibbutz farm, he earned his M.Sc. (1959) and Ph.D. (1971) degrees from the Hebrew University of Jerusalem. In 1989, in recognizing his achievements in selective breeding of common carp and tilapias, he was admitted to the degree of Doctor of Science (Genetics) by the University of Birmingham.

Scientifically, Giora's first and foremost love was the common carp. Together with the late Prof. Moav, his Ph.D. supervisor, Giora played a major role in the selective breeding of common carp in Israel, leading to a nationwide use of genetically tested stocks and crossbreds by commercial fish farmers. The "Dor-70" line of common carp, and its crossbreds, are examples to his achievements. To facilitate the simultaneous genetic testing of a large number of groups, they developed the method of 'multiple nursing' which enables correcting the bias in growth rate generated by differences in initial weight among groups tested under competition in communal ponds. This method was later adopted by fellow scientists working on genetic improvement of catfishes, salmonids and tilapias. A major research effort was the evaluation of the genetic differences between the European and Chinese races of common carp, undertaken by Moav, Wohlfarth and myself (as a Ph.D. student) in the 1970s. This investigation was integrated with another major investigation, led primarily by Giora (and colleague Gerald Schroeder), on the use of organic manures and other agricultural by-products as nutrient source in polyculture ponds as substitute for the costly pelleted feeds. The joint aim of these two studies was to develop a breed of carp specifically adapted for culture in highly manured fishponds.

In addition, Giora was involved in investigations into the genetic improvement of tilapias, especially through interspecific hybridization, and understanding the sex determination mechanism of tilapias.

Giora was a unique, practical scientist, who liked to do the work with his own hands. He loved to go out to the ponds, handle the fish and be personally involved in all activities in his experiments. He was very much concerned with the applicability of his work to fish farmers, and spent hours talking to farmers and extension officers who visited him frequently in his office. Giora was a man of culture, being interested in poetry, literature and arts, and in collecting old books, rare publications and stamps.

Giora's numerous articles, resulting from his work on selective breeding of carp and pond management, have been published in various scientific journals. Many of these publications were written after his official retirement (in 1992), while continuing his scientific work at the station. On his way to office, as he used to do for about 35 years, he found his death. Giora was very productive in his last few years, and his untimely death left many works unfinished, which we - friends and colleagues - will have to complete. Among those is a book on common carp, coordinated and edited by Giora, especially written in Hebrew to make the knowledge about this fish species readily available to farmers and others in Israel not reading foreign languages. This book, almost ready to be printed, was meant by him to be the climax of his many years of work with the common carp.

Giora was a lively participant of many international forums and meetings, always with a great sense of humor and intelligent questions and remarks. His spirit will, no doubt, be with us for many years to come in our struggle to further advance fish culture and selective breeding of fish worldwide.

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